UNIVERSIDADE
LUSÓFONA

Centro Universitário de Lisboa
Faculdade de Educação Física e Desporto - FEFD
Doutoramento em Educação Física e Desporto

The effectiveness of sit-stand desks in reducing sedentary behavior: A multi-timeframe evaluation of a multicomponent intervention in office workers

Tese defendida em provas públicas para a obtenção do grau de Doutor em Educação Física e Desporto, na especialidade de atividade física e saúde, orientada pelo Professor Doutor Pedro B. Júdice

Hélio Bruno Gomes da Silva/ nº a22113505

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"Versão final"

Tese defendida por Hélio Bruno Gomes da Silva em provas públicas na Universidade Lusófona, Centro Universitário de Lisboa, no dia 16 de janeiro de 2026, perante o júri, nomeado pelo despacho de nomeação nº 415/2025 de 28 de julho de 2025, com a seguinte composição:

Presidente: Prof. Doutor Jorge dos Santos Proença Martins, (Professor Catedrático da FEFD – Universidade Lusófona) por delegação do Senhor Reitor, Prof. Doutor José Bragança de Miranda;
Arguente: Prof.ª Doutora Anna Prats-Puig (Professora Associada da EUSES – Universidade de Girona);
Arguente: Prof.ª Doutora Sara Isabel Sampaio Pereira (Professora Auxiliar da Faculdade de Desporto da Universidade do Porto);
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Vogal: Prof. Doutor António José Videira da Silva (Professor Auxiliar da FEFD – Universidade Lusófona);
Orientador: Prof. Doutor Pedro Alexandre Barracha da Guerra Júdice (Professor Auxiliar da FEFD – Universidade Lusófona).

Hélio Bruno Gomes da Silva /nº a22113505

2026

Epígrafe

... Pouco importa quão estreito seja o caminho,
Quantas punições o destino me deu,
Sou o senhor do meu destino,
Sou o capitão da minha alma.
William Ernest Henley

Agradecimentos

Esta tese assinala o desfecho de uma jornada intensa e transformadora, marcada por desafios constantes, reconfigurações profundas na esfera profissional e a exigente na arte de conciliar múltiplas facetas da vida de pai, marido, formador e fisiologista do exercício. Entre os compromissos profissionais e os momentos irrepetíveis da vida familiar com filhos ainda tão pequenos, prevaleceu uma determinação inabalável em concluir uma obra que exigiu rigor, resiliência e uma entrega total ao conhecimento.

Foram anos de provação, de noites longas e, por vezes, de um cansaço quase desesperante. Ainda assim, o que permanece foi a certeza de que esta travessia forjou competências, fortaleceu a resiliência e aprofundou o conhecimento de forma ampla e transformadora. Realizar uma tese de doutoramento, sobretudo em contextos de elevada complexidade e exigência é, acima de tudo, um exercício de superação: pessoal, intelectual e emocional.

Por tudo isto, expresso aqui a minha mais honesta e profunda gratidão a todos aqueles que caminharam ao meu lado nesta jornada.

Assim, começo por expressar o meu mais sincero agradecimento ao meu orientador, **Professor Doutor Pedro B. Júdice**, por nunca me ter deixado perder o foco, nem mesmo nos momentos mais desafiantes. A sua notável capacidade de equilibrar exigência científica com humanidade foi determinante ao longo deste percurso. Agradeço-lhe profundamente pela sabedoria com que guiou este processo de doutoramento, pela firmeza com que orientou cada decisão e por ter sido uma bússola segura na exigente navegação da investigação científica. É, verdadeiramente, um privilégio e uma honra tê-lo tido como orientador.

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Resumo

O comportamento sedentário (CS) está associado a múltiplos riscos para a saúde, incluindo doenças cardiometabólicas e mortalidade prematura. Com o reconhecimento dos seus efeitos adversos, mesmo na presença de atividade física moderada a vigorosa, as intervenções em contexto laboral têm ganho destaque, sobretudo entre trabalhadores de escritório. Esta tese integra quatro estudos que analisam a eficácia das sit-stand desks (SSD) e de estratégias complementares na redução do CS, seguindo uma abordagem multitemporal e multicomponente. O Estudo 1, uma revisão sistemática, demonstrou reduções significativas no CS, com maior impacto durante o horário laboral. O Estudo 2, uma intervenção ecológica de seis meses, evidenciou comportamentos compensatórios no tempo de lazer, levantando questões sobre os limites das intervenções centradas apenas no trabalho. O Estudo 3 destacou a importância do momento da intervenção educativa, mostrando maior eficácia quando realizada imediatamente antes da disponibilização das SSD. O Estudo 4, com seguimento de 18 a 24 meses, revelou reduções sustentadas do CS no local de trabalho, mesmo sem um acompanhamento continuado. Em conjunto, os resultados reforçam a importância de integrar componentes educativas, organizacionais e comportamentais, e de considerar o timing da implementação. Esta tese oferece contributos relevantes para o desenho de intervenções sustentáveis e eficazes em saúde ocupacional, com o objetivo de reduzir o CS, com indicações a curto, médio e longo prazo.

Palavras-chave: comportamento sedentário, secretárias sit-stand, saúde ocupacional, psicoeducação, intervenção multicomponente.

Abstract

Sedentary behavior (SB) is associated with multiple health risks, including cardiometabolic diseases and premature mortality. With growing recognition of its harmful effects, independent of moderate-to-vigorous physical activity, workplace interventions have gained prominence, particularly among office workers. This thesis comprises four studies that evaluate the effectiveness of sit-stand desks (SSD) and complementary strategies to reduce SB, adopting a multitemporal and multicomponent approach. Study 1, a systematic review, demonstrated significant reductions in SB, with a greater impact during working hours. Study 2, a six-month ecological intervention, revealed compensatory behaviors during the leisure time, raising concerns about the limitations of workplace-only interventions. Study 3 emphasized the importance of intervention timing, showing greater behavioral impact when a psychoeducational session was delivered immediately before SSD deployment. Study 4, with a follow-up of 18 to 24 months, showed sustained reductions in SB in the workplace, even without ongoing intervention. Collectively, the findings underscore the value of integrating educational, organizational, and behavioral components while also considering the timing of implementation. This thesis offers meaningful contributions to the design of sustainable and effective workplace health promotion strategies, while considering the short, medium, and long term.

Keywords: sedentary behavior, sit-stand desks, occupational health, psychoeducation, multicomponent intervention.

Abbreviations

BMI - Body mass index

CONSORT - Consolidated Standards of Reporting Trials

EPHPP - Quality Assessment Tool for Quantitative Studies of the Effective Public Health Practice Project

G-18m - Participants that used the SSD for 18 months

G-24m - Participants that used the SSD for 24 months

MD - Musculoskeletal discomfort

NFR - Need for recovery after work

PA - Physical activity

PROSPERO - International Prospective Register of Systematic Reviews

PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PWF - Post-work fatigue

RCT - Randomized controlled trials

SB - Sedentary behavior

SSD - Sit-stand desk

ST - Sitting time

SUFHA - Stand Up for Healthy Aging

WHO - World Health Organization

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Chapter I

General introduction and purpose

O sucesso é ir de fracasso em fracasso sem perder o entusiasmo.

Winston Churchill

Chapter I

1. General introduction and purpose

Sedentary behavior (SB) refers to any waking activity performed in a seated, reclined, or lying position with an energy expenditure of ≤1.5 METs (Tremblay et al., 2017). Initially defined by the SB Research Network in 2012, this concept remains widely accepted in the scientific community (Jochem et al., 2019). Everyday sedentary activities include watching television, playing video games, using a computer, prolonged sitting at work or school, and sitting during transportation. SB is recognized as a significant risk factor for multiple chronic diseases, including obesity, type 2 diabetes, cardiovascular diseases, cancer, and dementia (Balducci et al., 2019; Cao et al., 2022). Specifically, excessive SB (i.e., 7.5 to 9.5 hours or more per day) has been linked to a gradual increase in mortality risk (Ekelund et al., 2019). Martinez-Gomez et al. (2013) identified a lower all-cause mortality rate in individuals who spent less than 8 hours per day sitting compared to their more sedentary peers. Similarly, a prospective study by Matthews et al. (2015) found that, over 6.8 years, sitting for 12 or more hours per day, compared to less than 5 hours, was associated with an increased risk of all-cause and cardiovascular disease mortality. Furthermore, among older adults with lower levels of physical activity, replacing one hour of sitting time (ST) per day with any form of activity—whether structured or daily—was associated with a reduced risk of all-cause mortality (Matthews et al., 2015).

The World Health Organization (WHO) highlights the need for policies to reduce SB to improve public health (Bull et al., 2020). Its "Physical Activity and SB Guidelines" provide evidence-based recommendations for different age groups, emphasizing the importance of limiting ST while promoting physical activity (Bull et al., 2020). In line with these recommendations, the WHO's "Global Action Plan on Physical Activity 2018-2030" also underscores the urgency of policy interventions to increase physical activity levels and mitigate SB-related health risks (Organization, 2018).

SB occurs across multiple life domains, including leisure time (e.g., watching TV or using social media (Kikuchi et al., 2014), transportation (e.g., prolonged sitting while commuting), and occupational settings (e.g., sitting for extended periods while working or studying (Teno et al., 2024). Among employed adults, workplace SB accounts for approximately 40% to 70% of total ST (Ishii et al., 2018; Kazi et al., 2019). This highlights the particularly significant impact of workplace environments on SB. Studies

indicate that individuals spend more time sitting at work than engaging in other sedentary activities, such as watching television or using a computer at home on weekdays. Furthermore, full-time office workers spend an estimated 60% to 90% of their total daily ST at work (Keown et al., 2018; Rosenkranz et al., 2020). Evidence also suggests that prolonged occupational sitting is not necessarily offset by increased physical activity outside of work (van Dommelen et al., 2016). The WHO highlights the workplace as a strategic setting for health promotion and the reduction of SB (Organization, 2018). Office workers are encouraged to limit ST by incorporating at least 2 to 4 hours of standing and light activity throughout the workday (Buckley et al., 2015; Sharma et al., 2019). Therefore, it is essential to implement targeted initiatives to minimize excessive ST at work, aiming for better health outcomes (Zhou et al., 2023).

Active workstations, such as sit-stand desks (SSD), treadmill desks and cycling workstations (Dupont et al., 2019), offer office workers an effective way to break up prolonged sitting by incorporating standing periods and/or light physical activity throughout the workday (Arguello et al., 2021). Consequently, these alternatives have gained widespread adoption as evidence-based strategies for reducing SB in office settings (Arguello et al., 2021).

SSD facilitates the transition between sitting and standing and is recognized as a promising solution to reduce SB in office environments (Zhou et al., 2023). However, evidence suggests that its impact is maximized when integrated into multicomponent interventions that combine organizational and individual strategies, making them more effective in reducing ST in the workplace and throughout the day (Edwardson et al., 2022).

A healthy work environment can be fostered through complementary approaches at both the individual and organizational levels. At the individual level, personalized coaching, the promotion of healthy habits, and continuous support help employees adopt and maintain healthier behaviors (Zhou et al., 2023). At the organizational level, initiatives such as psychoeducational sessions, workplace visits, and physiotherapy consultations contribute to a culture of wellbeing (Edwardson et al., 2022), promoting musculoskeletal health while mitigating post-work fatigue among employees (Silva, et al., 2024). For example, a systematic review by Shrestha et al. (2018) demonstrated that multicomponent interventions, including SSD, effectively reduce SB in the workplace, with reductions observed in the short to medium term (up to 12 months). However, the

evidence on sustained reductions beyond this period is limited, highlighting the need for further research on the long-term effectiveness of such interventions.

However, ensuring sustained reductions in ST requires extending interventions beyond the workplace. Since sedentary habits persist outside working hours, strategies should encompass broader lifestyle changes that encourage continued engagement in active behaviors throughout the day, fostering long-term health benefits (Edwardson et al., 2018). For example, in an intervention conducted by Healy et al. (2016), a significant reduction of 99.1 minutes in workplace ST was observed, but this was accompanied by a decrease of only 77.7 minutes in total daily ST, indicating that part of the reduction in the occupational context may have been offset by an increase of approximately 21 minutes in SB during leisure periods.

Similarly, the study by Mansoubi et al. (2016) reported a 20% reduction in ST at work and an 8% increase in ST outside working hours. These results suggest a possible compensation effect, reinforcing the need for approaches considering ST throughout the day.

Besides the impact of ST on overall health, musculoskeletal symptoms are highly prevalent among sedentary workers, with 90% of office workers reporting episodes of pain related to work posture (Parry et al., 2019). Factors such as prolonged use of the keyboard and mouse, high mental workload, and stress significantly contribute to the development of these symptoms (Coenen et al., 2019). Evidence suggests that prolonged sitting at work may be associated with discomfort in the neck and lower limbs, while upper limb issues tend to be linked to computer use (Andersen et al., 2016).

Previous interventions have successfully combined SSD implementation with frequent prompts and an initial psychoeducational session to enhance participants' knowledge and engagement (Edwardson et al., 2022; Pereira et al., 2020; Shrestha et al., 2015). These sessions, often structured as educational seminars, integrate educational and psychological elements to raise awareness of the health risks associated with excessive ST and encourage behavior change (Biddle et al., 2020; Gao & Lee, 2022; Júdice et al., 2023). Biddle et al. (2020) found that most participants reported increased awareness of ST-related health risks after attending such seminars. By fostering knowledge and motivation, these sessions contribute to the long-term success of workplace interventions that reduce ST.

Despite the limited data on the long-term impact of SSD on workers' physical behaviors, particularly from a free-living perspective (Nguyen et al., 2020; Shrestha et

al., 2018; Zhou et al., 2023), a 24-month follow-up study conducted by Nelson-Wong et al. (2021) demonstrated a sustained reduction in workplace ST. Initially, participants recorded an average of 439.5 min/day of ST, which decreased to 336.0 min/day after 24 months, highlighting the prolonged effect of the intervention.

However, while SSD interventions have effectively reduced SB in the workplace, a critical gap exists in understanding their impact on SB beyond working hours. Existing studies primarily focus on work-time reductions, with limited evidence on whether these interventions lead to sustained reductions in SB throughout the day or if individuals compensate by increasing SB during leisure time (Mansoubi et al., 2016; Neuhaus et al., 2014). Given the urgent need to identify the most effective strategies for mitigating SB both during and after work hours, it is essential to systematically evaluate the full-day impact of SSD interventions across different durations, particularly considering short-, medium-, and long-term effects (Nguyen et al., 2020; Shrestha et al., 2015; Shrestha et al., 2018; Zhou et al., 2023). Furthermore, while some studies suggest that SSD interventions can be effective in reducing 24 hour SB, inconsistencies in their design and outcomes highlight the need for further research to clarify whether individuals maintain these reductions outside the workplace or compensate by increasing ST during leisure time (Mansoubi et al., 2016; Neuhaus et al., 2014).

Additionally, although previous interventions have successfully incorporated psychoeducational sessions to increase awareness of SB risks and encourage behavioral changes (Biddle et al., 2020; Gao & Lee, 2022; Júdice et al., 2023), little is known about their long-term effectiveness in sustaining reductions in SB beyond the workplace. Educational interventions are crucial in promoting behavior change, but further research is needed to determine their impact on long-term adherence to reduced ST.

Moreover, there is a paucity of data on the long-term effects of SSD interventions from a free-living perspective, particularly after structured interventions have ended (Nguyen et al., 2020; Shrestha et al., 2018; Zhou et al., 2023). While some studies have examined the impact of SSD after extended periods (e.g., 12 to 18 months post-intervention), the extent to which these work-based interventions influence long-term SB outside of occupational settings remains unclear. Therefore, it is essential to understand better how SSD interventions affect workers' physical behaviors in the long term, both at work and during leisure time, to understand their sustainability and potential compensatory effects.

2. Summary of the thesis

This thesis's core consists of four scientific studies; all published in peer-reviewed journals with an established ISI impact factor. While each study has its specific objectives, they all share the same methodology and stem from a typical project, allowing for an integrated reflection on the impact of SSD in reducing SB. Thus, the presentation of the four articles is preceded by a literature review, which serves as a theoretical framework for all the work carried out, supporting its relevance. Similarly, at the end of the thesis, there is a discussion and joint analysis of the studies and appendices containing supplementary materials of scientific merit (already published and/or presented at academic forums).

This thesis is structured as follows:

2.1. Chapter I

This chapter provides an overview of the thesis objectives and structure, facilitating the reading and understanding of the document.

2.2. Chapter II

Dedicated to the description and characterization of the general methodological aspects of the thesis. As the thesis is organized into scientific articles, this section summarizes the methods used, while each study details its specific procedures in the respective chapters. Still, this chapter aims to provide an overview of the overall methodological approach adopted.

2.3. Chapter III

Study 1: Effect of sit-stand desks on office workers' sedentary behavior – systematic review.

A systematic review was conducted to identify the most effective interventions for interrupting SB during and after work hours to deepen the understanding of the critical need to mitigate SB throughout the day. This review sought to update the existing evidence, identifying already recognized factors and highlighting gaps that need clarification. It analyzed the impact of SSD interventions durations (short, medium, and long-term).

This systematic review was registered (PROSPERO CRD 42023418919) and was

published in the *Human Factors journal* with the following reference: Silva, H., Ramos, P. G. F., Teno, S. C., & Júdice, P. B. (2024). The Impact of Sit-Stand Desks on Full-Day and Work-Based Sedentary Behavior of Office Workers: A Systematic Review. *Hum Factors, 187208241305591*. https://doi.org/10.1177/00187208241305591.

2.4. Chapter IV

Study 2: Compensatory behaviors in response to sit-stand desk use.

This chapter follows an original study investigating the effectiveness of a six-month SSD intervention in reducing SB among office workers, both in the workplace and during leisure time. Although SSD interventions have been shown to reduce ST during working hours, it remains unclear whether this reduction persists beyond the workplace or if individuals compensate by increasing SB during their free time. Some studies suggest the possibility of this compensatory effect; however, the heterogeneity of interventions and methodological approaches makes it difficult to draw definitive conclusions. Given the limited literature on this topic, this study aimed to assess whether the reduction in workplace ST is sustained throughout the day or if there is a compensatory increase in SB during leisure hours.

This original study was published in the Journal of Occupational Health with the following reference:

Silva, H., Teno, S. C., & Júdice, P. B. (2024). Are there compensatory behaviors in response to a sit-stand desk intervention? J Occup Health. https://doi.org/10.1093/joccuh/uiae067.

2.5. Chapter V

Study 3: Psychoeducational session impact on three-month SSD Intervention.

This chapter presents an original study that assessed the impact of a three-month SSD intervention, preceded by a psychoeducational session, on reducing SB among office workers. Although SSD interventions are known to reduce ST during working hours, it remains unclear whether adding a psychoeducational session enhances the effectiveness of such interventions. While evidence suggests that psychoeducational sessions can increase awareness and promote healthier behaviors, the isolated impact of these sessions

on the overall success of SSD interventions has not been fully explored. This study aimed to assess whether the timing of the psychoeducational session — either before or alongside the SSD intervention — resulted in more sustained reductions in SB during work and leisure time.

This original study was published in the Journal of Occupational and environmental medicine with the following reference:

Silva, H., Teno, S. C., & Júdice, P. B. (2025). How can a psychoeducational session alter the results for a 3-month sit-stand desk-based intervention? Secondary analysis from SUFHA. *Journal of occupational and environmental medicine*, 10.1097/JOM.0000000000003378. Advance online publication. https://doi.org/10.1097/JOM.0000000000003378

2.6. Chapter VI

Study 4: Two-year follow-up on sit-stand desks use.

This chapter presents an original study that assessed the long-term impact of SSD usage on workers' physical behaviors, particularly from a free-living perspective. While SSD interventions have effectively reduced SB during working hours, limited evidence exists regarding their sustained effects beyond the structured intervention period. Specifically, it remained unclear whether workers maintained the behavioral changes induced by SSD in the long term or if compensatory behaviors emerged.

This study aimed to evaluate the impact of SSD usage following a 12 to 18-month follow-up period after completing a 6-month SSD intervention, totaling 18 to 24 months of SSD use. Furthermore, the analysis distinguished between workplace and leisure time SB to better understand potential compensatory effects, allowing for a comprehensive assessment of behavioral adaptations beyond the occupational setting.

This original study was published in the Silva, H., Teno, S. C., & Júdice, P. B. (2025). What if you let them stand? A two-year follow-up on sit-stand desk. *Journal of occupational and environmental medicine*, 10.1097/JOM.0000000000003438. Advance online publication. https://doi.org/10.1097/JOM.0000000000003438

2.7. Chapter VII

This chapter synthesizes the results of all studies, integrating a general conclusions section that articulates the main findings, discusses future directions, and presents a

critical analysis of the strengths and limitations of the research conducted. Additionally, the thesis includes a comprehensive bibliography and post-textual elements.

2.8. Conceptual Framework of the Thesis

To provide an integrative view of the thesis design, figure 1 presents the conceptual framework that guided the development of the four scientific studies in this work. This model illustrates the multitemporal, contextual, and strategic dimensions explored throughout the research process and clarifies how each study, comprising one systematic review and three experimental investigations, contributes to addressing the central research question regarding the effectiveness and long-term sustainability of SSD interventions.

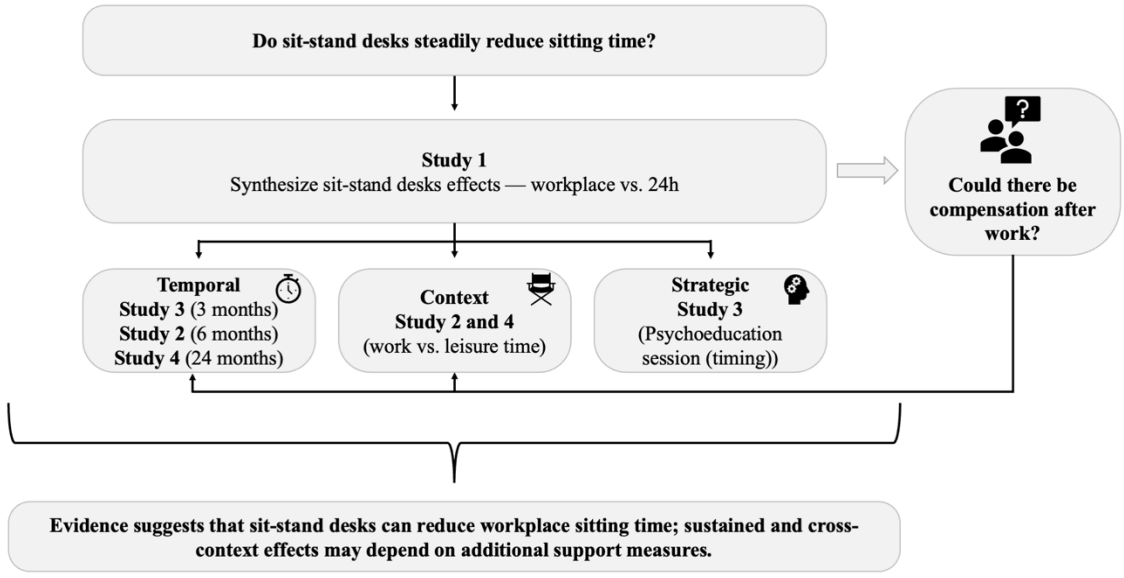

Figure 1 - Conceptual framework integrating temporal, contextual, and strategic dimensions of the SUFHA Trial.

The thesis also includes an annex section consisting of the following:

2.9. Annexes – section I: Complementary scientific production to the works integrated into the thesis

This thesis also includes an annex section compiling additional scientific works developed within the scope of the doctoral program. This complementary output reflects the deepening and dissemination of the knowledge generated throughout the research process. Specifically, it highlights the authorship of a published scientific article on the Impact of a 6-month SSD intervention on regional musculoskeletal

discomfort and overall post-work fatigue in office workers and the presentation of two oral communications at national scientific conferences. Additionally, it includes the authorship of a scientific poster presented at an international conference duly included in the annexes of this dissertation. To know:

2.9.1. Articles published

Silva, H., G F Ramos, P., Teno, S. C., & Júdice, P. B. (2024). Impact of a 6-month sit-stand desk-based intervention on regional musculoskeletal discomfort and overall post-work fatigue in office workers: a cluster randomized controlled trial. *Ergonomics*, 1–14. Advance online publication. https://doi.org/10.1080/00140139.2024.2414197 (annex III).

2.9.2. Panel communications at international scientific meetings

a. Silva, H., Teno, S. C., & Júdice, P. B. (2022). Is it the same? An analysis into the 75 min/week of vigorous physical activity or 150 min/week of moderate physical activity. *Congresso de Exercício e Saúde CIDEFES/MANZ – Portugal Fit 2022.* (annex V).

b. Silva, H., Ramos, P. G. F., Teno, S. C., & Júdice, P. B. (2023). The impact of sit-stand desks on sedentary behavior of office workers: Systematic review. *Congresso de Exercício e Saúde CIDEFES/MANZ – Portugal Fit 2023. (annex VI)*

c. Silva, H., Teno, S. C., & Júdice, P. B. (2024). Impact of a 6-month sit-stand desk-based intervention on musculoskeletal discomfort and overall post-work fatigue in office workers: a cluster randomised controlled trial. Poster presented at the 29th Annual Congress of the European College of Sport Science (ECSS), Glasgow, Scotland. (annex IV).

3. References

Andersen, L. L., Fallentin, N., Thorsen, S. V., & Holtermann, A. (2016). Physical workload and risk of long-term sickness absence in the general working population and among blue-collar workers: prospective cohort study with register

follow-up. *Occup Environ Med*, *73*(4), 246-253. https://doi.org/10.1136/oemed-2015-103314

Arguello, D., Thorndike, A. N., Cloutier, G., Morton, A., Castaneda-Sceppa, C., & John, D. (2021). Effects of an "Active-Workstation" Cluster RCT on Daily Waking Physical Behaviors. *Med Sci Sports Exerc*, *53*(7), 1434-1445. https://doi.org/10.1249/MSS.0000000000002594

Balducci, S., D'Errico, V., Haxhi, J., Sacchetti, M., Orlando, G., Cardelli, P.,…Investigators, I. D. a. E. S. I. (2019). Effect of a Behavioral Intervention Strategy on Sustained Change in Physical Activity and Sedentary Behavior in Patients With Type 2 Diabetes: The IDES_2 Randomized Clinical Trial. *JAMA*, *321*(9), 880-890. https://doi.org/10.1001/jama.2019.0922

Biddle, S. J. H., O'Connell, S. E., Davies, M. J., Dunstan, D., Edwardson, C. L., Esliger, D. W.,…Munir, F. (2020). Reducing sitting at work: process evaluation of the SMArT Work (Stand More At Work) intervention. *Trials*, *21*(1), 403. https://doi.org/10.1186/s13063-020-04300-7

Buckley, J. P., Hedge, A., Yates, T., Copeland, R. J., Loosemore, M., Hamer, M.,…Dunstan, D. W. (2015). The sedentary office: an expert statement on the growing case for change towards better health and productivity. *Br J Sports Med*, *49*(21), 1357-1362. https://doi.org/10.1136/bjsports-2015-094618

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G.,…Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. https://doi.org/10.1136/bjsports-2020-102955

Cao, C., Friedenreich, C. M., & Yang, L. (2022). Association of Daily Sitting Time and Leisure Time Physical Activity With Survival Among US Cancer Survivors. *JAMA Oncol*, *8*(3), 395-403. https://doi.org/10.1001/jamaoncol.2021.6590

Coenen, P., van der Molen, H. F., Burdorf, A., Huysmans, M. A., Straker, L., Frings-Dresen, M. H., & van der Beek, A. J. (2019). Associations of screen work with neck and upper extremity symptoms: a systematic review with meta-analysis. *Occup Environ Med*, *76*(7), 502-509. https://doi.org/10.1136/oemed-2018-105553

Dupont, F., Léger, P. M., Begon, M., Lecot, F., Sénécal, S., Labonté-Lemoyne, E., & Mathieu, M. E. (2019). Health and productivity at work: which active workstation

for which benefits: a systematic review. *Occup Environ Med*, *76*(5), 281-294. https://doi.org/10.1136/oemed-2018-105397

Edwardson, C. L., Biddle, S. J. H., Clemes, S. A., Davies, M. J., Dunstan, D. W., Eborall, H.,…Clarke-Cornwell, A. M. (2022). Effectiveness of an intervention for reducing sitting time and improving health in office workers: three arm cluster randomised controlled trial. *BMJ*, *378*, e069288. https://doi.org/10.1136/bmj-2021-069288

Ekelund, U., Brown, W. J., Steene-Johannessen, J., Fagerland, M. W., Owen, N., Powell, K. E.,…Lee, I. M. (2019). Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants. *Br J Sports Med*, *53*(14), 886-894. https://doi.org/10.1136/bjsports-2017-098963

Gao, Z., & Lee, J. E. (2022). Promoting Physical Activity and Reducing Sedentary Behavior to Prevent Chronic Diseases during the COVID Pandemic and Beyond. *J Clin Med*, *11*(16). https://doi.org/10.3390/jcm11164666

Ishii, K., Shibata, A., & Oka, K. (2018). Work Engagement, Productivity, and Self-Reported Work-Related Sedentary Behavior Among Japanese Adults: A Cross-Sectional Study. *J Occup Environ Med*, *60*(4), e173-e177. https://doi.org/10.1097/JOM.0000000000001270

Jochem, C., Wallmann-Sperlich, B., & Leitzmann, M. F. (2019). The Influence of Sedentary Behavior on Cancer Risk: Epidemiologic Evidence and Potential Molecular Mechanisms. *Curr Nutr Rep*, *8*(3), 167-174. https://doi.org/10.1007/s13668-019-0263-4

Júdice, P. B., Silva, H., Teno, S. C., Monteiro, P., Silva, M. N., Carraça, E. V.,…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

Kazi, A., Haslam, C., Duncan, M., Clemes, S., & Twumasi, R. (2019). Sedentary behaviour and health at work: an investigation of industrial sector, job role, gender and geographical differences. *Ergonomics*, *62*(1), 21-30. https://doi.org/10.1080/00140139.2018.1489981

Keown, M. K., Skeaff, C. M., Perry, T. L., Haszard, J. J., & Peddie, M. C. (2018). Device-Measured Sedentary Behavior Patterns in Office-Based University Employees. *J Occup Environ Med*, *60*(12), 1150-1157. https://doi.org/10.1097/JOM.0000000000001467

Kikuchi, H., Inoue, S., Sugiyama, T., Owen, N., Oka, K., Nakaya, T., & Shimomitsu, T. (2014). Distinct associations of different sedentary behaviors with health-related attributes among older adults. *Prev Med*, *67*, 335-339. https://doi.org/10.1016/j.ypmed.2014.08.011

Mansoubi, M., Pearson, N., Biddle, S. J., & Clemes, S. A. (2016). Using Sit-to-Stand Workstations in Offices: Is There a Compensation Effect? *Med Sci Sports Exerc*, *48*(4), 720-725. https://doi.org/10.1249/MSS.0000000000000802

Martinez-Gomez, D., Guallar-Castillon, P., Leon-Munoz, L. M., Lopez-Garcia, E., & Rodriguez-Artalejo, F. (2013). Combined impact of traditional and non-traditional health behaviors on mortality: a national prospective cohort study in Spanish older adults. *BMC Med*, *11*, 47. https://doi.org/10.1186/1741-7015-11-47

Matthews, C. E., Moore, S. C., Sampson, J., Blair, A., Xiao, Q., Keadle, S. K.,…Park, Y. (2015). Mortality Benefits for Replacing Sitting Time with Different Physical Activities. *Med Sci Sports Exerc*, *47*(9), 1833-1840. https://doi.org/10.1249/mss.0000000000000621

Nelson-Wong, E., Corrigan, J., Mertz, P., Kutcher, S., Carlson, I., DiRocco, T., & Hall-Nelson, B. (2021). Office-workers maintain decreased workplace sitting time long-term following participation in a sit-stand desk intervention study. *Ergonomics*, 1-9. https://doi.org/10.1080/00140139.2021.1998647

Neuhaus, M., Healy, G. N., Dunstan, D. W., Owen, N., & Eakin, E. G. (2014). Workplace sitting and height-adjustable workstations: a randomized controlled trial. *Am J Prev Med*, *46*(1), 30-40. https://doi.org/10.1016/j.amepre.2013.09.009

Nguyen, P., Le, L. K., Nguyen, D., Gao, L., Dunstan, D. W., & Moodie, M. (2020). The effectiveness of sedentary behaviour interventions on sitting time and screen time in children and adults: an umbrella review of systematic reviews. *Int J Behav Nutr Phys Act*, *17*(1), 117. https://doi.org/10.1186/s12966-020-01009-3

Organization, W. H. (2018). G*lobal action plan on physical activity 2018-2030: more active people for a healthier world*. In (World Health Organization ed.).

Parry, S. P., Coenen, P., Shrestha, N., O'Sullivan, P. B., Maher, C. G., & Straker, L. M. (2019). Workplace interventions for increasing standing or walking for decreasing

musculoskeletal symptoms in sedentary workers. *Cochrane Database Syst Rev*, *2019*(11). https://doi.org/10.1002/14651858.CD012487.pub2

Pereira, M. A., Mullane, S. L., Toledo, M. J. L., Larouche, M. L., Rydell, S. A., Vuong, B.,…Buman, M. P. (2020). Efficacy of the 'Stand and Move at Work' multicomponent workplace intervention to reduce sedentary time and improve cardiometabolic risk: a group randomized clinical trial. *Int J Behav Nutr Phys Act*, *17*(1), 133. https://doi.org/10.1186/s12966-020-01033-3

Rosenkranz, S. K., Mailey, E. L., Umansky, E., Rosenkranz, R. R., & Ablah, E. (2020). Workplace Sedentary Behavior and Productivity: A Cross-Sectional Study. *Int J Environ Res Public Health*, *17*(18). https://doi.org/10.3390/ijerph17186535

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. *Hum Factors*, *61*(5), 816-824. https://doi.org/10.1177/0018720818807043

Shrestha, N., Ijaz, S., Kukkonen-Harjula, K. T., Kumar, S., & Nwankwo, C. P. (2015). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *1*, Cd010912. https://doi.org/10.1002/14651858.CD010912.pub2

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Pedisic, Z. (2018). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *6*(6), Cd010912. https://doi.org/10.1002/14651858.CD010912.pub4

Silva, H., G F Ramos, P., Teno, S. C., & Júdice, P. B. (2024). Impact of a 6-month sit-stand desk-based intervention on regional musculoskeletal discomfort and overall post-work fatigue in office workers: a cluster randomised controlled trial. *Ergonomics*, 1-14. https://doi.org/10.1080/00140139.2024.2414197

Silva, H., Ramos, P. G. F., Teno, S. C., & Júdice, P. B. (2024). The Impact of Sit-Stand Desks on Full-Day and Work-Based Sedentary Behavior of Office Workers: A Systematic Review. *Hum Factors*, 187208241305591. https://doi.org/10.1177/00187208241305591

Silva, H., Teno, S. C., & Júdice, P. B. (2024). Are there compensatory behaviors in response to a sit-stand desk intervention? *J Occup Health*. https://doi.org/10.1093/joccuh/uiae067

Teno, S. C., Silva, M. N., & Júdice, P. B. (2024). Physical activity and sedentary behaviour-specific domains and their associations with mental health in adults: a systematic review. . In (pp. 1–28): A*dvances in Mental Health*.

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E.,…Participants, S. T. C. P. (2017). Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. *Int J Behav Nutr Phys Act*, *14*(1), 75. https://doi.org/10.1186/s12966-017-0525-8

van Dommelen, P., Coffeng, J. K., van der Ploeg, H. P., van der Beek, A. J., Boot, C. R., & Hendriksen, I. J. (2016). Objectively Measured Total and Occupational Sedentary Time in Three Work Settings. *PLoS One*, *11*(3), e0149951. https://doi.org/10.1371/journal.pone.0149951

Zhou, L., Deng, X., Xu, M., Wu, Y., Shang, X., E, F.,…Li, X. (2023). The effects of active workstations on reducing work-specific sedentary time in office workers: a network meta-analysis of 23 randomized controlled trials. *Int J Behav Nutr Phys Act*, *20*(1), 92. https://doi.org/10.1186/s12966-023-01467-5

Chapter II

General Methodology

Duvidar de si mesmo é o primeiro sinal de sabedoria.

Sócrates

Chapter II

1. Methods

1.1. Study design

This was a parallel-group (1:1), cluster-randomized controlled trial (RCT) with a 6-month intervention period and a 3-month follow-up. Cluster randomization was applied at the workplace level to reduce contamination between groups. The study protocol was pre-registered on the Open Science Framework (OSF) [https://doi.org/10.17605/OSF.IO/JHGPW] and approved by the Ethics Committee of the Faculty of Physical Education and Sport of Universidade Lusófona de Lisboa (Ref. D0522), in accordance with the Declaration of Helsinki (annex I).

Additionally, this thesis presents two secondary analyses using data from subgroups of participants assessed at further time points: (i) at 3 months after the start of SSD use and (ii) 24 months post-baseline. These extensions were designed to explore both the medium and long-term impact of sit-stand desks (SSD) implementation on sedentary behavior (SB).

1.2. Participants

Participants were recruited among office workers at Universidade Lusófona de Lisboa through internal institutional communication (emails, banners, posters, and direct contact). Inclusion criteria were: (i) ≥0.6 full-time equivalent workload; (ii) age ≥20 years; and (iii) spending ≥70% of weekly working hours in sedentary desk-based tasks. Exclusion criteria included current SSD use, lack of space for SSD installation, musculoskeletal or medical conditions contraindicating standing work, or being in full-time telework (due to inability to provide two SSD per participant for home and office use).

1.3. Informed consent

All participants received comprehensive verbal and written information regarding the study's objectives, procedures, risks, and benefits. Informed consent was obtained before enrolment in all study phases, including follow-up and secondary analyses.

1.4. Randomization and allocation

Cluster randomization by workplace was performed using a computer-generated random sequence, with 20 participants assigned to the intervention group (with SSD) and 20 to the control group (with conventional desks). Allocation was managed by an independent researcher who was not involved in assessments to ensure allocation concealment.

1.5. Intervention

Both groups participated in a psychoeducational session addressing the health risks of prolonged SB and strategies to interrupt it. The intervention group received a SSD (Vinsetto 923-043) (figure 1) installed at their regular workstations. Ergonomic guidance, progressive usage recommendations, and motivational strategies based on Self-Determination Theory (SDT) were provided via email and a dedicated website (https://sufha.ulusofona.pt/). The control group maintained regular desks and received only the initial educational session. This waiting-list control group did not undergo any contextual change during the 6-month intervention period; they had no access to the SSD or any motivational prompts. Following the intervention, however, they were given access to the SSD.

Figure 1 - Sit-stand desk Vinsetto, Model 923-043.

1.6. Follow-up assessments in subsamples

1.6.1. Medium-term assessment at 3 months

To evaluate the medium-term effects of SSD implementation, a subsample of 20 participants (10 from each group) was randomly selected to undergo an additional assessment 3 months after beginning SSD use. This allowed a comparison between two temporally distinct intervention conditions:

- PE-0 group**:** Participants who received the psychoeducational session immediately began SSD use (original intervention group).
- PE-6 group**:** Participants who initially belonged to the control group and started SSD use 6 months after the psychoeducational session.

Both subgroups received the same SSD model, ergonomic guidance, and motivational support for 3 months. The only difference was the timing of implementation, enabling assessment of how early versus delayed exposure to SSD influenced medium-term outcomes. Selection for this follow-up was random among eligible participants who consented to additional assessment. Only participants with valid ActivPAL data (minimum of 4 valid days, including one weekend day) were included in the final analysis.

1.6.2. Long-term follow-up at 24 months

A second secondary analysis was conducted on a subsample assessed 24 months after baseline to explore long-term effects. Participants were classified according to the total duration of SSD use:

- G-24m group**:** Participants who started SSD use immediately after the psychoeducational session and used it continuously for 24 months.
- G-18m group**:** Participants who began SSD use after a 6-month delay (originally in the control group), thus using it for 18 months.

Following the main intervention phase, no further structured motivational input was provided. SSD use was self-regulated, and only those reporting consistent use throughout the follow-up period and consenting to reassessment were included. Participants who discontinued use or lacked valid accelerometer data were excluded.

1.7. Outcomes and assessments

1.7.1. Body composition

Body weight was measured using a calibrated electronic scale (TANITA BC-601), and height was measured using a portable stadiometer (Seca, Hamburg, Germany). BMI was calculated and classified per WHO guidelines. Multi-frequency bioelectrical impedance analysis (BIA) (Akern, Italy) was used to estimate fat mass, lean mass, and phase angle based on resistance and reactance.

1.7.2. SB and physical activity

Participants continuously wore the ActivPAL4 device (PAL Technologies Ltd., Glasgow, UK) on the front and middle of the right thigh for 7 consecutive days (24 hours/day), which was applied by a trained researcher and secured with medical-grade adhesive in the first day. This device detects postural behaviors such as sitting, standing, and stepping. Data were processed separately for total time and occupational time. Valid wear time was defined as a minimum of 21 hours per day on at least 4 days, including one weekend day. The CREA classification algorithm (v1.3) was used to differentiate between non-wear time, lying, sitting, standing, cycling, seated transport, and stepping. The following variables were extracted: sitting time (min/day), number of sit-to-upright transitions per day, prolonged sitting bouts (≥30 minutes and >60 minutes), sitting while commuting (min/day), awake lying time (secondary lying, min/day), sleep lying time (primary lying, min/day), cycling time (min/day), standing time (min/day), stepping time (min/day), and number of steps per day. Assessments were conducted at baseline and at the end of the 6-month intervention, with an additional measurement at 3 months during the intervention period on both groups at diferente timepoints in a subsample, and 2 years after usage of SSD on a subsample.

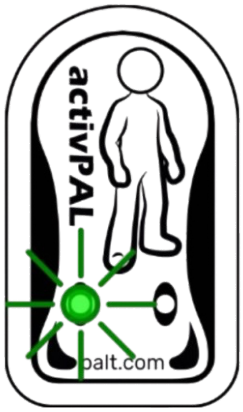

Figure 2 - ActivPAL4 device (PAL Technologies Ltd., Glasgow, UK).

1.8. Sociodemographic and health data

Sociodemographic, occupational, and health-related data were collected using an online questionnaire (Qualtrics). Collected variables included age, sex, country of birth, educational attainment, financial status, occupation, specific task assignments, weekly working hours, and years of employment. Health-related information encompassed smoking status, alcohol consumption, presence of chronic diseases, total number of medication, and any reported changes in medication use during the study period. Participants were also asked about their usual mode of commuting, structured physical activity, and SB during weekdays and weekends. Additionally, participants completed a self-report diary throughout the study to record symptoms, relevant health events, and adherence to SSD use. These data supported contextual interpretation of outcomes and monitoring of potential confounding factors.

1.9. Sample size calculation

The sample size was estimated taking into account the clustered nature of the study, with participants nested within workplaces, which were defined as the unit of clustering. A conservative intra-cluster correlation coefficient of 0.01 was assumed. Based on the primary outcome of the intervention (sitting time), an effect size of 0.80, 80% statistical power, and a two-sided significance level of 0.05 were considered, resulting in a required sample of 34 participants for between-group comparisons. To mitigate the impact of potential attrition, an additional 20% was incorporated, leading to a final target sample size of 40 participants, equally allocated to the intervention and control groups.

1.10. Data confidentiality

All participant data were pseudonymized and stored in an encrypted, access-restricted database. Records will be retained for at least 10 years in compliance with institutional and ethical guidelines.

1.11. Assessments

Assessments were conducted at predefined time points, as illustrated in Figure 3:

- Assessment 1 – Baseline assessment for all participants;

- Assessment 2 – Conducted three months after the start of the intervention, in a randomly selected subsample of intervention group participants, who provided consent to participate in this additional phase;
- Assessment 3 – Post-intervention assessment at six months for all participants;
- Assessment 4 – Conducted three months after the SSD was introduced in the control group, also based on voluntary participation;
- Assessment 5 – Follow-up assessment at 24 months, conducted in a subsample of participants who volunteered and reported continued SSD usage.

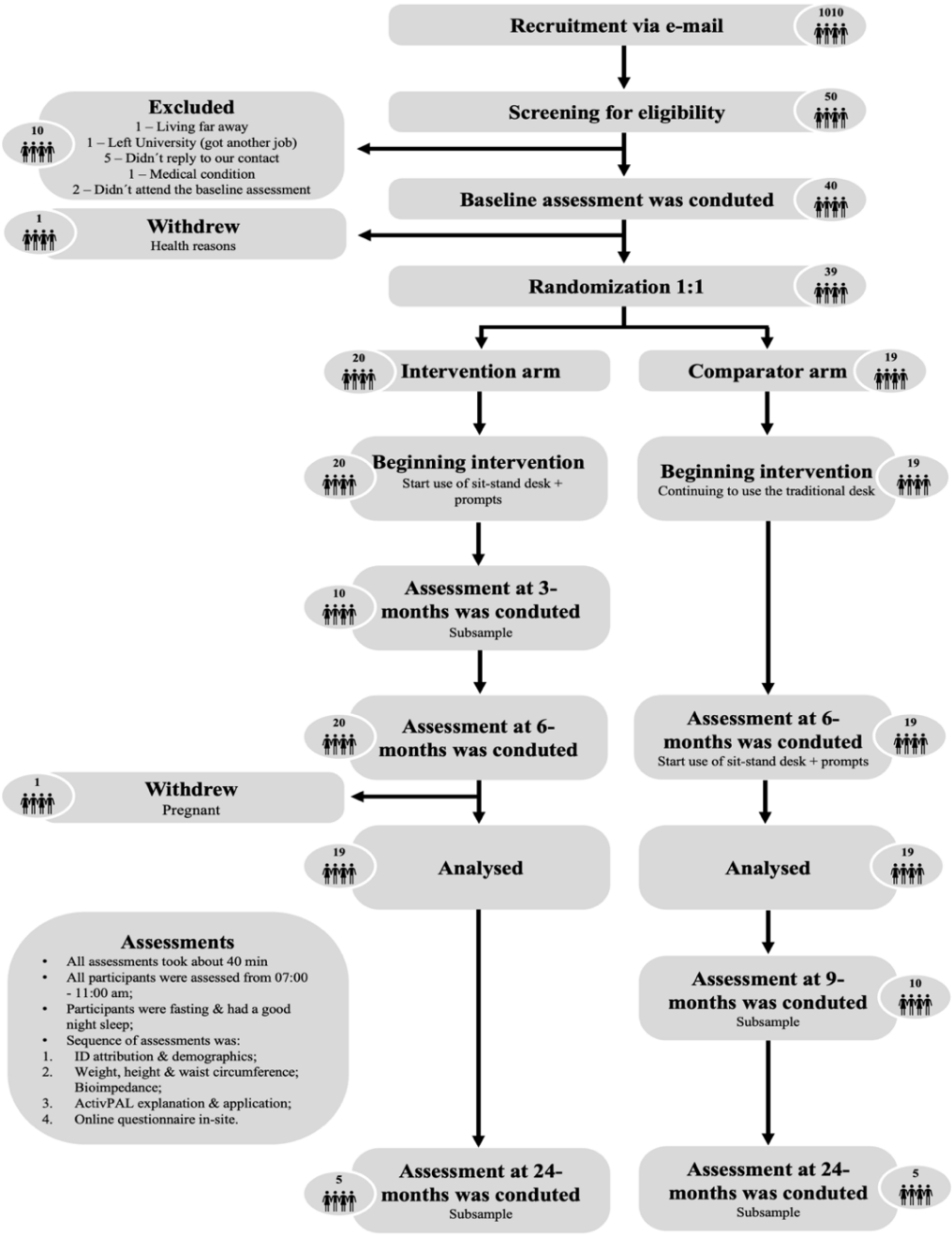

Figure 3 - Flow diagram of enrolment, interventions, assessments, and visits for participants.

Chapter III

Study 1: Effect of sit-stand desks on office workers' sedentary behavior: systematic review.

A adversidade desperta em nós capacidades que, em circunstâncias favoráveis, teriam ficado adormecidas.

Horácio

Chapter III

The impact of sit-stand desks on full-day and work-based sedentary behavior of office workers: A systematic review. *

Abstract

Objective: To gather the existing evidence on the impact of sit-stand desk-based interventions on working-time and full-day sedentary behavior and compare their impact across different intervention lengths.

Background: Reducing sedentary behavior is vital for improving office workers' health. Sit-stand desks promote sitting and standing alternation, but understanding their effects outside the workplace is essential for success.

Methods: Studies published between January 2008 and January 2024 were searched through electronic databases (PubMed, Google Scholar, Cochrane Library). The quality of the studies was assessed using the Quality Assessment Tool for Quantitative Studies of the Effective Public Health Practice Project.

Results: Twelve included studies showed that the intervention group experienced average reductions in full-day sedentary behavior of 68.7 min/day at 3 months, 77.7 min/day at 6 months, and 62.1 min/day at 12 months compared to the control group. For working hours sedentary behavior, reductions were observed in the intervention group at 9 weeks (73.0 min/day), 3-months (88.0 min/day), 6-months (80.8 min/day), and 12-months (48.0 min/day) relative to the control group.

Conclusions: Sit-stand desk interventions can be effective in helping office workers reduce sedentary behavior in the short, medium, and long-term both at work and throughout the full-day.

Application: Active workstation interventions, including sit-stand desks, educational sessions, and alert software, aim to reduce sedentary behavior among office workers. While sit-stand desks show promise in decreasing sitting time during working hours, their long-term effectiveness and impact beyond the workplace remain uncertain. This review evaluates their effectiveness across different durations, addressing both workplace and full-day impact.

Keywords - office workers; sit-stand desk; sedentary behavior; workday sitting time; full-day sitting time.

*Silva, H., Ramos, P. G. F., Teno, S. C., & Júdice, P. B. (2024). The Impact of Sit-Stand Desks on Full-Day and Work-Based Sedentary Behavior of Office Workers: A Systematic Review. *Human factors*, 187208241305591. https://doi.org/10.1177/001872

1. Introduction

Sedentary behavior is any activity with low energy expenditure, including prolonged sitting or resting during commuting, work, home, and leisure time, with an energy expenditure of ≤ 1.5 metabolic equivalents, while awake (Tremblay et al., 2010). At the macro level, the cost of physical inactivity and sedentary behavior is calculated at 47.6 billion $ per year with non-communicable diseases and mental disorders (Santos et al., 2023). Prolonged uninterrupted sedentary bouts exceeding 30 minutes are strongly associated with a heightened risk of chronic diseases like cardiovascular disease and type 2 diabetes, as well as increased mortality (Patterson et al., 2018). Excessive sedentary behavior quantified at 7.5 to 9.5 hours or more daily has been linked to higher mortality risks (Ekelund, Brown, et al., 2019).

Office workers represent a high-risk group, spending 65-75% of their work hours in prolonged sitting, often without interruption (Clemes et al., 2014; Johansson et al., 2020). Additionally, the sedentary behavior pattern persists beyond the work environment, further compounding health risks (Clemes et al., 2014). Public health guidelines recommend that office workers aim to reduce their sedentary time by integrating at least 2 to 4 hours of standing and light activity during working hours (Buckley et al., 2015; Sharma et al., 2019).

Sit-stand desks allow alternating between sitting and standing and have emerged as promising to reduce sedentary behavior in office settings (Grunseit et al., 2013; Shrestha & Dunn, 2020; Zhou et al., 2023). Despite evidence supporting the effectiveness of sit-stand desks in reducing sedentary time during work hours, it remains unclear whether these benefits extend beyond the workplace or if compensatory increases in sedentary behavior occur outside working hours (Mansoubi et al., 2016; Neuhaus, Healy, et al., 2014). For example, a study by Mansoubi et al. (2016) reported a 20% reduction in sedentary behavior during work but an 8% increase in sedentary time outside work.

Given the critical need to mitigate sedentary behavior throughout the day, it is imperative to identify the most effective interventions for interrupting sedentary behavior both during and after work hours (Dupont et al., 2019). Also, previous reviews have focused on interventions during work hours, a systematic review that evaluates the full-day impact of sit-stand desk interventions across different intervention durations—short, medium, and long-term remains lacking (Nguyen et al., 2020; Shrestha et al., 2015; Shrestha et al., 2018; Zhou et al., 2023).

*Silva, H., Ramos, P. G. F., Teno, S. C., & Júdice, P. B. (2024). The Impact of Sit-Stand Desks on Full-Day and Work-Based Sedentary Behavior of Office Workers: A Systematic Review. *Human factors*, 187208241305591. https://doi.org/10.1177/001872

Since there is an urgent need to identify the most effective and appropriate interventions to reduce sedentary behavior and assess their sustainability over time, this review systematically analyses the effect of workplace sit-stand desk interventions on full-day sedentary behavior (wakefulness period) and working-time sedentary behavior and compares their effectiveness across different durations.

2. Method

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021). The protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) (CRD42023418919).

2.1. Search strategy and study selection

A search of studies published between January 2008 and January 2024 was performed through PubMed, Google Scholar, Cochrane Library, manual research, and cross-checking the references of the integrated articles. According to the PICOS strategy, the search combined several groups of terms (table 1).

Table 1 - Database search (PICOS Model).

Research terms	
P (Population)	adult* office workers OR desk workers OR desk-based workers
I (Intervention)	sit-stand desk OR active workstation* OR vertical workstation* OR height-adjustable workstation
C (Control group)	no intervention
O (Outcomes)	sedentary behavior OR sitting time
S (Study Design)	randomized controlled trials OR quasi-experimental OR non-randomized controlled trials
P+I+C+O+S	((((((((((adult* office workers) OR (desk workers)) OR (desk-based workers)) AND (sit-stand desk)) OR (active workstation*)) OR (vertical workstation*)) OR (height-adjustable workstation)) AND (sedentary behavior)) OR (sitting time)) AND (randomized controlled trials)) OR (quasi-experimental)) OR (non-randomized controlled trials)

2.2. Inclusion and exclusion criteria

In this review, randomized controlled trials, cluster randomized controlled trials, crossover, and quasi-experimental designs published in English involving interventions that utilized sit-stand desks as an environmental strategy to reduce sedentary behavior

and explicitly targeted office workers aged 18 years or older whose jobs predominantly involved desk-based tasks were included. Also, included studies were required to focus on using sit-stand desks as a primary intervention to reduce sedentary behavior in the workplace.

Studies that did not meet the appropriate study design (e.g., qualitative studies), population (e.g., the population under analysis consisted of students), or outcomes (without measurement of sedentary behavior or sitting time) were excluded.

2.3. Data extraction

Two authors screened all retrieved studies' titles and abstracts for relevance. The authors subsequently screened the full-text articles whose abstracts were identified as relevant or potentially relevant. Each study strictly adhered to the predefined criteria. This extracted data included detailed information on the study (author, year, and country), sample (participants and mean age), duration, intervention details, assessment details, and main results for each study.

2.4. Quality assessment of the included studies

The quality of the studies was assessed using the Quality Assessment Tool for Quantitative Studies of the Effective Public Health Practice Project (EPHPP) (Thomas et al., 2004). This tool allows the evaluation of experimental studies in eight domains: selection bias, study design, confounders, blinding, data collection, withdrawals and drop-outs, intervention integrity, and analysis appropriate to the question. Each domain is evaluated as strong, moderate, or low, and the final score is determined by assessing all domains (strong if all domains are moderate or strong, moderate if it has one weak domain, and weak if two or more domains are rated as weak. Two authors independently evaluated the quality of the studies, solving discrepancies through consensus with a third author.

2.5. Data synthesis

A comprehensive analysis examined how interventions to reduce sedentary behavior affect sedentary time and sitting time. The data were compiled and organized into a table that included the authors, countries where the interventions were developed, sample size, participants' average age, intervention details (type, duration, frequency),

assessment methods for sedentary behavior and sitting time, and the main results comparing the intervention and control groups.

These results were visually represented in a series of figures, meticulously organized based on the duration of the interventions—less than 3 months, 3 months, 4 months, 6 months, 8 months, and 12 months. This organization allowed for a clear and systematic comparison of the interventions' impact over different periods. By presenting the data in this way, it was possible to identify patterns and trends, highlighting which interventions were more effective over time.

3. Results

3.1. Study selection

From the several databases searched, 6810 articles were retrieved, and 3 more were manually added, totaling 6813. After screening the titles, 4425 articles were removed for not meeting the inclusion criteria, leaving 38 studies for full-text analysis. During full-text analysis, 26 articles were removed due to design (n=11), incorrect outcome (n=13), incorrect population (n=1), and incorrect intervention (n=1), leaving 12 studies included in this review, as shown in Figure 1.

Overall, the quality of the included studies was moderate (n=9), and the remaining were rated as weak (n=2) and strong (n=1). Supplementary Table 1. The most frequent limitations were the trials' blinding and participants' selection process.

*Silva, H., Ramos, P. G. F., Teno, S. C., & Júdice, P. B. (2024). The Impact of Sit-Stand Desks on Full-Day and Work-Based Sedentary Behavior of Office Workers: A Systematic Review. *Human factors*, 187208241305591. https://doi.org/10.1177/001872

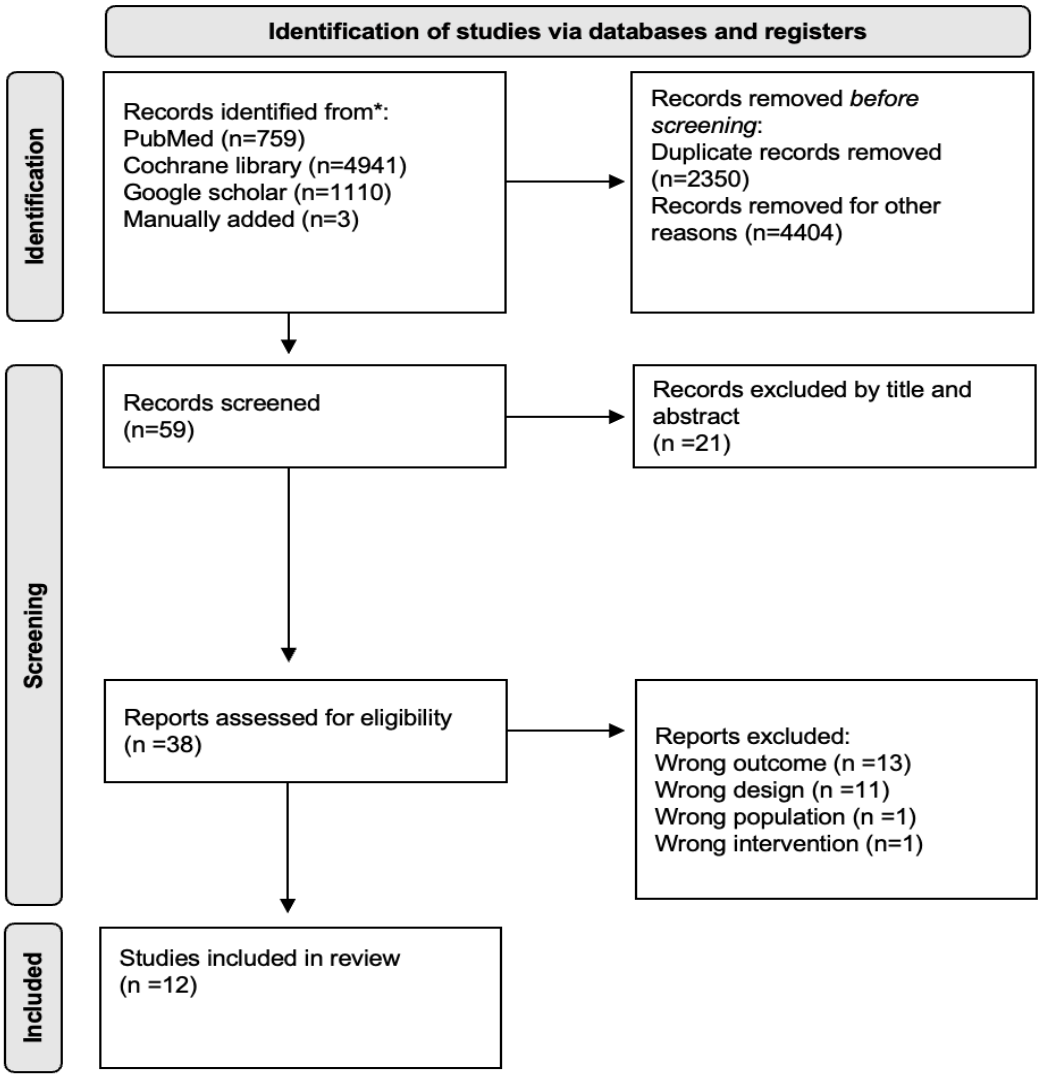

Figure 1 - PRISMA flowchart of included studies.

3.2.Study characteristics

Amongst the 12 studies analyzed, there were 1801 participants (ranging from 18 to 756). Most studies were RCTs (n=11), and one was a non-randomized trial. The interventions' duration ranged from 9 weeks to 12 months. Out of the 12 analyzed studies, 7 used objective measures, 2 employed self-reported measures, and 3 used both objective and self-reported measures. All studies used sit-stand desks as the primary strategy, with 11 interventions consisting of sit-stand desks plus multicomponent as the intervention strategy (i.e., organizational strategies, environmental strategies, and individual and group strategies), and 1 intervention used only sit-stand desks. Detailed information on each study included in the systematic review can be found in Table 2

Table 2 - Study and outcomes details on sedentary behavior during work and full-day.

Studies	Sample	Duration	Intervention details	Assessment details	Results
(Edwardson et al., 2022) **UK**	756 participants Mean age=44.7±10.5 yrs Intervention 1, n=249 Intervention 2, n=240 Control, n=267	12 months	Intervention group 1: SWAL[1] Intervention group 2: SWAL + sit-stand desk + information booklet and guidance on how to use the desk Control group: usual practice	Objective: ActivPAL Subjective: OSPAQ[6] Past Recall of Sedentary Time	**Objective measures valid day (min/day):** Sitting time (3 months): Intervention 1 ↓***; **Intervention 2 ↓*** vs Control**; Intervention 2 ↓*** vs Intervention 1 Sitting time (12 months): Intervention 1 ↓** vs Control; **Intervention 2 ↓*** vs Control**; Intervention 2 ↓*** vs Intervention 1 **Objective measures worktime (min/work hours):** Sitting time (3 months): Intervention 1 ↔; **Intervention 2 ↓*** vs Control** Sitting time (12 months): Intervention 1 ↔; Intervention 2 ↓*** vs Control **Self-reported behaviors** All sitting (3 months): Intervention 1 ↓1; **Intervention 2 ↓ vs. Control** All sitting (12 months): Intervention 1 ↓; **Intervention 2 ↑ vs. Control**
(Hergenroeder et al., 2022) **USA**	24 participants Intervention group, n=12 Mean age=48.8 ± 12.5 yrs Control group, n=12 Mean age=51.5±9.2 yrs	6 months	Intervention group: behavior counseling; sit-stand desk attachment + activity prompter; in-person counseling sessions + monthly phone calls from trained interventionist Control group: no intervention during the 6 months; received a 60-minute in-person meeting to review intervention materials post-study	Subjective: GPAQ[4]	**Sitting time (min/day) at 6-month follow-up**: Intervention ↓** vs. Control
(Arguello et al., 2021) **USA**	66 participants Sit-stand desk group, n=23 Mean age=43.6±12.2 yrs Treadmill desk (TD) group, n=22 Mean age=50.4±12.0 yrs	12 months	Intervention group 1 (Treadmill desk): Acclimation (wk 1) walk at 0.7-1.0 mph for 10-min bouts; after, walk at 1.0-2.0 mph while working in 10-30 min bouts Intervention group 2 (Sit-stand desk): Acclimation (wk 1) accumulate ≥ 3h of standing in 10-30 min bouts after acclimation	Objective: ActivPAL	Total daily sedentary behavior: Sit-Stand Desk and TD groups ↔ vs Control Daily workplace sedentary behavior: Sit-Stand Desk and TD groups ↔ vs Control

	Control group, n=21 Mean age=41.9±11.5 yrs		Control group: 3x10-min of moderate-to-vigorous walking during workday		
(Renaud et al., 2020) **Netherlands**	244 participants Intervention group, n=121 Mean age=48.8±12.5 yrs Control group, n=123 Mean age=51.5±9.2 yrs	8 months	Intervention group: usual practice +Dynamic Work intervention[7] (sit-stand workstations + sitting tracker; deployment of occupational physiotherapists) Control group: usual practice	Objective: ActivPAL	**Sedentary Behavior (min/day)**: Total sitting time (4 months): Intervention ↔ vs Control Total standing and stepping time and total step count (4 months): Intervention ↔ vs Control Movement behavior during work (4 months): Intervention ↔ vs Control Total sitting time (8 months): Intervention ↔ vs Control Total standing and stepping time and total step count (8 months): Intervention ↔ vs Control Movement behavior during work (8 months): Intervention ↔ vs Control
(Schwartz et al., 2019) **Austria**	18 participants Intervention group, n=12 Mean age=35.7±9.6 yrs Control group, n=6 Mean age=37.5±12.5 yrs	6 months	Intervention group: traditional workplace replacement with two-desk sit-stand workstation Control group: traditional seated workstations	Subjective: IPAQ[5]	**Sitting time (min/day)**: Occupational days: Intervention ↓** vs. Control Weekly sitting time: Intervention ↓* vs. Control
(Stephens et al., 2018) **Australia**	196 participants Intervention group, n=114 Mean age=44.9±8.9 yrs Control group, n=82 Mean age=45.9±9.8 yrs	3 months	Intervention group: sit-stand workstations + in-person coaching on set-up Counseling phone calls at wk 2,4,8 and 12 to reduce sitting and move more at work Control group: Usual activities + written feedback on activity outcomes post-follow-up	Objective: ActivPAL	**Sitting time (min/16h) all days:** Intervention ↓*** Sitting time (min/8h) worktime: Intervention ↓*** vs. Control

(Edwardson et al., 2018) **UK**	146 participants Intervention group, n=77 Mean age=40.8±11.3 yrs Control group, n=69 Mean age=41.7±11.0 yrs	12 months	Intervention group: SMArT[7] Control group: no intervention; received results of health measures	Objective: ActivPAL	Occupational sitting time (min/workday) at 3 months: Intervention ↓*** vs Control Occupational sitting time (min/workday) at 6 months: Intervention ↓*** vs Control Sitting time (min/day) 3 months: Intervention ↓ * vs Control Sitting time (min/day) 6 months: Intervention ↓*** vs Control Sitting time (min/day) 12 months: Intervention ↓*** vs Control
(MacEwen et al., 2017) **Canada**	25 participants Intervention group, n=15 Mean age=43.2±9.7 yrs Control group, n= 10 Mean age=48.9±11.4 yrs	3 months	Intervention group: height adjustable desk + multicomponent intervention involving organizational, environmental, and individual/group strategies Control group: regular seated work routine	Objective: ActivPAL	Sitting time workday (min/day): Intervention ↓** vs Control Total sitting (min/day): Intervention ↓* vs Control
(Healy et al., 2016) **Australia**	231 participants Intervention group, n=136 Mean age=44.6±9.1 yrs Control group, n=95 Mean age=47.0±9.7 yrs	12 months	Intervention group: multicomponent intervention involving organizational, environmental, and individual/group strategies Control group: written feedback on their activity and biomarker outcomes at 3 and 12 months	Objective: ActivPAL	Sitting time workplace (min/8h) at 3 months: Intervention ↓ *** vs Control Sitting time workplace (min/8h) at 12 months: Intervention ↓ *** vs Control Sitting waking day (min/16h) at 3 months: Intervention ↓*** vs Control Sitting waking day (min/16h) at 12 months: Intervention ↓*** vs Control
(Chau et al., 2014) **Australia**	42 participants Group 1, n=4 Groups 2-9, n=38 Mean age=38.0±11.0 yrs	9 weeks	Intervention group: sit-stand workstation + brief training on how to use and adjust the desk Control group: waitlist control condition	Objective: ActivPAL Subjectively: OSPAQ; WSQ[8]	**Objective measures**: Sitting workday (min/day): Intervention ↓*** vs Control **Subjective Measures**: OSPAQ: Sitting at work: Intervention ↔ vs Control WSQ: Time spent sitting on workday: Intervention ↓ vs Control WSQ: Sitting time whole workday: Intervention ↔ vs Control Sitting time whole non-workday: Intervention ↔ vs Control

(Dutta et al., 2014) **USA**	28 participants Mean age=40.4 yrs Intervention period 1, n=17 Intervention period 2, n=12	3 months	Intervention group: adjustable sit-stand desk; goal: replacing 50% from sitting time to standing across the month Control group: usual work habits	Objective: accelerometer Subjectively: OSPAQ	**Objective measure**: Sitting time work: Intervention ↓ vs Control **Subjective measure**: Sitting time: Intervention ↓ vs Control
(Alkhajah et al., 2012) **Australia**	25 participants Intervention group, n=18 Mean age=33.5±8.7 yrs Control group, n=14 Mean age=39.9±7.2 yrs	3 months	Intervention group: sit-stand workstation; verbal and written instructions covering the use of the desk and the correct ergonomic sitting and standing posture Control group: usual daily activity.	Objective: ActivPAL	**Sedentary Behavior at workplace (8h workday) at 3 months**: Sitting and time: Intervention ↓*** vs Control **Sedentary Behavior during overall walking time (16h day) at 3 months**: Sitting time: Intervention ↓** vs Control

[1]SWAL, Smart Work and Life intervention; [2]COM-B, capability, opportunity, motivation and behavior approach; [3]SB, sedentary behavior; [4]GPAQ, Modified Global Physical Activity Questionnaire; [5]IPAQ, International Physical Activity Questionnaire; [6]OSPAQ, Occupational Sitting and Physical Activity Questionnaire; [7]SMArT, Stand More AT Work intervention; [8]WSQ, Workforce Sitting Questionnaire.

*SMArT Work intervention multicomponent intervention based on various theories (social cognitive theory, organizational development theory, habit theory, self-regulation theory, relapse prevention theory), involving organizational[(a)], environmental[(b)], and individual and group[(c)] strategies based on COM-B[2] approach

*SWAL intervention, adaptation from the SMArT Work intervention

[a] Organizational strategies: senior leaders and management support, through various tools provided to the participants (workers); training sessions for workplace champions (council employees enrolled as participants in the study)

[b]Environmental strategies: changes or restructure of the workplace to facilitate frequent movement (ex., relocation of certain objects); motivational posters; sit-stand workstations; other tools to facilitate sitting behavior reduction

[c]Individual and group strategies: group sessions/discussions and/or in-person consultations/coaching sessions to review targets, set goals, discuss strategies and action plans, perceived barriers and facilitators, and raise awareness to the benefits of sitting less and consequences of prolonged sitting at work, and provide other tools and advices to facilitate sitting behavior change among participants in the study; positive role modeling and dynamics, and various tools, strategies, and assistance provided by the workplace champions to other participants in the study, to facilitate intervention engagement; personalized emails and/or phone calls to support goal achievement

↓ significant reduction/changes; ↑ significant increase/changes, ↔ no significant changes between groups

*P ≤.05, **P .01, ***P .001

3.3. Workplace Sedentary Behavior

The reduction in sedentary behavior at the workplace was also evaluated according to the duration of the interventions. In studies examining interventions lasting 12 months, the average reduction in workplace sedentary behavior was 48.0 minutes per workday compared to the control group (Figure 2A). In 8-month interventions, the reduction was smaller, with an average of 6.6 min/workday (Figure 2B). 6-month interventions substantially reduced 80.8 min/workday (Figure 3A). In 4-month interventions, the reduction was 16.2 min/workday (Figure 3B), while 3-month interventions showed a decrease of 88.0 min/workday (Figure 4A).
Additionally, in a 9-week intervention using sit-stand desks, the experimental group recorded an average reduction of 73.0 min/workday in sedentary behavior (Figure 4B).

These results indicate that the effectiveness of interventions in reducing sedentary behavior, both during the wakefulness period and in the workplace, is influenced by the duration of the interventions, with significant variations observed across different time intervals.

3.4. Full-Day Sedentary Behavior

The effectiveness of interventions on sedentary behavior during the wakefulness period was evaluated by considering different implementation durations. The interventions were compared at 3, 4, 6, 8, and 12 months, allowing for a detailed analysis of changes in sedentary behavior over time.

For interventions lasting 12 months, an average reduction of 62.1 min/day in daily sedentary behavior was observed (Figure 2A). This reduction was less pronounced in 8-month interventions, with an average of 16.2 min/day (Figure 2B). In contrast, 6-month interventions demonstrated a significantly greater reduction, averaging 77.7 min/day (Figure 3A). Interventions lasting 4 months showed an average decrease of 6.6 min/day (Figure 3B), while 3-month interventions resulted in an average reduction of 68.7 minutes per day (Figure 4A).

For subjectively measured sedentary behavior, the average reductions varied according to the duration of the interventions. Interventions lasting less than 3 months (n=1) resulted in an average decrease of 85.0 min/day. Interventions lasting 3 months (n=2) showed an average reduction of 59.4 min/day, while 6-month interventions (n=2)

had the greatest average reduction, with 130.5 min/day. Interestingly, the 12-month intervention (n=1) increased sedentary behavior by 44.4 min/day (Figure 5A).

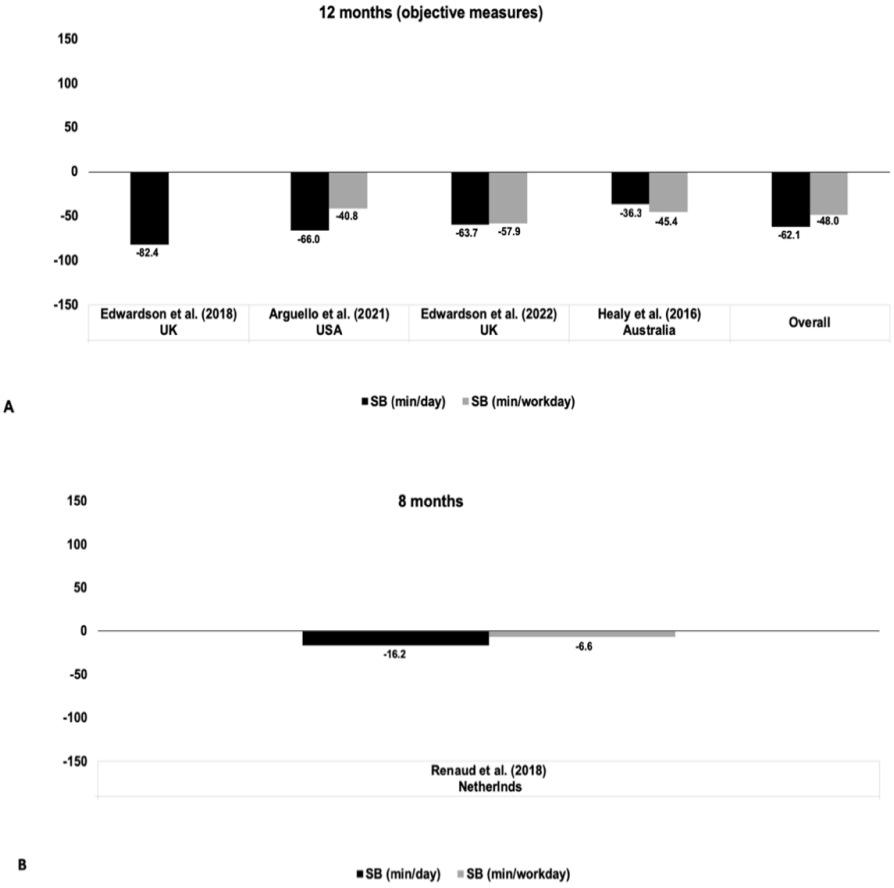

Figure 2 - Objective measures of sedentary behavior (min/day) at work and full-day at 12 and 8 months.

Note: 'Overall' represents the average values from the different interventions.

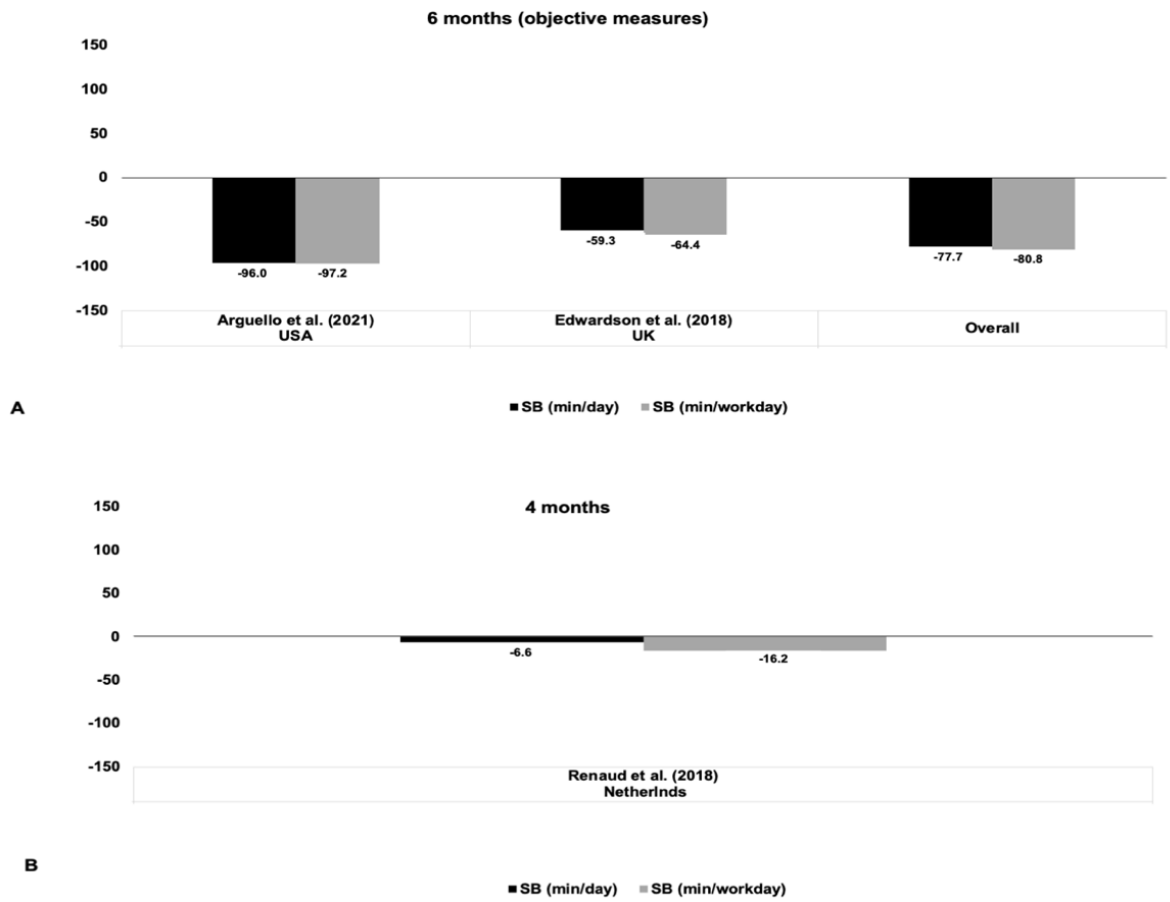

Figure 3 - Objective measures of sedentary behavior (min/day) at work and full-day at 6 and 4 months.

Note: 'Overall' represents the average values from the different interventions.

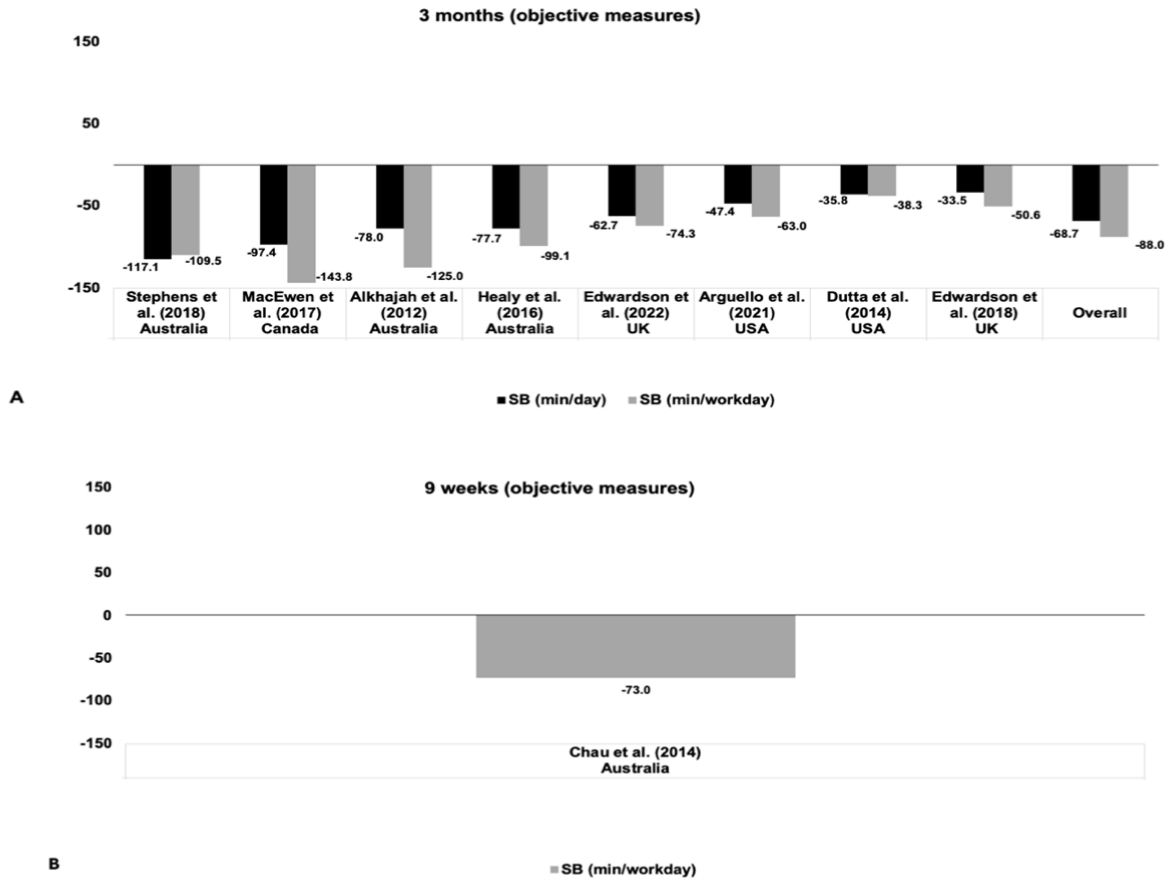

Figure 4 – Objective measures of sedentary behavior (min/day) at work and for the full-day at 3 months and 9 weeks.

Note: 'Overall' represents the average values from the different interventions.

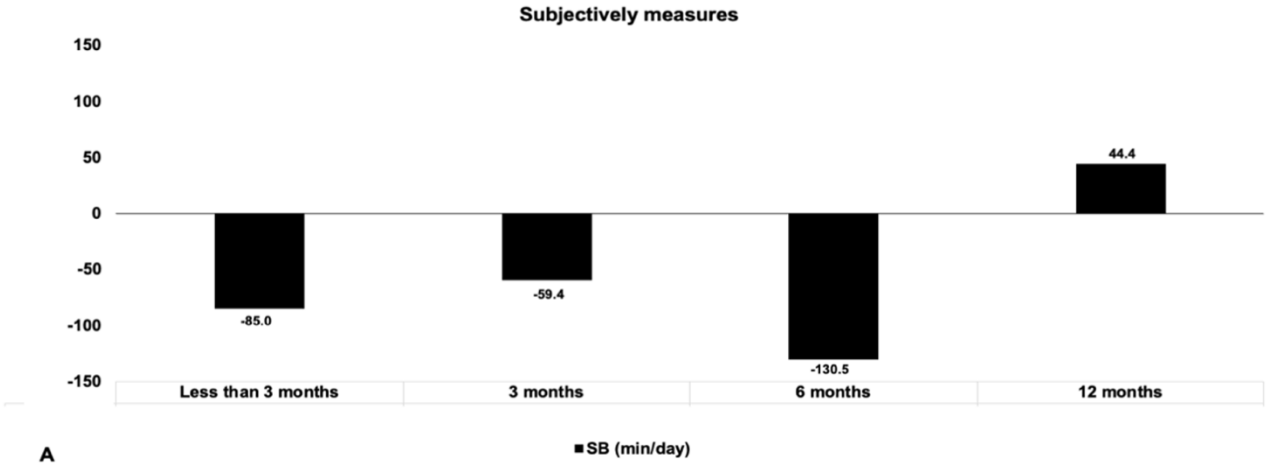

Figure 5 - Subjective measures of sedentary behavior (min/day) for the full-day at less than 3, 3, 6, and 12 months.

4. Discussion

As sedentary behavior continues to rise globally, understanding the effectiveness of sit-stand desk interventions is crucial for promoting healthier work environments and reduce associated health risks, both at work and throughout the full-day. The results showed reduced sedentary behavior during the full-day and in the workplace over 3, 6, and 12 months. These findings corroborate previous research highlighting the effectiveness of sit-stand desks in reducing sedentary behavior (Ekelund, Tarp, et al., 2019). However, the reduction in sedentary behavior was more pronounced during working hours than throughout the whole day, especially in the first 3 to 6 months of interventions. This difference suggests that factors outside the work environment may significantly influence sedentary behavior, potentially leading to compensatory behaviors in the non-occupational setting (Chau et al., 2014; Neuhaus, Eakin, et al., 2014). For instance, individuals who become more active at work by spending more time standing or moving around may feel the need to compensate by sitting or resting more during their free time at home, creating a compensatory effect that balances the increased physical activity at work with greater inactivity outside of working hours. This may inadvertently lead to more sedentary behavior in other contexts, such as at home or during the leisure time, thus contributing to a lower effectiveness of the interventions when the whole day was considered in the analyses (Mansfeldt & Magkos, 2023). Research by Mansoubi et al. (2016) suggests that this increase in sedentary behavior outside of work could neutralize the benefits of workplace interventions to reduce sedentary behavior, and this issue was recently confirmed by another 6-month sit-stand desk intervention (Silva, et al., 2024).

Contrary to the findings of Shrestha et al. (2019), which focused on reducing sedentary behavior in adults and older individuals, our review reveals that interventions lasting 8 to 12 months resulted in greater reductions in sedentary behavior in the full-day, as compared to those attained solely on the work environment. These results suggest that longer interventions may be crucial for consolidating new habits that promote the reduction of sedentary behavior in various daily contexts, without the need for compensatory behaviors.

Although our results showed notable changes at different time intervals, the 4- and 8-month interventions exhibited only marginal differences in reducing sedentary behavior both at work and throughout the full-day. Even though there are less studies considering

these time frames, these data suggest that the effect of sit-stand desks may possibly not be linear but instead follow a sinusoidal curve, in which the effectiveness of such interventions seems to go up and down according to time, a potential spurious effect or a natural cycle driven by the participants' differential motivation. The influence of the predominant sedentary culture in many office environments and participants' workload may have contributed to a return to sedentary habits during periods of high demand (Brierley et al., 2022). For example, in an office where sit-stand desks are introduced, their use may vary in response to external factors such as workload and organizational culture (Zhou et al., 2023). During low-pressure periods, employees are more inclined to use their desks in elevated positions, fostering a more active posture that can enhance productivity through increased energy and engagement in their tasks (Ma et al., 2021). In contrast, high-pressure situations due to excessive workload may lead to a return to sedentary habits, resulting in decreased use of sit-stand desks. For instance, Júdice et al. (2024) observed that the increased workload reported by participants in the last month of the intervention likely affected their use of sit-stand desks, making this data less representative of earlier months. Notably, 9 out of 19 participants indicated that they experienced a higher workload during the data collection week, potentially due to specific job demands, affecting their sit-stand desk usage.

Additionally, cultural factors may pose significant barriers to reduce sedentary behavior in the office context, which may also explain some of the lower effectiveness found in some interventions (Waters et al., 2016). Another reason could be the seasonal variation, which impacts the measurements of sedentary behavior due to various factors, such as climate and temperature, light exposure, and daylight hours (Chan & Ryan, 2009; Tucker & Gilliland, 2007). During the warmer months, people generally engage in more outdoor activities, thus reducing sedentary behavior. A systematic review by Turrisi et al. (2021) indicates that physical activity tends to be higher in summer than in winter. However, all these potential explanatory factors deserve future investigation to isolate them and in this way further understand their impact on the effectiveness of sit-stand desk based interventions.

Additionally, the lack of intensive individual follow-up (such as coaching sessions or frequent phone calls) may influence the results (Renaud et al., 2020). A healthy work environment can be promoted through individual and organizational strategies. At the individual level, personalized coaching, the promotion of healthy habits, and ongoing support can help employees adopt healthier behaviors (Zhou et al.,

2023). At the organizational level, conducting workshops, workplace visits, and physiotherapy consultations can create a culture of well-being and promote employees' physical and mental health (Edwardson et al., 2022). Given the growing body of evidence on the adverse effects of prolonged sedentary behavior, these strategies must be implemented to mitigate the health risks associated with sedentary lifestyles (Buckley et al., 2015). Our results showed that in comparison to simply using sit-stand desk, adopting these approaches can enhance the effectiveness of interventions across various organizational levels (Zhou et al., 2023).

This systematic review showed that multi-component interventions, including sit-stand desks, can effectively reduce sedentary behavior, aligning with previous systematic reviews and meta-analyses (Danquah et al., 2017; Healy et al., 2016; Neuhaus, Eakin, et al., 2014; Zhou et al., 2023). The observed positive impact may be associated with the collaborative nature of these interventions, where exposure to colleagues' behaviors influence adherence to change (Gilson et al., 2011; Healy et al., 2016). Single-component interventions showed smaller reductions in sedentary behavior compared to multi-component interventions. In the case of the single-component intervention, the reduction at 3 months were 35.8 min/day and 38.3 min/workday. In contrast, multi-component interventions resulted in significantly larger average reductions, with 73.4 min/day and 95.1 min/workday. These data reinforce the evidence that interventions addressing multiple levels of strategies (environmental, organizational, and individual) are more effective in reducing sedentary behavior compared to those focused on a single aspect (Sharma et al., 2019). Moreover, two of the included studies reported reductions in sedentary behavior at 3 months comparable to other follow-up time points (6 and 12 months), using a sit-stand desk and a multi-component approach (Arguello et al., 2021; Healy et al., 2016).

The data highlights consistent differences in sedentary behavior reductions when measured subjectively versus objectively over time. At 3 months, both subjective and objective measures indicate reductions, with subjective reports showing a 59.4 min/day daily decrease and objective measures reflecting a slightly greater 68.7 min/day decrease in sedentary behavior. At 6 months, subjective reports suggest a substantial reduction of 130.5 minutes per day, compared to a more moderate 77.7 min/day reduction by objective metrics. At 12 months, the subjective measures report a daily increase of 44.4 min/day, while objective data still show a 62.1 min/day reduction. These discrepancies may result from participant misclassification of sitting time, as self-reported data often

underestimates sedentary behavior, particularly when participants become more aware of their habits over the intervention period (Júdice, et al., 2023; Liu et al., 2016).

Finally, there is literature showing that financial incentives may positively influence intervention participation and enhance sedentary behavior reduction amongst participants(Mitchell et al., 2013). While monetary rewards may motivate behavioral changes, it is essential to consider that this may not translate into sustainable changes in real-world contexts (Edwardson et al., 2022; Hergenroeder et al., 2022), and it can explain some of the heterogeneous results found between studies.

4.1. Strengths and Limitations

This systematic review entails several strengths, making it a significant contribution to the literature on interventions designed to reduce sedentary behavior based on sit-stand desks, among office workers. One of its major strengths is the comprehensive scope of the research, which includes studies published between 2008 and 2024, ensuring that the analysis reflects the most current evidence available. Additionally, the review incorporates multicomponent interventions that addressed environmental, organizational, and individual factors. This approach provides a more holistic understanding of effective strategies and offers practical insights for future implementation. Another strength is the inclusion of studies that analyzed sedentary behavior over the full-day versus the working hours, allowing for a deeper understanding on how interventions not only impact working hours but also the extra-work time, addressing the potential for compensatory behaviors outside the workplace.

However, this systematic review also has some limitations. The primary limitation is the absence of a meta-analysis, which was not conducted due to the substantial heterogeneity among the interventions. This heterogeneity was manifested in different interventions' duration, study design variations, distinct sample sizes, and differences in the outcome measures used. This variability in intervention length could have significantly impacted both the analysis and interpretation of the results. The diverse durations may lead to inconsistencies and complicate the combination and comparison of outcomes, potentially skewing the overall findings.

Another limitation is the lack of control over the sample characteristics, which may have potentially restricted the workers' capacity to stand at work (for instance, certain studies have concentrated on individuals who were overweight or obese and experienced back pain, as they are typically less physically active than those with a healthy weight).

However, to translate the findings to the real world, the heterogeneity of profiles among workers is something to consider. Additionally, the reliability of these studies can be questioned due to variations in the type of work, duration of work, level of autonomy, postural variation, and physical and cognitive workloads in different sectors and industries. Furthermore, the interventions studied only lasted up to 12 months, highlighting the need for longer interventions. Lastly, there is a lack of post-intervention follow-up. It is crucial to include follow-up to assess the long-term sustainability and persistence of the effects of the intervention on the acquisition of new habits.

4.2. Implications for Practice

Although active workstations can effectively reduce sedentary behavior of office workers, different combinations of sit-stand desks and support strategies must be tested to identify the most effective intervention approach. Considering these findings, interventions that combine sit-stand desks with multi-component strategies are recommended. These strategies may include educational sessions, face-to-face meetings, alerting software, or other alerting techniques. This combination effectively reduces sedentary behavior in the short, medium, and long term (3, 6, and 12 months). These interventions are expected to have essential health benefits, which may persuade companies and governments to invest in these new approaches and promote the sustainable implementation of preventive interventions adapted to the work context. Ultimately, this will improve workplace conditions, physical activity levels, and well-being and may help to stem the rise in non-communicable diseases and associated health costs. Future research should aim to identify and test the most effective intervention approaches in the workplace. These interventions should be extended to the extra working hours for a full potential. Additional strategies must be developed to make the interventions even more effective (e.g., health-oriented events or challenges to promote active participation and foster community among staff). A follow-up analysis must be conducted to determine the effectiveness of sit-stand desk interventions in the post-intervention period, assessing whether the new habits acquired during the intervention period persist. Also, it was evident that most interventions took place in English-speaking countries, with a lack of information in non-English speaking nations, especially in the southern countries of Europe, where there is no information regarding the effectiveness and acceptance of these strategies.

*Silva, H., Ramos, P. G. F., Teno, S. C., & Júdice, P. B. (2024). The Impact of Sit-Stand Desks on Full-Day and Work-Based Sedentary Behavior of Office Workers: A Systematic Review. *Human factors*, 187208241305591. https://doi.org/10.1177/001872

5. Conclusion

Sedentary behavior is a significant public health issue, as individuals often engage in prolonged periods of inactivity, which is strongly linked to various chronic diseases. Implementing sit-stand desks and multi-component interventions can effectively reduce sedentary behavior. It is essential to utilize innovative, evidence-based strategies that promote physical activity and reduce sitting time among office workers. This systematic review presents compelling evidence that multi-component interventions, particularly those that include sit-stand desks, can significantly help office workers decrease sedentary behavior over the short (3 months), medium (6 months), and long-term (12 months) periods, both in the workplace and in a 24h perspective. Notably, the results reveal that reductions in sedentary behavior are more pronounced in the workplace compared to full-day sedentary behavior in the short term; however, this effect tends to diminish over time. These findings highlight the critical need for investment in such interventions, as they show considerable potential for improving health outcomes among office workers. However, it is essential to note that no intervention involving sit-stand desks has lasted beyond 12 months. This limitation emphasizes the necessity for developing longer-term strategies to maintain these positive effects and ensure sustainable lifestyle changes.

6. References

Alkhajah, T. A., Reeves, M. M., Eakin, E. G., Winkler, E. A., Owen, N., & Healy, G. N. (2012). Sit-stand workstations: a pilot intervention to reduce office sitting time. *Am J Prev Med*, *43*(3), 298-303. https://doi.org/10.1016/j.amepre.2012.05.027

Arguello, D., Thorndike, A. N., Cloutier, G., Morton, A., Castaneda-Sceppa, C., & John, D. (2021). Effects of an "Active-Workstation" Cluster RCT on Daily Waking Physical Behaviors. *Med Sci Sports Exerc*, *53*(7), 1434-1445. https://doi.org/10.1249/MSS.0000000000002594

Brierley, M. L., Smith, L. R., Bailey, D. P., Ojo, S. O., Hewson, D. J., Every, S. A.,…Chater, A. M. (2022). Evaluating a multi-component intervention to reduce and break up office workers' sitting with sit-stand desks using the APEASE criteria. *BMC Public Health*, *22*(1), 458.

Buckley, J. P., Hedge, A., Yates, T., Copeland, R. J., Loosemore, M., Hamer, M.,…Dunstan, D. W. (2015). The sedentary office: an expert statement on the

growing case for change towards better health and productivity. *Br J Sports Med*, *49*(21), 1357-1362. https://doi.org/10.1136/bjsports-2015-094618

Chan, C. B., & Ryan, D. A. (2009). Assessing the effects of weather conditions on physical activity participation using objective measures. *Int J Environ Res Public Health*, *6*(10), 2639-2654. https://doi.org/10.3390/ijerph6102639

Chau, J. Y., Daley, M., Dunn, S., Srinivasan, A., Do, A., Bauman, A. E., & van der Ploeg, H. P. (2014). The effectiveness of sit-stand workstations for changing office workers' sitting time: results from the Stand@Work randomized controlled trial pilot. *Int J Behav Nutr Phys Act*, *11*, 127. https://doi.org/10.1186/s12966-014-0127-7

Danquah, I. H., Kloster, S., Holtermann, A., Aadahl, M., Bauman, A., Ersbøll, A. K., & Tolstrup, J. S. (2017). Take a Stand!-a multi-component intervention aimed at reducing sitting time among office workers-a cluster randomized trial. *Int J Epidemiol*, *46*(1), 128-140. https://doi.org/10.1093/ije/dyw009

Dupont, F., Léger, P. M., Begon, M., Lecot, F., Sénécal, S., Labonté-Lemoyne, E., & Mathieu, M. E. (2019). Health and productivity at work: which active workstation for which benefits: a systematic review. *Occup Environ Med*, *76*(5), 281-294. https://doi.org/10.1136/oemed-2018-105397

Dutta, N., Koepp, G. A., Stovitz, S. D., Levine, J. A., & Pereira, M. A. (2014). Using sit-stand workstations to decrease sedentary time in office workers: a randomized crossover trial. *Int J Environ Res Public Health*, *11*(7), 6653-6665. https://doi.org/10.3390/ijerph110706653

Edwardson, C. L., Biddle, S. J. H., Clemes, S. A., Davies, M. J., Dunstan, D. W., Eborall, H.,…Clarke-Cornwell, A. M. (2022). Effectiveness of an intervention for reducing sitting time and improving health in office workers: three arm cluster randomised controlled trial. *BMJ*, *378*, e069288. https://doi.org/10.1136/bmj-2021-069288

Edwardson, C. L., Yates, T., Biddle, S. J. H., Davies, M. J., Dunstan, D. W., Esliger, D. W.,…Munir, F. (2018). Effectiveness of the Stand More AT (SMArT) Work intervention: cluster randomised controlled trial. *BMJ*, *363*, k3870. https://doi.org/10.1136/bmj.k3870

Ekelund, U., Brown, W. J., Steene-Johannessen, J., Fagerland, M. W., Owen, N., Powell, K. E.,…Lee, I. M. (2019). Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical

activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants. *Br J Sports Med*, *53*(14), 886-894. https://doi.org/10.1136/bjsports-2017-098963

Ekelund, U., Tarp, J., Steene-Johannessen, J., Hansen, B. H., Jefferis, B., Fagerland, M. W.,…Lee, I. M. (2019). Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis. *BMJ*, *366*, l4570. https://doi.org/10.1136/bmj.l4570

Gilson, N. D., Burton, N. W., van Uffelen, J. G., & Brown, W. J. (2011). Occupational sitting time: employees' perceptions of health risks and intervention strategies. *Health Promot J Austr*, *22*(1), 38-43. https://doi.org/10.1071/he11038

Grunseit, A. C., Chau, J. Y., van der Ploeg, H. P., & Bauman, A. (2013). "Thinking on your feet": A qualitative evaluation of sit-stand desks in an Australian workplace. *BMC Public Health*, *13*, 365. https://doi.org/10.1186/1471-2458-13-365

Healy, G. N., Eakin, E. G., Owen, N., Lamontagne, A. D., Moodie, M., Winkler, E. A.,…Dunstan, D. W. (2016). A Cluster Randomized Controlled Trial to Reduce Office Workers' Sitting Time: Effect on Activity Outcomes. *Med Sci Sports Exerc*, *48*(9), 1787-1797. https://doi.org/10.1249/MSS.0000000000000972

Hergenroeder, A., Quinn, T. D., Perdomo, S. J., Kline, C. E., & Gibbs, B. B. (2022). Effect of a 6-month sedentary behavior reduction intervention on well-being and workplace health in desk workers with low back pain. *Work*, *71*(4), 1145-1155. https://doi.org/10.3233/WOR-205178

Júdice, P. B., Silva, H., Teno, S. C., & Hetherington-Rauth, M. (2024). The effectiveness of a 6-month intervention with sit-stand workstation in office workers: Results from the SUFHA cluster randomized controlled trial. *Work*. https://doi.org/10.3233/WOR-230624

Júdice, P. B., Sousa-Sá, E., & Palmeira, A. L. (2023). Discrepancies Between Self-reported and Objectively Measured Smartphone Screen Time: Before and During Lockdown. *J Prev (2022)*, *44*(3), 291-307. https://doi.org/10.1007/s10935-023-00724-4

Liu, S. H., Eaton, C. B., Driban, J. B., McAlindon, T. E., & Lapane, K. L. (2016). Comparison of self-report and objective measures of physical activity in US

adults with osteoarthritis. In *Rheumatol Int* (Vol. 36, pp. 1355-1364). https://doi.org/10.1007/s00296-016-3537-9

Ma, J., Ma, D., Li, Z., & Kim, H. (2021). Effects of a Workplace Sit-Stand Desk Intervention on Health and Productivity. *Int J Environ Res Public Health*, *18*(21). https://doi.org/10.3390/ijerph182111604

MacEwen, B. T., Saunders, T. J., MacDonald, D. J., & Burr, J. F. (2017). Sit-Stand Desks To Reduce Workplace Sitting Time In Office Workers With Abdominal Obesity: A Randomized Controlled Trial. *J Phys Act Health*, *14*(9), 710-715. https://doi.org/10.1123/jpah.2016-0384

Mansfeldt, J. M., & Magkos, F. (2023). Compensatory Responses to Exercise Training As Barriers to Weight Loss: Changes in Energy Intake and Non-exercise Physical Activity. *Curr Nutr Rep*, *12*(2), 327-337. https://doi.org/10.1007/s13668-023-00467-y

Mansoubi, M., Pearson, N., Biddle, S. J., & Clemes, S. A. (2016). Using Sit-to-Stand Workstations in Offices: Is There a Compensation Effect? *Med Sci Sports Exerc*, *48*(4), 720-725. https://doi.org/10.1249/MSS.0000000000000802

Mitchell, M. S., Goodman, J. M., Alter, D. A., John, L. K., Oh, P. I., Pakosh, M. T., & Faulkner, G. E. (2013). Financial incentives for exercise adherence in adults: systematic review and meta-analysis. *Am J Prev Med*, *45*(5), 658-667. https://doi.org/10.1016/j.amepre.2013.06.017

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

Neuhaus, M., Healy, G. N., Dunstan, D. W., Owen, N., & Eakin, E. G. (2014). Workplace sitting and height-adjustable workstations: a randomized controlled trial. *Am J Prev Med*, *46*(1), 30-40. https://doi.org/10.1016/j.amepre.2013.09.009

Nguyen, P., Le, L. K., Nguyen, D., Gao, L., Dunstan, D. W., & Moodie, M. (2020). The effectiveness of sedentary behaviour interventions on sitting time and screen time in children and adults: an umbrella review of systematic reviews. *Int J Behav Nutr Phys Act*, *17*(1), 117. https://doi.org/10.1186/s12966-020-01009-3

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D.,…Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. https://doi.org/10.1136/bmj.n71

Patterson, R., McNamara, E., Tainio, M., de Sá, T. H., Smith, A. D., Sharp, S. J.,…Wijndaele, K. (2018). Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *Eur J Epidemiol*, *33*(9), 811-829. https://doi.org/10.1007/s10654-018-0380-1

Renaud, L. R., Jelsma, J. G. M., Huysmans, M. A., van Nassau, F., Lakerveld, J., Speklé, E. M.,…van der Ploeg, H. P. (2020). Effectiveness of the multi-component dynamic work intervention to reduce sitting time in office workers - Results from a pragmatic cluster randomised controlled trial. *Appl Ergon*, *84*, 103027. https://doi.org/10.1016/j.apergo.2019.103027

Santos, A. C., Willumsen, J., Meheus, F., Ilbawi, A., & Bull, F. C. (2023). The cost of inaction on physical inactivity to public health-care systems: a population-attributable fraction analysis. *Lancet Glob Health*, *11*(1), e32-e39. https://doi.org/10.1016/S2214-109X(22)00464-8

Schwartz, B., Kapellusch, J. M., Baca, A., & Wessner, B. (2019). Medium-term effects of a two-desk sit/stand workstation on cognitive performance and workload for healthy people performing sedentary work: a secondary analysis of a randomised controlled trial. *Ergonomics*, *62*(6), 794-810. https://doi.org/10.1080/00140139.2019.1577497

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. *Hum Factors*, *61*(5), 816-824. https://doi.org/10.1177/0018720818807043

Shrestha, B., & Dunn, L. (2020). The Declaration of Helsinki on Medical Research involving Human Subjects: A Review of Seventh Revision. *J Nepal Health Res Counc*, *17*(4), 548-552. https://doi.org/10.33314/jnhrc.v17i4.1042

Shrestha, N., Grgic, J., Wiesner, G., Parker, A., Podnar, H., Bennie, J. A.,…Pedisic, Z. (2019). Effectiveness of interventions for reducing non-occupational sedentary behaviour in adults and older adults: a systematic review and meta-analysis. *Br J Sports Med*, *53*(19), 1206-1213. https://doi.org/10.1136/bjsports-2017-098270

Shrestha, N., Ijaz, S., Kukkonen-Harjula, K. T., Kumar, S., & Nwankwo, C. P. (2015). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *1*, Cd010912. https://doi.org/10.1002/14651858.CD010912.pub2

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Pedisic, Z. (2018). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *6*(6), Cd010912. https://doi.org/10.1002/14651858.CD010912.pub4

Silva, H., Teno, S. C., & Júdice, P. B. (2024). Are there compensatory behaviors in response to a sit-stand desk intervention? *J Occup Health*. https://doi.org/10.1093/joccuh/uiae067

Stephens, S. K., Eakin, E. G., Clark, B. K., Winkler, E. A. H., Owen, N., LaMontagne, A. D.,…Healy, G. N. (2018). What strategies do desk-based workers choose to reduce sitting time and how well do they work? Findings from a cluster randomised controlled trial. *Int J Behav Nutr Phys Act*, *15*(1), 98. https://doi.org/10.1186/s12966-018-0731-z

Thomas, B. H., Ciliska, D., Dobbins, M., & Micucci, S. (2004). A process for systematically reviewing the literature: providing the research evidence for public health nursing interventions. *Worldviews Evid Based Nurs*, *1*(3), 176-184. https://doi.org/10.1111/j.1524-475X.2004.04006.x

Tremblay, M. S., Colley, R. C., Saunders, T. J., Healy, G. N., & Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Appl Physiol Nutr Metab*, *35*(6), 725-740. https://doi.org/10.1139/H10-079

Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: a systematic review. *Public Health*, *121*(12), 909-922. https://doi.org/10.1016/j.puhe.2007.04.009

Turrisi, T. B., Bittel, K. M., West, A. B., Hojjatinia, S., Mama, S. K., Lagoa, C. M., & Conroy, D. E. (2021). Seasons, weather, and device-measured movement behaviors: a scoping review from 2006 to 2020. *Int J Behav Nutr Phys Act*, *18*(1), 24. https://doi.org/10.1186/s12966-021-01091-1

Waters, C. N., Ling, E. P., Chu, A. H., Ng, S. H., Chia, A., Lim, Y. W., & Müller-Riemenschneider, F. (2016). Assessing and understanding sedentary behaviour in office-based working adults: a mixed-method approach. *BMC Public Health*, *16*, 360. https://doi.org/10.1186/s12889-016-3023-z

Zhou, L., Deng, X., Xu, M., Wu, Y., Shang, X., E, F.,…Li, X. (2023). The effects of active workstations on reducing work-specific sedentary time in office workers: a network meta-analysis of 23 randomized controlled trials. *Int J Behav Nutr Phys Act*, *20*(1), 92. https://doi.org/10.1186/s12966-023-01467-5

Table Supplementary 1 - Studies' quality assessment.

Study	Design	Blinding	Selection bias	Drop-outs	Confounders	Data collection	Data analysis	Report	Global rating
Edwardson 2022	Strong	Weak	Moderate	Strong	Strong	N/D	Strong	Strong	Moderate
Hergenroeder 2022	Strong	Weak	Moderate	Strong	Strong	N/D	Strong	Strong	Moderate
Arguello 2021	Strong	Weak	Moderate	Weak	Moderate	N/D	Strong	Strong	Weak
Renaud 2020	Strong	Moderate	Weak	Strong	Moderate	Strong	Strong	Strong	Moderate
Schwartz 2019	Strong	Wrong	Moderate	Weak	Strong	N/D	Strong	Strong	Moderate
Stephens 2019	Strong	Weak	Moderate	Strong	Moderate	N/D	Strong	Strong	Moderate
Edwardson 2018	Strong	Moderate	Moderate	Strong	Moderate	Strong	Strong	Strong	Strong
MacEwen 2017	Strong	Weak	Moderate	Strong	Moderate	N/D	Strong	Strong	Moderate
Healy 2016	Strong	Weak	Moderate	Strong	Strong	N/D	Strong	Strong	Moderate
Chau 2014	Strong	Wrong	Weak	Strong	Moderate	Strong	Strong	Strong	Moderate
Dutta 2014	Strong	Wrong	Weak	Strong	Moderate	N/D	Strong	Strong	Moderate
Alkhajah 2012	Strong	Weak	Weak	Strong	Moderate	Strong	Strong	Strong	Weak

Chapter IV

Study 2: Compensatory behaviors in response to sit-stand desk use

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Nada grande se alcança de repente, é necessário tempo, disciplina e consistência.

Epicteto

Chapter IV

Are there compensatory behaviors in response to a sit-stand desk intervention? *

Abstract

Background: Office workers represent one of the most sedentary groups. Alarmingly, more than a third of their sitting time during workdays occurs in prolonged bouts. Sit-stand desk (SSD) interventions have been found to be effective in reducing sitting time, but heterogeneity exists amongst studies, which may be due to compensations outside the workplace. This study aimed to assess the impact of a 6-month SSD intervention on office workers' sitting and standing times during the work shift and outside work (leisure time).

Methods: A two-arm (1:1) clustered randomized controlled trial was conducted with 38 participants randomly assigned to either the intervention or control group. The intervention included a psychoeducational session, motivational prompts, and environmental modification (SSD implemented in the workplace). The waiting-list control group maintained the usual work conditions and only received the initial session. We employed repeated measures ANCOVA to compare changes between groups while adjusting for relevant covariates, with significance set at 5%.

Results: In the intervention group, there was a significant reduction in sitting time at work by 32.97 min, along with a notable increase in standing time by 27.88 min ($p<0.05$). Although not significant ($p>0.05$), there was an increase in sitting time in the leisure context of about 23.07 min.

Conclusions: This study underscores the effectiveness of SSD as a key strategy to mitigate sitting time among office workers. However, future interventions should consider integrating comprehensive behavioral strategies beyond the workplace to sustain potential increases in sitting time during the leisure time and avoid compensatory behaviors.

Keywords: compensatory behavior; work setting; sedentary behavior; interindividual variability; standing desk.

*Silva, H., Teno, S. C., & Júdice, P. B. (2024). Are there compensatory behaviors in response to a sit-stand desk intervention? *Journal of occupational health*, *66*(1), uiae067. https://doi.org/10.1093/joccuh/uiae067.

1. Introduction

Sedentary behavior (SB) has seen a significant rise over the past decade and is responsible for approximately 1.9 million deaths globally (Tremblay et al., 2017). Excessive SB is difficult to define due to the lack of a specific threshold, but there are indications that from 7.5 to 9.5 hours or more, has been associated with increased mortality risk (Ekelund, Brown, et al., 2019). Adults typically accumulate sitting time (ST) (i.e., an indicator of SB) in three domains: in the workplace, during leisure time (e.g., at home in front of a television), and for transport (Chau et al., 2012), and although there are few studies on the prevalence of specific SB domains, some studies indicate that the occupational SB is more prevalent (Mielke et al., 2014).

Office workers typically spend a significant portion of their workday seated at their desks (Landais et al., 2022). For example, a study found that office workers spent, on average, 79% of working hours sitting, more than half of which were in prolonged sitting (≥30 min bouts) (Hadgraft et al., 2016). This amount of SB, compounded by insufficient physical activity, exposes many workers to intensified risk of non-communicable diseases and premature mortality (Prince et al., 2019). Occupational SB has also been explicitly linked to elevated risk of diabetes, mortality (Shrestha et al., 2018b), and musculoskeletal issues such as neck and shoulder discomfort (Blackburn et al., 2020). Moreover, extensive SB detrimentally impacts crucial work-related outcomes such as engagement (Rhodes et al., 2017) and presenteeism (Edwardson et al., 2022). The World Health Organization (WHO) defines overweight as a body mass index (BMI) between 25 and 29.9 kg/m², while obesity is classified as a BMI ≥ 30 kg/m². There is evidence that longer ST is directly associated with adiposity in office workers but not in non-office workers (Sugiyama et al., 2020), which can be attributed to different patterns of ST accumulation (Sugiyama et al., 2020). Interestingly, these associations disappear in those workers who were sufficiently physically active during leisure time (Sugiyama et al., 2020).

SB in the leisure time has been the domain most associated with deleterious mental health, especially among inactive people (Teno et al., 2024). Since office workers exhibit high levels of SB, interventions have emerged focusing on reducing ST in the workplace (Blackburn et al., 2020; Shrestha et al., 2018). Interventions incorporating sit-stand desk (SSD) alongside multifaceted strategies are often implemented to target SB, aiming to simultaneously increase standing time (Edwardson et al., 2022; Rhodes et al., 2017).

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Evidence analyzing the impact of SB reduction interventions during working hours (Nguyen et al., 2020; Renaud et al., 2020; Shrestha et al., 2015; Shrestha et al., 2018b; Zhou et al., 2023) show that SSD-based interventions can significantly reduce ST in the workplace by 6 to 120 min/day. Therefore, SSD is considered a potential strategy to reduce ST and increase standing time among office workers (Grunseit et al., 2013; Shrestha & Dunn, 2020; Zhou et al., 2023). Current recommendations suggest replacing two hours of ST in an eight-hour workday with standing or light activity, along with frequent posture changes (Buckley et al., 2015).

However, while SSD can effectively lower SB in the workplace, it is unclear whether this reduction is maintained outside of work, or if individuals can somehow compensate after working hours by increasing SB on the leisure time (Mansoubi et al., 2016; Neuhaus, Healy, et al., 2014). One of the few studies conducted to examine the use of SSD at work and the potential compensation effect outside work concluded that a 3-month SSD intervention with healthy workers resulted in a 20% reduction in SB during working hours, however, there was an 8% increase in SB outside work (Mansoubi et al., 2016).

Thus, although some SSD interventions suggest effectiveness in reducing 24 hour based SB among office workers, some heterogeneity exists amongst interventions, and it remains unclear whether individuals maintain this reduction outside the workplace or if they compensate during the leisure time by increasing ST (Mansoubi et al., 2016; Neuhaus, Healy, et al., 2014). Given the lack of literature on this topic, this study aimed to evaluate the effectiveness of a 6-month SSD intervention, on office workers' sitting time at work and analyze its impact in the leisure time.

2. Method

2.1. Study design

This study is an ancillary analysis of data derived from a randomized controlled trial (RCT). The primary trial adhered to the Consolidated Standards of Reporting Trials (CONSORT) guidelines for cluster randomized clinical trials and it was designed as a two-arm (1:1) parallel randomized controlled trial. Assessments were conducted at baseline and 6-months later. The entire protocol has been previously published for detailed information (Júdice et al., 2023). In summary, after the initial measurements, cluster randomization was performed using a random list generator (www.random.org)

by a researcher not involved in the recruitment or data collection processes. Recruitment occurred between December 2022 and January 2023, with baseline data collected in February 2023 and follow-up data gathered in August 2023. For these analyses, data was reanalyzed in 2024.

2.2. Setting and participants

Detailed information on recruitment has been previously described (Júdice et al., 2023), but in summary, office workers were recruited through university promotions, such as banners, posters, and emails sent within the institution.

Researchers evaluated the workspaces of interested participants to ensure they were suitable for installing the SSD. The inclusion criteria required participants to work at least 0.6 full-time equivalent, be over 20 years old, and spend at least 70% of their week on desk-related tasks. Exclusion criteria included current SSD usage, insufficient personal space for desk setup, and musculoskeletal or health conditions that would make standing difficult. Additionally, individuals who worked from home were excluded due to the logistical challenges of providing two SSD for each participant. Of the 38 participants included in the study, the majority (30 participants) had a working schedule between 9:00 AM and 5:00 PM, seven participants had a schedule from 10:00 AM to 6:00 PM, and only one participant had a schedule from 2:45 PM to 10:45 PM.

2.3. Data Collection

An online questionnaire, administered in person with the assistance of research team members, was used to collect information on the participants' sociodemographic profiles, health conditions, and work-related characteristics. In accordance with ethical guidelines, the data from this study was securely stored in a restricted-access folder, accessible only to the research team. Participant's consent did not include permission to share these data publicly.

2.4. Interventions

In summary, participants in the intervention group attended an initial psychoeducational session and were provided with an SSD (Vinsetto, Model 923-043). The intervention included assembling the SSD at participants' desks before the start of the program. Participants received personalized instructions on the desired progression of

SSD use, ergonomic posture advice, and individualized support to increase standing time gradually.

Motivational nudges were integrated throughout the intervention to address potential disruptions to new routines, such as holidays. These efforts aimed to enhance relatedness, perceived competence, and autonomy, consistent with Self-Determination Theory (Ryan & Deci, 2000), to encourage autonomous motivation for sustained behavior change (Ng et al., 2012). The session aimed to increase awareness and understanding, as similar approaches have effectively promoted behavior change (Biddle et al., 2020).

The waiting-list control group only participated in the same psychoeducational session, with no changes in the work environment.

2.5. Main outcomes

The time spent sitting, standing, and stepping were objectively measured at baseline and 6 months later. Participants were instructed to continuously wear an ActivPAL4 activity monitor (PAL Technologies Ltd., Glasgow, Scotland, UK) for 24 hours a day over seven days. The detailed methodology for this assessment has been previously published (Júdice et al., 2023). For these analyses, we focused on three specific variables: ST, standing time, and stepping time, both during work and in leisure time, using the valid monitored days and the specific working schedules of each participant.

We decided to present the ActivPAL data in percentages instead of minutes, to be clearer and easily comparable with previous data. To calculate the percentages of time spent sitting and standing during work and in leisure time, as presented in Figure 1, we used 24 hours as the basis. We divided the time spent in each activity (sitting or standing) by 24 hours and multiplied by 100 to obtain the corresponding percentage. We applied the same rationale to calculate the ratio of time explicitly spent at work, dividing the time by 8 hours and multiplying by 100 to obtain the corresponding percentage.

2.6. Assessment procedures

Assessment procedures have been detailed in a prior publication (Júdice et al., 2023). A trained assessor gave participants the device attached to the midpoint of their right thigh using a waterproof medical dressing. Participants were instructed to wear the device continuously for seven consecutive days. Subsequently, participants filled out an online questionnaire, with a trained assessor available to help with any questions. This

questionnaire was developed using Qualtrics online software and addressed various topics as previously described (Júdice et al., 2023).

The data collected by ActivPAL was analyzed by summing the hourly information generated by the ActivPAL software for the period in which each participant was at work and outside work. This means that 38*6*2*3*2 (i.e., participants*full-days*work vs leisure*variables*baseline vs 6-month) periods were manually calculated based on the hourly data and the actual working shift for each participant, which translates into 2736 calculated units that allowed us to accurately identify and quantify the time spent sitting, standing, and stepping, both in the work environment and during leisure time.

2.7. Secondary outcomes

Participants were weighed while wearing minimal clothes and without shoes on an electronic scale (TANITA BC-601 scale). Height was measured with a stadiometer (Seca, Hamburg, Germany). Body mass index (BMI) was calculated as body mass (kg)/height^2 (m).

2.8. Sample size

Considering the type of investigation (clustered RCT) and primary outcome of the intervention (i.e., ST) while using an effect size of 0.80, the total number of participants for between-group analyses, with a power of 0.80 and a significance level of 0.05 (two-tailed test), would have been 34 participants.

2.9. Statistical analyses

Statistical analyses were conducted using PASW Statistics version 29.0.2.0 (SPSS Inc., an IBM Company, Chicago, IL, USA). Paired-sample t-tests were used to compare groups at baseline and 6-months. A repeated measures ANCOVA was performed, with time (baseline vs. 6-month) as the within-subject factor and the intervention group as the between-subject factor, to evaluate time*group interaction effect on the outcomes. The significance level was set at 5%.

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3. Results

This study included 38 participants, evenly distributed with 19 in each group. Table 1 provides an overview of the baseline characteristics of the Stand Up for Healthy Aging (SUFHA) study participants.

Table 1 - Baseline characteristics by group: control and intervention. Values are means (standard deviations); except for gender distribution.

Characteristics	Control	Intervention	Total
Sample size	(n=19)	(n=19)	(n=38)
Age (years)	42.3 (9.5)	45.3 (6.0)	43.8 (8.0)
Nº (%) women	14 (73.3%)	16 (80.0%)	30 (76.6%)
Biometric measurements			
Body mass index (kg/m^2)	30.5 (7.4)	27.2 (6.1)	28.8 (6.9)
Body weight (kg)	82.3 (21.1)	72.0 (16.5)	77.0 (19.4)
Height (m)	1.64 (0.1)	1.63 (0.1)	1.63 (0.1)

The participants ranged from 24 to 60 y and predominantly consisted of females (76.3%). At the beginning of the study, no differences were observed between the intervention and control groups ($p>0.05$), except for stepping in the leisure time (see Table 2), which was 15 min higher in the intervention group ($p=0.038$). At baseline, one participant was underweight, 13 participants were classified as normal weight, 10 participants were overweight, and 14 participants were obese.

Table 2 - Sitting, standing, and stepping at work and leisure, baseline and 6-months, for both groups.

Outcomes	Mean (SD) at Baseline (min)		Mean (SD) at 6 months (min)		p-value	Mean Difference from Baseline to 6 Months (95% CI) (min)			
	CG (n=19)	IG (n=19)	CG (n=19)	IG (n=19)	Time *group	CG (n=19)	Time p-value	IG (n=19)	Time p-value
Sitting time work	332.27 (95.67)	357.18 (79.38)	328.47 (106.39)	324.21 (89.86)	0.083	-3.80 (-16.19 to 23.78)	0.695	-32.97 (-60.97 to -4.98)	**0.024 #**
Standing time work	112.94 (55.79)	113.70 (71.06)	119.97 (85.28)	141.58 (80.76)	0.239	7.03 (-22.14 to 36.20)	0.619	27.88 (5.83 to 49.94)	**0.016 #**
Stepping time work	39.31 (13.17)	40.73 (12.58)	42.60 (25.38)	40.38 (13.21)	0.438	3.29 (-12.34 to 5.77)	0.456	-0.35 (-0.39 to 3.19)	0.839
Sitting leisure	143.60 (78.30)	114.21 (66.13)	156.03 (79.76)	137.28 (60.67)	0.658	12.43 (-26.11 to 50.97)	0.507	23.07 (-8.98 to 55.11)	0.148
Standing leisure	135.42 (56.67)	164.59 (68.27)	116.64 (52.17)	142.66 (58.17)	0.859	-18.78 (-43.55 to 5.98)	0.128	-21.93 (-49.38 to 5.53)	0.111
Stepping leisure	42.17 (19.42)	57.25 **§** (23.47)	44.16 (24.55)	57.78 (20.91)	0.857	1.99 (-9.67 to 13.65)	0.724	0.53 (-11.70 to 12.76)	0.928

CG, Control group; IG, Intervention group

Note: * significant time*group interaction, thus a difference between groups for the changes from baseline to the 6 months. # significant time effect within group. § significant differences between groups at baseline based on the independent sample T-test.

Table 2 shows the time differences observed in the intervention group for ST at work, showing a reduction of 32.97 min/workday ($p=0.024$), and for standing time at work, indicating an increase of 27.88 min/workday ($p=0.016$). The control group had no time differences ($p>0.05$). Despite the differences in the intervention group and the non-significant differences in the control group, there was no time*group interaction effect for the different outcomes ($p>0.05$), neither in the work setting nor in the leisure time. Finally, although non-significant, in the intervention group, we observed an increase in ST of approximately 23 min and a decrease in standing time of about 22 min in the leisure setting, which also happened in the control group in a more attenuated manner, with an increase of 12.43 min in sitting time and a decrease of 18.78 min in standing time in the leisure setting.

Figure 1 shows the inter-individual variability in response to the intervention, both in the work and leisure contexts, for both groups. At the beginning of the intervention, the percentage of ST at work was over 60% for the control and intervention groups, with values of 61.53% and 62.42%, respectively. After 6 months, the control group showed a slight reduction in ST, but the average remained above 60% (60.83%). In contrast, the intervention group showed a more significant reduction, with the average working ST dropping to 57.32%.

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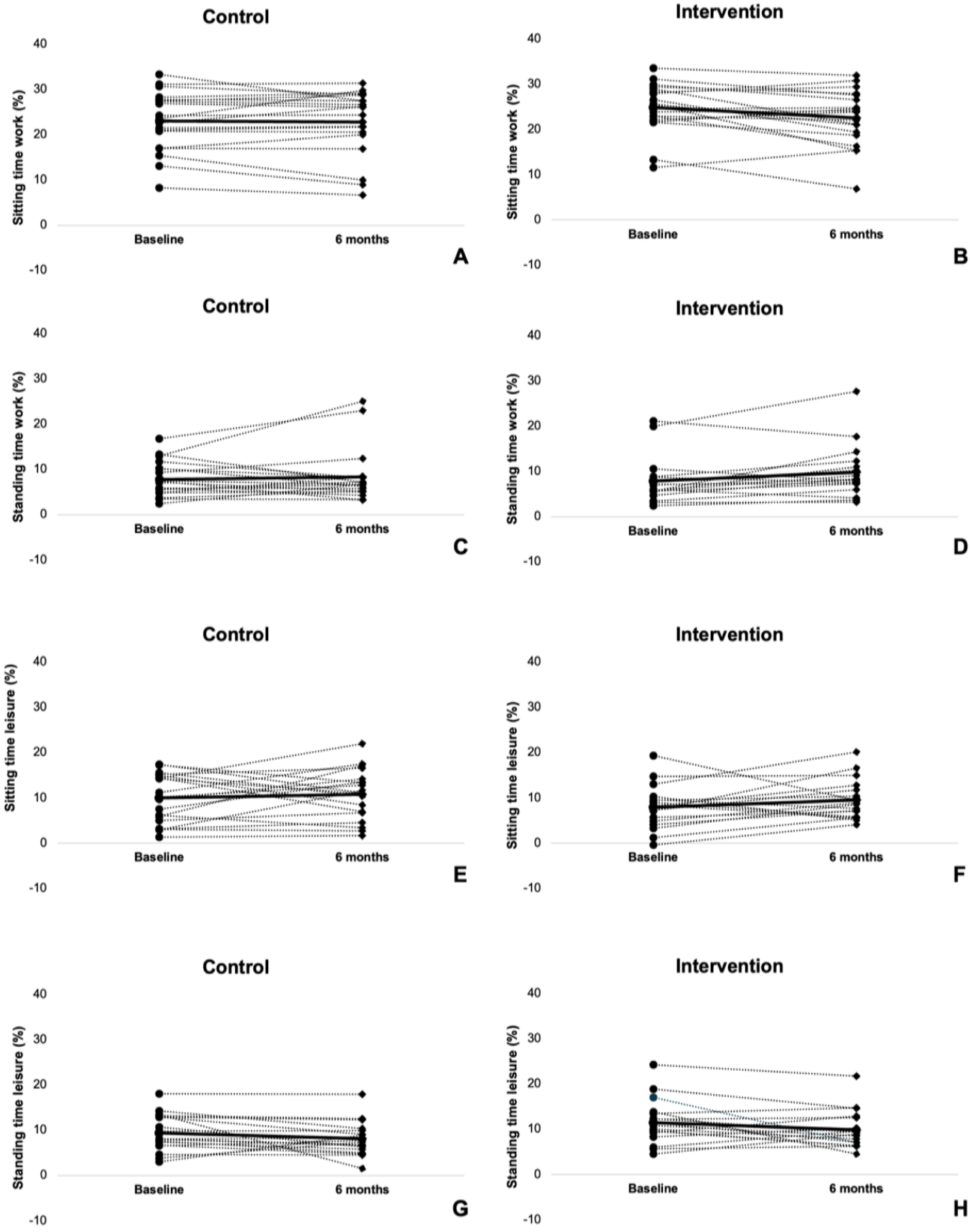

Figure 1 - Sitting and standing times at work and Leisure, measured over 24 hours, at baseline and 6 months, for the control and intervention groups.

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4. Discussion

This study examined the effectiveness of a 6-month SSD intervention in reducing office workers' ST during working hours and in the leisure time. Our results indicated significant reductions in ST and increased standing time at work, only in the intervention group ($p<0.05$). Although no time*group interaction effect was found, there was an approximate difference of 30 minutes per workday between the intervention and control groups, consistent with previous research findings (Dutta et al., 2014; Edwardson et al., 2018). The reduction in ST in the intervention group can be attributed to the combination of SSD with multifaceted strategies, as multicomponent interventions involving SSD seem to consistently reduce ST of office workers (Commissaris et al., 2016; Neuhaus, Eakin, et al., 2014). For example, a systematic review of multicomponent SSD interventions in the workplace supports this observation by reporting an average decrease of 29.96 min/day (Nguyen et al., 2020), which is like the reduction found in our intervention.

Although not statistically significant, an increase in sitting during leisure time was observed in the intervention group (23.07 min). This result aligns with a previous study Mansoubi et al. (2016), which documented an increase in sitting during leisure time 3 months after the implementation of new workstations. Additionally, the control group also experienced a non-significant compensatory increase in ST of 12.43 min during leisure hours, suggesting that both groups adapted their behavior in response to alterations in their daily sitting patterns. Research conducted by Ball et al. (2010) has demonstrated that behavioral changes can be driven by social influences, environmental cues, and the perception of colleagues' behaviors, even without direct intervention. This highlights the critical need to consider leisure activities when evaluating the overall impact of interventions to reduce SB.

The increase in sitting during leisure time is concerning as it can be associated with adverse effects on the well-being of employed adults (Atkin et al., 2012), including increased depressive symptoms, perceived stress, and anxiety (Felez-Nobrega et al., 2020; Werneck et al., 2019). The observed increase in sitting during leisure time may be partially attributed to fatigue or discomfort experienced later in the day, which may have negatively influenced the overall effectiveness of the intervention (Júdice et al., 2024). Stephens et al. (2019) highlighted that the positive impact of interventions were more

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pronounced earlier in the day, with decreasing effects observed as the day progressed, likely due to worker fatigue or muscle discomfort. This pattern is supported by qualitative research, which reveals a preference for standing in the morning that diminishes throughout the day (Henderson et al., 2018). Therefore, fatigue and discomfort later in the day may have played a significant role in the increased ST in the extra-work hours in both the control and intervention groups.

This is not the first time an SSD intervention does not result in an interaction effect between groups. A study by Renaud et al. (2020) did not find a reduction in ST at work from baseline to 4 months. In fact, the difference between the intervention and control groups after 4 months of follow-up was only -16.2 minutes per workday (Renaud et al., 2020). The absence of effects during specific intervention periods can be attributed to the prevalent sitting culture in most office environments (Renaud et al., 2020). A study that combined qualitative and quantitative methods (Graves et al., 2015) found that the social environment, particularly the presence and actions of colleagues, influences workers' behavior regarding standing at work. Seeing colleagues working while standing motivated others to do the same, while some workers mentioned feeling insecure, which led them to remain seated (Graves et al., 2015).

A relevant factor to consider is that the average BMI of participants in both the intervention and control groups at baseline is within the overweight category (28.8 kg/m²). Individuals with overweight or obesity tend to spend more time sitting, which can be partially attributed to difficulties in engaging in more standing time and lower motivation to adopt active behaviors (Bora et al., 2024). However, our sample's BMI varied from 16.28 to 46.63 kg/m², meaning that although the average BMI was within the overweight category, we included participants with normal weight and even underweight, so these results are expected in office workers with normal or underweight body types. Despite this, being sedentary office workers made our sample present a higher percentage of individuals with overweight or obesity (i.e., 63%), which must be recognized as a factor that could have contributed to the lower reduction of ST in the workplace found in the current investigation, in comparison to previous interventions (Edwardson et al., 2018; Healy et al., 2016).

It is important to note that, although there was no time*group interaction in the present study, these results may be relevant for various outcomes. Previous studies have indicated that replacing 30 min of ST with physical activity of any intensity is associated

with a lower risk of several cardiovascular disease indicators and all-cause mortality (Del Pozo-Cruz et al., 2018), as well as lower levels of depressive symptoms (Sadarangani et al., 2023), which can be clinically relevant. Our intervention is consistent with the study conducted by (Edwardson et al., 2018; Healy et al., 2016). With a duration of 6 months, that intervention employed multifaceted organizational, environmental, and individual strategies and reduced ST during working hours by 68.34 min/workday. However, the study also revealed an increase in ST during leisure periods of 25.96 min/day, thus corroborating our results and suggesting that when office workers reduce their ST at work, some compensation seems to occur in the leisure time, by increasing this behavior. Thus, we believe that, besides the accumulated fatigue or discomfort throughout the day, the lower effectiveness of some SSD interventions may also be explained by a psychological mechanism, in which some individuals rely on the reduction they attained during the work shift and compensate by being more sedentary in the extra-work setting.

As depicted in Figure 1, although some individuals showed a reduction in ST while at work, there were cases of increasing ST at work from baseline to the end of the intervention. Additionally, variability in standing time was also observed, further highlighting the differential impact of the intervention across participants. Previous studies usually report the mean and standard deviation of a group but showing the individual heterogeneity in the response to this type of intervention is paramount, so that future studies can focus on the individual response to SSD interventions and explore potential mediators of effectiveness. In this way, one must tailor the best strategy that can be applied to each office worker. Further studies on this issue are needed to verify participant variability in response to SSD-based interventions.

These findings underscore the importance of extending behavioral interventions beyond the workplace to achieve sustained reductions in SB. Educating individuals about the long-term benefits of reducing SB and providing tools like activity trackers during leisure time can further enhance intervention effectiveness (Arguello et al., 2021).

4.1. Strengths and Limitations

The study presented several strengths. Firstly, randomizing participants into clusters minimized the risk of contamination between groups, ensuring greater internal validity of the study. Secondly, physical behaviors were objectively measured using ActivPAL4 activity monitors, providing precise and reliable data on sitting, standing, and

stepping times. The intervention included an initial psychoeducational session and continuous motivational stimuli to promote sustained behavioral change.

However, the study also had some limitations. The study population was predominantly female, which may limit the applicability of the results to a more gender-balanced or male-dominated workforce. Additionally, the 6-month follow-up period, while helpful in assessing initial changes, may not be sufficient to evaluate the long-term sustainability of the observed behavioral changes. Another point is that, although the sample included underweighted, normal weighted, and overweighted office workers, the sample size prevents secondary analysis depicting the results amongst groups based on this feature, and naturally we had a higher percentage of our sample with overweight or obesity. Finally, despite the clinical meaningfulness of some of our findings, the lack of significant results (e.g., no time*group interaction effect) must be recognized as a limitation regarding the sample size, as a higher number of participants could have diluted the large variability amongst participants in response to the intervention. Future studies including larger sample sizes, may explore the weight category as a potential mediator of effectiveness to the SSD-based interventions.

4.2. Implications for Practice

To optimize interventions aiming to reduce ST and promote standing, it is essential to extend these actions beyond the workplace. Encouraging exercise during leisure time can be facilitated through wellness programs, such as walking challenges, which help integrate light intensity physical activity into employees' daily routines.

5. Conclusion

We demonstrated that a 6-month intervention using an SSD significantly reduced office workers' ST while increasing standing time during working hours. However, these findings underscore the potential compensatory behaviors that may also exist amongst participants (i.e., increasing ST and reducing standing time in the leisure time) that researchers must be aware of, even for an accurate assessment of the actual changes in physical behaviors. We highlighted that considering a 24h period may not translate the modifications that genuinely occurred(Júdice et al., 2024). Finally, extending behavioral strategies beyond the workplace to maximize health benefits in future interventions is crucial. Further research is needed to assess the long-term sustainability of SSD

interventions in different occupational contexts and to explore their scalability in diverse settings. These efforts are essential for promoting healthier workplaces and reducing the global impact of non-communicable diseases.

6. References

Alkhajah, T. A., Reeves, M. M., Eakin, E. G., Winkler, E. A., Owen, N., & Healy, G. N. (2012). Sit-stand workstations: a pilot intervention to reduce office sitting time. *Am J Prev Med*, *43*(3), 298-303. https://doi.org/10.1016/j.amepre.2012.05.027

Andersen, L. L., Fallentin, N., Thorsen, S. V., & Holtermann, A. (2016). Physical workload and risk of long-term sickness absence in the general working population and among blue-collar workers: prospective cohort study with register follow-up. *Occup Environ Med*, *73*(4), 246-253. https://doi.org/10.1136/oemed-2015-103314

Arguello, D., Thorndike, A. N., Cloutier, G., Morton, A., Castaneda-Sceppa, C., & John, D. (2021). Effects of an "Active-Workstation" Cluster RCT on Daily Waking Physical Behaviors. *Med Sci Sports Exerc*, *53*(7), 1434-1445. https://doi.org/10.1249/MSS.0000000000002594

Atkin, A. J., Adams, E., Bull, F. C., & Biddle, S. J. (2012). Non-occupational sitting and mental well-being in employed adults. *Ann Behav Med*, *43*(2), 181-188. https://doi.org/10.1007/s12160-011-9320-y

Balducci, S., D'Errico, V., Haxhi, J., Sacchetti, M., Orlando, G., Cardelli, P.,…Investigators, I. D. a. E. S. I. (2019). Effect of a Behavioral Intervention Strategy on Sustained Change in Physical Activity and Sedentary Behavior in Patients With Type 2 Diabetes: The IDES_2 Randomized Clinical Trial. *JAMA*, *321*(9), 880-890. https://doi.org/10.1001/jama.2019.0922

Ball, K., Jeffery, R. W., Abbott, G., McNaughton, S. A., & Crawford, D. (2010). Is healthy behavior contagious: associations of social norms with physical activity and healthy eating. *Int J Behav Nutr Phys Act*, *7*, 86. https://doi.org/10.1186/1479-5868-7-86

Biddle, S. J. H., O'Connell, S. E., Davies, M. J., Dunstan, D., Edwardson, C. L., Esliger, D. W.,…Munir, F. (2020). Reducing sitting at work: process evaluation of the SMArT Work (Stand More At Work) intervention. *Trials*, *21*(1), 403. https://doi.org/10.1186/s13063-020-04300-7

Blackburn, N. E., Wilson, J. J., McMullan, I. I., Caserotti, P., Giné-Garriga, M., Wirth, K.,…Tully, M. A. (2020). The effectiveness and complexity of interventions targeting sedentary behaviour across the lifespan: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*, *17*(1), 53. https://doi.org/10.1186/s12966-020-00957-0

Bora, N., K, V., Verma, A., Bharti, A. K., & Sinha, M. K. (2024). Physical activity and sedentary behavior perceptions in overweight and obese adults: A systematic review of qualitative study. *F1000Res*, *13*, 787. https://doi.org/10.12688/f1000research.152905.1

Brierley, M. L., Smith, L. R., Bailey, D. P., Ojo, S. O., Hewson, D. J., Every, S. A.,…Chater, A. M. (2022). Evaluating a multi-component intervention to reduce and break up office workers' sitting with sit-stand desks using the APEASE criteria. *BMC Public Health*, *22*(1), 458.

Buckley, J. P., Hedge, A., Yates, T., Copeland, R. J., Loosemore, M., Hamer, M.,…Dunstan, D. W. (2015). The sedentary office: an expert statement on the growing case for change towards better health and productivity. *Br J Sports Med*, *49*(21), 1357-1362. https://doi.org/10.1136/bjsports-2015-094618

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G.,…Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. https://doi.org/10.1136/bjsports-2020-102955

Cao, C., Friedenreich, C. M., & Yang, L. (2022). Association of Daily Sitting Time and Leisure Time Physical Activity With Survival Among US Cancer Survivors. *JAMA Oncol*, *8*(3), 395-403. https://doi.org/10.1001/jamaoncol.2021.6590

Chan, C. B., & Ryan, D. A. (2009). Assessing the effects of weather conditions on physical activity participation using objective measures. *Int J Environ Res Public Health*, *6*(10), 2639-2654. https://doi.org/10.3390/ijerph6102639

Chau, J. Y., Daley, M., Dunn, S., Srinivasan, A., Do, A., Bauman, A. E., & van der Ploeg, H. P. (2014). The effectiveness of sit-stand workstations for changing office workers' sitting time: results from the Stand@Work randomized controlled trial pilot. *Int J Behav Nutr Phys Act*, *11*, 127. https://doi.org/10.1186/s12966-014-0127-7

Chau, J. Y., van der Ploeg, H. P., Merom, D., Chey, T., & Bauman, A. E. (2012). Cross-sectional associations between occupational and leisure time sitting, physical activity and obesity in working adults. *Prev Med*, *54*(3-4), 195-200. https://doi.org/10.1016/j.ypmed.2011.12.020

Coenen, P., van der Molen, H. F., Burdorf, A., Huysmans, M. A., Straker, L., Frings-Dresen, M. H., & van der Beek, A. J. (2019). Associations of screen work with neck and upper extremity symptoms: a systematic review with meta-analysis. *Occup Environ Med*, *76*(7), 502-509. https://doi.org/10.1136/oemed-2018-105553

Commissaris, D. A. C. M., Huysmans, M. A., Mathiassen, S. E., Srinivasan, D., Koppes, L. L. J., & Hendriksen, I. J. M. (2016). Interventions to reduce sedentary behavior and increase physical activity during productive work: a systematic review. *Scand J Work Environ Health*, *42*(3), 181-191. https://doi.org/10.5271/sjweh.3544

Danquah, I. H., Kloster, S., Holtermann, A., Aadahl, M., Bauman, A., Ersbøll, A. K., & Tolstrup, J. S. (2017). Take a Stand!-a multi-component intervention aimed at reducing sitting time among office workers-a cluster randomized trial. *Int J Epidemiol*, *46*(1), 128-140. https://doi.org/10.1093/ije/dyw009

Del Pozo-Cruz, J., García-Hermoso, A., Alfonso-Rosa, R. M., Alvarez-Barbosa, F., Owen, N., Chastin, S., & Del Pozo-Cruz, B. (2018). Replacing Sedentary Time: Meta-analysis of Objective-Assessment Studies. *Am J Prev Med*, *55*(3), 395-402. https://doi.org/10.1016/j.amepre.2018.04.042

Dupont, F., Léger, P. M., Begon, M., Lecot, F., Sénécal, S., Labonté-Lemoyne, E., & Mathieu, M. E. (2019). Health and productivity at work: which active workstation for which benefits: a systematic review. *Occup Environ Med*, *76*(5), 281-294. https://doi.org/10.1136/oemed-2018-105397

Dutta, N., Koepp, G. A., Stovitz, S. D., Levine, J. A., & Pereira, M. A. (2014). Using sit-stand workstations to decrease sedentary time in office workers: a randomized crossover trial. *Int J Environ Res Public Health*, *11*(7), 6653-6665. https://doi.org/10.3390/ijerph110706653

E F Graves, L., C Murphy, R., Shepherd, S. O., Cabot, J., & Hopkins, N. D. (2015). Evaluation of sit-stand workstations in an office setting: a randomised controlled trial. *BMC Public Health*, *15*, 1145. https://doi.org/10.1186/s12889-015-2469-8

Edwardson, C. L., Biddle, S. J. H., Clemes, S. A., Davies, M. J., Dunstan, D. W., Eborall, H.,…Clarke-Cornwell, A. M. (2022). Effectiveness of an intervention for reducing sitting time and improving health in office workers: three arm cluster randomised controlled trial. *Bmj*, *378*, e069288. https://doi.org/10.1136/bmj-2021-069288

Edwardson, C. L., Yates, T., Biddle, S. J. H., Davies, M. J., Dunstan, D. W., Esliger, D. W.,…Munir, F. (2018). Effectiveness of the Stand More AT (SMArT) Work intervention: cluster randomised controlled trial. *BMJ*, *363*, k3870. https://doi.org/10.1136/bmj.k3870

Ekelund, U., Brown, W. J., Steene-Johannessen, J., Fagerland, M. W., Owen, N., Powell, K. E.,…Lee, I. M. (2019). Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants. *Br J Sports Med*, *53*(14), 886-894. https://doi.org/10.1136/bjsports-2017-098963

Ekelund, U., Tarp, J., Steene-Johannessen, J., Hansen, B. H., Jefferis, B., Fagerland, M. W.,…Lee, I. M. (2019). Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis. *BMJ*, *366*, l4570. https://doi.org/10.1136/bmj.l4570

Felez-Nobrega, M., Bort-Roig, J., Briones, L., Sanchez-Niubo, A., Koyanagi, A., Puigoriol, E., & Puig-Ribera, A. (2020). Self-reported and activPAL. *J Sports Sci*, *38*(13), 1566-1574. https://doi.org/10.1080/02640414.2020.1748359

Gao, Z., & Lee, J. E. (2022). Promoting Physical Activity and Reducing Sedentary Behavior to Prevent Chronic Diseases during the COVID Pandemic and Beyond. *J Clin Med*, *11*(16). https://doi.org/10.3390/jcm11164666

Gilson, N. D., Burton, N. W., van Uffelen, J. G., & Brown, W. J. (2011). Occupational sitting time: employees' perceptions of health risks and intervention strategies. *Health Promot J Austr*, *22*(1), 38-43. https://doi.org/10.1071/he11038

Grunseit, A. C., Chau, J. Y., van der Ploeg, H. P., & Bauman, A. (2013). "Thinking on your feet": A qualitative evaluation of sit-stand desks in an Australian workplace. *BMC Public Health*, *13*, 365. https://doi.org/10.1186/1471-2458-13-365

*Silva, H., Teno, S. C., & Júdice, P. B. (2024). Are there compensatory behaviors in response to a sit-stand desk intervention? *Journal of occupational health*, *66*(1), uiae067. https://doi.org/10.1093/joccuh/uiae067.

Hadgraft, N. T., Healy, G. N., Owen, N., Winkler, E. A., Lynch, B. M., Sethi, P.,…Dunstan, D. W. (2016). Office workers' objectively assessed total and prolonged sitting time: Individual-level correlates and worksite variations. *Prev Med Rep*, *4*, 184-191. https://doi.org/10.1016/j.pmedr.2016.06.011

Healy, G. N., Eakin, E. G., Owen, N., Lamontagne, A. D., Moodie, M., Winkler, E. A.,…Dunstan, D. W. (2016). A Cluster Randomized Controlled Trial to Reduce Office Workers' Sitting Time: Effect on Activity Outcomes. *Med Sci Sports Exerc*, *48*(9), 1787-1797. https://doi.org/10.1249/MSS.0000000000000972

Henderson, B., Stuckey, R., & Keegel, T. (2018). Current and ceased users of sit stand workstations: a qualitative evaluation of ergonomics, safety and health factors within a workplace setting. *BMC Public Health*, *18*(1), 1374. https://doi.org/10.1186/s12889-018-6296-6

Hergenroeder, A., Quinn, T. D., Perdomo, S. J., Kline, C. E., & Gibbs, B. B. (2022). Effect of a 6-month sedentary behavior reduction intervention on well-being and workplace health in desk workers with low back pain. *Work*, *71*(4), 1145-1155. https://doi.org/10.3233/WOR-205178

Ishii, K., Shibata, A., & Oka, K. (2018). Work Engagement, Productivity, and Self-Reported Work-Related Sedentary Behavior Among Japanese Adults: A Cross-Sectional Study. *J Occup Environ Med*, *60*(4), e173-e177. https://doi.org/10.1097/JOM.0000000000001270

Jochem, C., Wallmann-Sperlich, B., & Leitzmann, M. F. (2019). The Influence of Sedentary Behavior on Cancer Risk: Epidemiologic Evidence and Potential Molecular Mechanisms. *Curr Nutr Rep*, *8*(3), 167-174. https://doi.org/10.1007/s13668-019-0263-4

Júdice, P. B., Silva, H., Teno, S. C., & Hetherington-Rauth, M. (2024). The effectiveness of a 6-month intervention with sit-stand workstation in office workers: Results from the SUFHA cluster randomized controlled trial. *Work*. https://doi.org/10.3233/WOR-230624

Júdice, P. B., Silva, H., Teno, S. C., Monteiro, P., Silva, M. N., Carraça, E. V.,…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

*Silva, H., Teno, S. C., & Júdice, P. B. (2024). Are there compensatory behaviors in response to a sit-stand desk intervention? *Journal of occupational health*, *66*(1), uiae067. https://doi.org/10.1093/joccuh/uiae067.

Júdice, P. B., Sousa-Sá, E., & Palmeira, A. L. (2023). Discrepancies Between Self-reported and Objectively Measured Smartphone Screen Time: Before and During Lockdown. *J Prev (2022)*, *44*(3), 291-307. https://doi.org/10.1007/s10935-023-00724-4

Kazi, A., Haslam, C., Duncan, M., Clemes, S., & Twumasi, R. (2019). Sedentary behaviour and health at work: an investigation of industrial sector, job role, gender and geographical differences. *Ergonomics*, *62*(1), 21-30. https://doi.org/10.1080/00140139.2018.1489981

Keown, M. K., Skeaff, C. M., Perry, T. L., Haszard, J. J., & Peddie, M. C. (2018). Device-Measured Sedentary Behavior Patterns in Office-Based University Employees. *J Occup Environ Med*, *60*(12), 1150-1157. https://doi.org/10.1097/JOM.0000000000001467

Kikuchi, H., Inoue, S., Sugiyama, T., Owen, N., Oka, K., Nakaya, T., & Shimomitsu, T. (2014). Distinct associations of different sedentary behaviors with health-related attributes among older adults. *Prev Med*, *67*, 335-339. https://doi.org/10.1016/j.ypmed.2014.08.011

Landais, L. L., Jelsma, J. G. M., Dotinga, I. R., Timmermans, D. R. M., Verhagen, E. A. L. M., & Damman, O. C. (2022). Office workers' perspectives on physical activity and sedentary behaviour: a qualitative study. *BMC Public Health*, *22*(1), 621. https://doi.org/10.1186/s12889-022-13024-z

Liu, S. H., Eaton, C. B., Driban, J. B., McAlindon, T. E., & Lapane, K. L. (2016). Comparison of self-report and objective measures of physical activity in US adults with osteoarthritis. In *Rheumatol Int* (Vol. 36, pp. 1355-1364). https://doi.org/10.1007/s00296-016-3537-9

Ma, J., Ma, D., Li, Z., & Kim, H. (2021). Effects of a Workplace Sit-Stand Desk Intervention on Health and Productivity. *Int J Environ Res Public Health*, *18*(21). https://doi.org/10.3390/ijerph182111604

MacEwen, B. T., Saunders, T. J., MacDonald, D. J., & Burr, J. F. (2017). Sit-Stand Desks To Reduce Workplace Sitting Time In Office Workers With Abdominal Obesity: A Randomized Controlled Trial. *J Phys Act Health*, *14*(9), 710-715. https://doi.org/10.1123/jpah.2016-0384

Mansfeldt, J. M., & Magkos, F. (2023). Compensatory Responses to Exercise Training As Barriers to Weight Loss: Changes in Energy Intake and Non-exercise

Physical Activity. *Curr Nutr Rep*, *12*(2), 327-337. https://doi.org/10.1007/s13668-023-00467-y

Mansoubi, M., Pearson, N., Biddle, S. J., & Clemes, S. A. (2016). Using Sit-to-Stand Workstations in Offices: Is There a Compensation Effect? *Med Sci Sports Exerc*, *48*(4), 720-725. https://doi.org/10.1249/MSS.0000000000000802

Martinez-Gomez, D., Guallar-Castillon, P., Leon-Munoz, L. M., Lopez-Garcia, E., & Rodriguez-Artalejo, F. (2013). Combined impact of traditional and non-traditional health behaviors on mortality: a national prospective cohort study in Spanish older adults. *BMC Med*, *11*, 47. https://doi.org/10.1186/1741-7015-11-47

Matthews, C. E., Moore, S. C., Sampson, J., Blair, A., Xiao, Q., Keadle, S. K.,…Park, Y. (2015). Mortality Benefits for Replacing Sitting Time with Different Physical Activities. *Med Sci Sports Exerc*, *47*(9), 1833-1840. https://doi.org/10.1249/mss.0000000000000621

Mielke, G. I., da Silva, I. C., Owen, N., & Hallal, P. C. (2014). Brazilian adults' sedentary behaviors by life domain: population-based study. *PLoS One*, *9*(3), e91614. https://doi.org/10.1371/journal.pone.0091614

Mitchell, M. S., Goodman, J. M., Alter, D. A., John, L. K., Oh, P. I., Pakosh, M. T., & Faulkner, G. E. (2013). Financial incentives for exercise adherence in adults: systematic review and meta-analysis. *Am J Prev Med*, *45*(5), 658-667. https://doi.org/10.1016/j.amepre.2013.06.017

Nelson-Wong, E., Corrigan, J., Mertz, P., Kutcher, S., Carlson, I., DiRocco, T., & Hall-Nelson, B. (2021). Office-workers maintain decreased workplace sitting time long-term following participation in a sit-stand desk intervention study. *Ergonomics*, 1-9. https://doi.org/10.1080/00140139.2021.1998647

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

Neuhaus, M., Healy, G. N., Dunstan, D. W., Owen, N., & Eakin, E. G. (2014). Workplace sitting and height-adjustable workstations: a randomized controlled trial. *Am J Prev Med*, *46*(1), 30-40. https://doi.org/10.1016/j.amepre.2013.09.009

Ng, J. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Duda, J. L., & Williams, G. C. (2012). Self-Determination Theory Applied to Health Contexts: A Meta-Analysis. *Perspect Psychol Sci*, *7*(4), 325-340. https://doi.org/10.1177/1745691612447309

Nguyen, P., Le, L. K., Nguyen, D., Gao, L., Dunstan, D. W., & Moodie, M. (2020). The effectiveness of sedentary behaviour interventions on sitting time and screen time in children and adults: an umbrella review of systematic reviews. *Int J Behav Nutr Phys Act*, *17*(1), 117. https://doi.org/10.1186/s12966-020-01009-3

Organization, W. H. (2018). G*lobal action plan on physical activity 2018-2030: more active people for a healthier world*. In (World Health Organization ed.).

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D.,…Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. https://doi.org/10.1136/bmj.n71

Parry, S. P., Coenen, P., Shrestha, N., O'Sullivan, P. B., Maher, C. G., & Straker, L. M. (2019). Workplace interventions for increasing standing or walking for decreasing musculoskeletal symptoms in sedentary workers. *Cochrane Database Syst Rev*, *2019*(11). https://doi.org/10.1002/14651858.CD012487.pub2

Patterson, R., McNamara, E., Tainio, M., de Sá, T. H., Smith, A. D., Sharp, S. J.,…Wijndaele, K. (2018). Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *Eur J Epidemiol*, *33*(9), 811-829. https://doi.org/10.1007/s10654-018-0380-1

Pereira, M. A., Mullane, S. L., Toledo, M. J. L., Larouche, M. L., Rydell, S. A., Vuong, B.,…Buman, M. P. (2020). Efficacy of the 'Stand and Move at Work' multicomponent workplace intervention to reduce sedentary time and improve cardiometabolic risk: a group randomized clinical trial. *Int J Behav Nutr Phys Act*, *17*(1), 133. https://doi.org/10.1186/s12966-020-01033-3

Prince, S. A., Elliott, C. G., Scott, K., Visintini, S., & Reed, J. L. (2019). Device-measured physical activity, sedentary behaviour and cardiometabolic health and fitness across occupational groups: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*, *16*(1), 30. https://doi.org/10.1186/s12966-019-0790-9

Renaud, L. R., Jelsma, J. G. M., Huysmans, M. A., van Nassau, F., Lakerveld, J., Speklé, E. M.,…van der Ploeg, H. P. (2020). Effectiveness of the multi-

component dynamic work intervention to reduce sitting time in office workers - Results from a pragmatic cluster randomised controlled trial. *Appl Ergon*, *84*, 103027. https://doi.org/10.1016/j.apergo.2019.103027

Rhodes, R. E., Janssen, I., Bredin, S. S. D., Warburton, D. E. R., & Bauman, A. (2017). Physical activity: Health impact, prevalence, correlates and interventions. *Psychol Health*, *32*(8), 942-975. https://doi.org/10.1080/08870446.2017.1325486

Rosenkranz, S. K., Mailey, E. L., Umansky, E., Rosenkranz, R. R., & Ablah, E. (2020). Workplace Sedentary Behavior and Productivity: A Cross-Sectional Study. *Int J Environ Res Public Health*, *17*(18). https://doi.org/10.3390/ijerph17186535

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol*, *55*(1), 68-78. https://doi.org/10.1037//0003-066x.55.1.68

Sadarangani, K. P., Schuch, F. B., De Roia, G., Martínez-Gomez, D., Chávez, R., Lobo, P.,…Meyer, J. (2023). Exchanging screen for non-screen sitting time or physical activity might attenuate depression and anxiety: A cross-sectional isotemporal analysis during early pandemics in South America. *J Sci Med Sport*, *26*(6), 309-315. https://doi.org/10.1016/j.jsams.2023.04.007

Santos, A. C., Willumsen, J., Meheus, F., Ilbawi, A., & Bull, F. C. (2023). The cost of inaction on physical inactivity to public health-care systems: a population-attributable fraction analysis. *Lancet Glob Health*, *11*(1), e32-e39. https://doi.org/10.1016/S2214-109X(22)00464-8

Schwartz, B., Kapellusch, J. M., Baca, A., & Wessner, B. (2019). Medium-term effects of a two-desk sit/stand workstation on cognitive performance and workload for healthy people performing sedentary work: a secondary analysis of a randomised controlled trial. *Ergonomics*, *62*(6), 794-810. https://doi.org/10.1080/00140139.2019.1577497

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. *Hum Factors*, *61*(5), 816-824. https://doi.org/10.1177/0018720818807043

Shrestha, B., & Dunn, L. (2020). The Declaration of Helsinki on Medical Research involving Human Subjects: A Review of Seventh Revision. *J Nepal Health Res Counc*, *17*(4), 548-552. https://doi.org/10.33314/jnhrc.v17i4.1042

Shrestha, N., Grgic, J., Wiesner, G., Parker, A., Podnar, H., Bennie, J. A.,…Pedisic, Z. (2019). Effectiveness of interventions for reducing non-occupational sedentary behaviour in adults and older adults: a systematic review and meta-analysis. *Br J Sports Med*, *53*(19), 1206-1213. https://doi.org/10.1136/bjsports-2017-098270

Shrestha, N., Ijaz, S., Kukkonen-Harjula, K. T., Kumar, S., & Nwankwo, C. P. (2015). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *1*, Cd010912. https://doi.org/10.1002/14651858.CD010912.pub2

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Pedisic, Z. (2018). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *6*(6), Cd010912. https://doi.org/10.1002/14651858.CD010912.pub4

Silva, H., G F Ramos, P., Teno, S. C., & Júdice, P. B. (2024). Impact of a 6-month sit-stand desk-based intervention on regional musculoskeletal discomfort and overall post-work fatigue in office workers: a cluster randomised controlled trial. *Ergonomics*, 1-14. https://doi.org/10.1080/00140139.2024.2414197

Silva, H., Ramos, P. G. F., Teno, S. C., & Júdice, P. B. (2024). The Impact of Sit-Stand Desks on Full-Day and Work-Based Sedentary Behavior of Office Workers: A Systematic Review. *Hum Factors*, 187208241305591. https://doi.org/10.1177/00187208241305591

Silva, H., Teno, S. C., & Júdice, P. B. (2024). Are there compensatory behaviors in response to a sit-stand desk intervention? *J Occup Health*. https://doi.org/10.1093/joccuh/uiae067

Stephens, S. K., Eakin, E. G., Clark, B. K., Winkler, E. A. H., Owen, N., LaMontagne, A. D.,…Healy, G. N. (2018). What strategies do desk-based workers choose to reduce sitting time and how well do they work? Findings from a cluster randomised controlled trial. *Int J Behav Nutr Phys Act*, *15*(1), 98. https://doi.org/10.1186/s12966-018-0731-z

Stephens, S. K., Winkler, E. A. H., Eakin, E. G., Clark, B. K., Owen, N., Moodie, M.,…Healy, G. N. (2019). Temporal features of sitting, standing and stepping changes in a cluster-randomised controlled trial of a workplace sitting-reduction

intervention. *Int J Behav Nutr Phys Act*, *16*(1), 111. https://doi.org/10.1186/s12966-019-0879-1

Sugiyama, T., Hadgraft, N., Clark, B. K., Dunstan, D. W., & Owen, N. (2020). Sitting at work & waist circumference-A cross-sectional study of Australian workers. *Prev Med*, *141*, 106243. https://doi.org/10.1016/j.ypmed.2020.106243

Teno, S. C., Silva, M. N., & Júdice, P. B. (2024). Physical activity and sedentary behaviour-specific domains and their associations with mental health in adults: a systematic review. . In (pp. 1–28): A*dvances in Mental Health*.

Thomas, B. H., Ciliska, D., Dobbins, M., & Micucci, S. (2004). A process for systematically reviewing the literature: providing the research evidence for public health nursing interventions. *Worldviews Evid Based Nurs*, *1*(3), 176-184. https://doi.org/10.1111/j.1524-475X.2004.04006.x

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E.,…Participants, S. T. C. P. (2017). Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. *Int J Behav Nutr Phys Act*, *14*(1), 75. https://doi.org/10.1186/s12966-017-0525-8

Tremblay, M. S., Colley, R. C., Saunders, T. J., Healy, G. N., & Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Appl Physiol Nutr Metab*, *35*(6), 725-740. https://doi.org/10.1139/H10-079

Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: a systematic review. *Public Health*, *121*(12), 909-922. https://doi.org/10.1016/j.puhe.2007.04.009

Turrisi, T. B., Bittel, K. M., West, A. B., Hojjatinia, S., Mama, S. K., Lagoa, C. M., & Conroy, D. E. (2021). Seasons, weather, and device-measured movement behaviors: a scoping review from 2006 to 2020. *Int J Behav Nutr Phys Act*, *18*(1), 24. https://doi.org/10.1186/s12966-021-01091-1

van Dommelen, P., Coffeng, J. K., van der Ploeg, H. P., van der Beek, A. J., Boot, C. R., & Hendriksen, I. J. (2016). Objectively Measured Total and Occupational Sedentary Time in Three Work Settings. *PLoS One*, *11*(3), e0149951. https://doi.org/10.1371/journal.pone.0149951

Waters, C. N., Ling, E. P., Chu, A. H., Ng, S. H., Chia, A., Lim, Y. W., & Müller-Riemenschneider, F. (2016). Assessing and understanding sedentary behaviour

in office-based working adults: a mixed-method approach. *BMC Public Health*, *16*, 360. https://doi.org/10.1186/s12889-016-3023-z

Werneck, A. O., Stubbs, B., Fernandes, R. A., Szwarcwald, C. L., & Silva, D. R. (2019). Leisure time physical activity reduces the association between TV-viewing and depressive symptoms: A large study among 59,401 Brazilian adults. *J Affect Disord*, *252*, 310-314. https://doi.org/10.1016/j.jad.2019.03.066

Zhou, L., Deng, X., Xu, M., Wu, Y., Shang, X., E, F.,…Li, X. (2023). The effects of active workstations on reducing work-specific sedentary time in office workers: a network meta-analysis of 23 randomized controlled trials. *Int J Behav Nutr Phys Act*, *20*(1), 92. https://doi.org/10.1186/s12966-023-01467-5

*Silva, H., Teno, S. C., & Júdice, P. B. (2024). Are there compensatory behaviors in response to a sit-stand desk intervention? *Journal of occupational health*, *66*(1), uiae067. https://doi.org/10.1093/joccuh/uiae067.

Chapter V

Study 3: Psychoeducational session impact on three-month SSD Intervention

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A mente que se abre a uma nova ideia jamais volta ao seu tamanho original.

Albert Einstein

Chapter V

How can a psychoeducational session alter the results for a 3-month sit-stand desk-based intervention? Secondary analysis from SUFHA. *

Abstract

Purpose: Compare the effectiveness of a 3-month sit-stand desk (SSD) intervention preceded by one psychoeducational-session (PE-0), against a group that used the SSD for 3-months but had the psychoeducational session 6-months earlier (PE-6).

Method: A two-arm (1:1) cluster randomized trial with 20 office workers. Outcomes were measured via ActivPAL4®-inclinometer. Repeated-measures ANCOVA analyzed group differences, adjusting for several covariates, with significance at 5%.

Results: A time*group interaction for sitting-time (ST) (p=0.006) was found, where PE-0 (N=10; 48.5±5.7y) reduced ST by 44.20min/day, while the PE-6 (N=10; 45.8±9.4y) reduced ST by 33.20min/day. A significant time*group interaction was also found for prolonged-ST (p=0.040), with the PE-0 reducing by 27.60min/day, while the PE-6 only reduced by 5.70min/day.

Conclusion: When the aim is to increase standing-time and reduce prolonged-ST, having the psychoeducational-session right before the intervention may potentiate the intervention.

Keywords: informative session; office workers; sedentary behavior; sitting time; standing time.

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1. Introduction

Prolonged periods of sitting time (ST) are linked to an increased risk of various health issues including type 2 diabetes, cardiovascular diseases, and early mortality (Ekelund, Brown, et al., 2019; Prince, Reid, et al., 2019; Stamatakis et al., 2019). Office workers spend about two thirds of their day seated, often engaged in long and uninterrupted bouts (Clemes et al., 2014; Parry & Straker, 2013; Thorp et al., 2012). Interventions have been developed to reduce ST in the workplace (Blackburn et al., 2020; Shrestha et al., 2018), particularly targeting extended periods of ST (Chu et al., 2016).

Recent evidence suggests that modifying the physical environment, mainly through active workstations, is the most effective approach to reduce ST in the office setting (Lam et al., 2022; Nguyen et al., 2020). Sit-stand desks (SSD), which are adjustable desks allowing both sitting and standing while working, have emerged as a promising strategy to reduce ST and increase standing time among office workers, without compromising work productivity (Grunseit et al., 2013; Shrestha & Dunn, 2020; Zhou et al., 2023). A systematic review indicated that providing workers with SSD can reduce ST by 33 to 137 minutes per eight-hour workday (Shrestha et al., 2016). Previous interventions have combined the introduction of SSD with frequent prompts and mostly kicked of with an initial psychoeducational session to enhance knowledge of the participants and boost effectiveness (Edwardson et al., 2022; Pereira et al., 2020; Shrestha et al., 2016).

These sessions combine educational and psychological elements to increase participants' knowledge and awareness of specific health and behavior topics (Júdice et al., 2023). Often implemented as educational seminars, these approaches have proven effective in facilitating behavior change in various contexts (Biddle et al., 2020). In a study by Biddle et al. (2020), most participants reported that the seminars significantly raised their awareness for the negative health consequences of excessive ST. In addition to providing information, these seminars motivate individuals to adopt healthier behaviors, encouraging proactive changes in their daily routines (Gao & Lee, 2022).

Considering the high prevalence of ST during office workers' waking hours (Bennie et al., 2015; Colley et al., 2011), and given the lack of investigation on the isolated impact that a psychoeducational session can present on boosting the effectiveness for this type of intervention, our goal was to compare the effectiveness of a 3-month SSD intervention preceded by a psychoeducational session, in relation to another group that

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also used the same SSD for 3 months but had the psychoeducational session 6 months before receiving the SSD, thus allowing to somehow isolate the additional impact of this session on the SSD-based intervention.

2. Method

2.1. Study design

The original study followed the CONSORT guidelines for cluster randomized clinical trials and it was structured as a two-arm (1:1) parallel randomized controlled trial with a 6-month duration. The complete protocol has been published previously for detailed reference (Júdice et al., 2023). After the initial assessments, cluster randomization was executed using a random list generator (www.random.org) by a researcher not involved in recruitment or data collection. Randomization used different locations as units to minimize contamination risks. To ensure balance between the original waiting-list control group and the intervention group, stratified randomization accounted for critical factors, such as daily ST, frequency of sit-to-stand transitions, body mass index (BMI), age, and gender distribution (Júdice et al., 2023). Participant allocation was communicated via email following the baseline evaluations to all the participants. Recruitment occurred between December 2022 and January 2023, with baseline data collected in February 2023.

This research represents a secondary analysis of the original study, focusing specifically on data collected at the end of the first 3 months of SSD usage, within a subsample of participants from both the original groups, that were randomly contacted and that accepted to participate in this time-point assessment.

In the current study, participants were divided into two subgroups: the PE-0 group, which began using the SSD immediately after attending the psychoeducational session, and the PE-6 group, which started using the SSD 6 months after the psychoeducational session. The PE-6 group was assigned to a delayed intervention condition, as participants were originally from a waiting-list control group. The delayed condition is a key element of the original study design that allows for a more comprehensive understanding of the impact that different timing for the psychoeducational session can entail on medium-term SSD effectiveness.

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2.2. Setting and Participants

Office employees were enlisted through promotional activities at the university, including banners, posters, and emails circulated within the institution. Those interested and meeting the eligibility criteria were invited to join the study. To offer details about the trial, assessments, expectations, and tools for encouraging SSD usage during the intervention, a specialized website (https://sufha.ulusofona.pt) was established.

Eligibility criteria required participants to work at least part-time, be over 20, and spend at least 70% of their work week engaged in desk-based tasks. Exclusion criteria included current use of SSD, insufficient personal space for SSD installation, and any musculoskeletal or health conditions that would make standing difficult. Additionally, individuals working from home were excluded due to the logistical difficulties of providing two SSD for each participant.

After the initial evaluation of the original sample, a subsample of 20 individuals (10 from the PE-0 group and 10 from the PE-6 group) was randomly selected and contacted for a follow-up assessment 3 months after the start of SSD usage. In the PE-0 group, participants received a psychoeducational session and began using the SSD immediately after the session. In contrast, participants in the PE-6 group started using the SSD 6-months after the psychoeducational session. All participants gave their written informed consent, and the project received ethical approval from the appropriate institutional ethics committee in accordance with the guidelines for research involving human participants.

2.3. Data Collection

An online survey collected data on participants' sociodemographic information including age, gender, biometric measurements. In compliance with ethical standards, the data from this study has been securely stored in a restricted-access folder, available only to the research team.

2.4. Study Assessments

For these analyses, we utilized data from both the PE-0 and PE-6 groups at baseline and after 3 months of using the SSD. Participants' weights were measured to the nearest 0.01 kg using an electronic scale (TANITA BC-601), with individuals wearing

minimal clothing and no shoes. Heights were recorded to the nearest 0.1 cm using a stadiometer (Seca, Hamburg, Germany). Body mass index (BMI) was then calculated as body mass (kg)/height^2 (m).

2.5. Physical Behaviors

Physical behaviors including time spent sitting, standing, and stepping were objectively measured. Participants were instructed to continuously wear an ActivPAL4® activity monitor (produced by PAL Technologies Ltd.®, Glasgow, Scotland, UK) for 24 hours over seven days. Only data from valid days were included in the analysis. The detailed methodology for this measurement has been previously published (Júdice et al., 2023).

2.6. Psychoeducational session

In this initial session, a comprehensive theoretical framework on the issue of ST was presented. We discussed the state of the art nationally and globally and detailed the contexts in which ST most frequently occur, such as the work setting, during leisure time, and in transportation. The negative health consequences of ST were also highlighted. We explained the benefits of interrupting ST through SSD, emphasizing that using these desks does not impair work productivity. The session demonstrated how these desks can be effectively integrated into the work environment to promote employee health and well-being. This session lasted approximately 30 min and was conducted by a specialist in the field with the entire group of participants at the same moment. A social interaction was organized following the session to extend and reinforce the discussion with the participants.

Furthermore, we provided a clear summary of our intervention procedure, including the structure of the intervention and the different scheduled evaluation periods. We specified how and when each evaluation would be conducted to monitor and analyze the effects of the intervention over time. Participants were provided with both verbal and written resources, including (i) a demonstration on how to operate their sit-stand desk, (ii) tailored guidance on maintaining correct ergonomic posture, and (iii) individualized advice on progressively increasing standing durations. Motivational content was also shared via email throughout the intervention period and made available on the SUFHA website (https://sufha.ulusofona.pt) to foster relatedness, perceived competence, and

autonomy in utilizing the desk. These resources were distributed four times in the first month, twice during the second and third months. This approach ensured that participants were fully informed and prepared for each study stage.

2.7. PE-0 group

The PE-0 group received the SSD installed on top of a conventional desk using a clamping arm. The initial psychoeducational session was held right before starting using the SSD and motivational nudges were delivered via email and on the SUFHA's website throughout the 3 months.

2.8. PE-6 group

The PE-6 group attended the same initial psychoeducational session but experienced no contextual change in the work setting for 6 months (i.e., waiting list control group in the original study). After this period, this group gained access to the SSD and the same motivational nudges for three months. The only difference between groups was the timing for the psychoeducational session. The PE-6 group was assessed at 6 months (before starting SSD usage) and at 9 months (i.e., 3 months after using the SSD). This design enabled a comparison of results between the PE-0 and PE-6 groups at different time points but encompassing the same intervention period (i.e., 3 months).

2.9. Statistical Analysis

Data was analyzed with SPSS Statistics for Windows version 28.0, 2024 (SPSS Inc., an IBM Company, Chicago). On the descriptive analysis, continuous variables are presented as mean and standard deviation and as frequencies for the categorical variables.

Independent sample T-tests were performed to assess differences between groups at baseline. Paired-sample T-tests were conducted to investigate the time effect within groups. Finally, a repeated measures analysis of variance (ANCOVA) was used to examine differences between groups from baseline to 3 months to compare the effect of the timing of the psychoeducational session on the dependent variables. The analyses were controlled for age, sex, clustering, and BMI. Statistical significance was set at 5%.

3. Results

Figure 1 shows the flow of participants throughout the study. After the initial assessments, participants were randomly assigned to two groups: the PE-0 group, which

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began using the SSD immediately after the psychoeducational session, and the PE-6 group, which waited 6 months after the session before using the SSD.

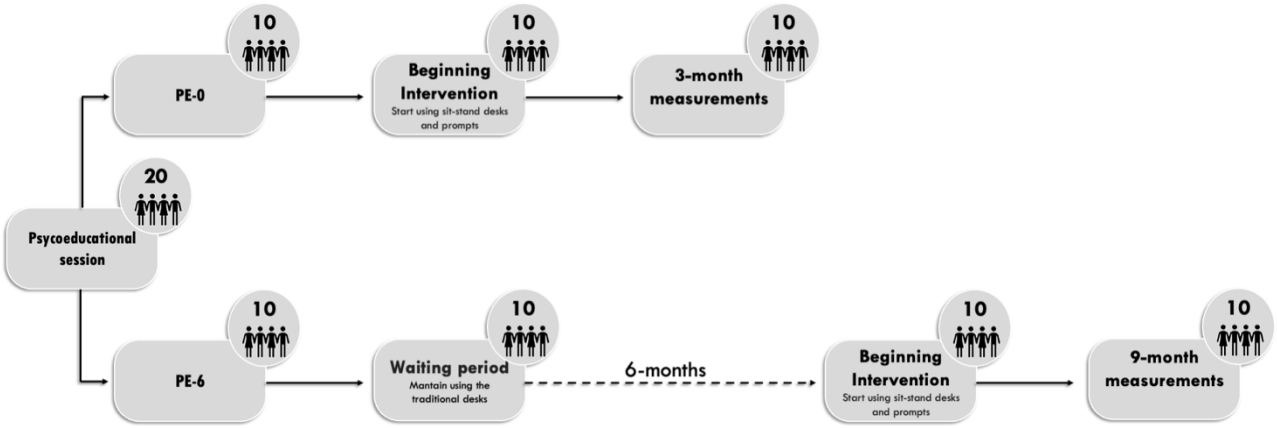

Figure 1 - Study flowchart and participant in action.

Table 1 provides an overview of the baseline characteristics of the study participants. Participants ranged in age from 25 to 60 years, averaging 47.2 years (SD=7.7). The average BMI was 30.0 kg/m² (SD=6.3). The sample predominantly consisted of women, representing 90% of the participants (n=18).

At the beginning of the study, no significant differences were found between the PE-0 and PE-6 groups for ST, number of sit-stand transitions, and prolonged ST (≥60 min) ($p>0.05$). However, significant differences were observed for standing time ($p=0.03$) and stepping time ($p=0.05$), favoring the PE-0 group.

Table 1 - Baseline characteristics according to randomized groups

Characteristics	PE-0	PE-6	Total
Sample size	(n=10)	(n=10)	(n=20)
Age (years)	48.5 (5.7)	45.8 (9.4)	47.2 (7.7)
Nº (%) women	9 (90.0%)	9 (90.0%)	18 (90.0%)
Biometric measurements			
Body mass index (kg/m²)	30.7 (6.5)	29.4 (6.4)	30.0 (6.3)
Body weight (kg)	79.4 (17.3)	78.4 (21.1)	78.9 (18.8)
Height (m)	1.61 (0.1)	1.63 (0.1)	1.62 (0.1)
ActivPAL outcomes			
Sitting time (min/day)	459.9 (85.6)	511.4 (119.2)	485.6 (104.4)
Prolonged (≥60 min) sitting (min/day)	153.5 (88.9)	150.0 (116.2)	151.8 (100.7)
Standing time (min/day)	318.5 (110.9)	220.8 (69.5)	269.7 (103.1) *
Stepping time (min/day)	103.5 (30.1)	78.4 (22.9)	90.9 (29.0) *
Nº sit to stand transitions (n/day)	43.6 (9.8)	45.5 (10.9)	44.6 (10.1)
Nº of valid days	6.0 (0.0)	6.0 (0.0)	6.0 (0.0)

PE-0, Psychoeducational 0 + Immediate Intervention group; PE-6, Psychoeducational + 6-Month Wait for Intervention group.
Note: *significant differences between groups based on the independent-sample T-test ($p<0.05$)

Table 2 shows a time*group interaction for ST (p=0.006), with the PE-0 group significantly reducing ST by 44.20 min/day, while a PE-6 group non-significantly reduced ST by 33.20 min/day. Additionally, there was a time*group interaction for prolonged ST (≥60 min) (p=0.040), with the PE-0 reducing these prolonged sitting periods by 27.60 min/day, while the PE-6 reduced them by 5.70 min/day. In terms of standing time, the PE-0 group increased standing by 47.20 min/day compared to only 11.90 min/day in the PE-6 group. For stepping time and sit-to-stand transitions, marginal increases were found in both groups.

Table 2 - Changes in ActivPAL outcomes at 3 months for both group

Outcomes	**Mean change from baseline (SD)**		**Time*group interaction effect**
	PE-0 (n=10)	PE-6 (n=10)	P value
Sitting time (min/day)	-44.20 (76.4) *	-33.20 (73.5)	**0.006#**
Prolonged (≥60 min) sitting (min/day)	-27.60 (80.6)	-5,70 (89.6)	**0.040#**
Standing time (min/day)	47.20 (53.9) *	11.90 (53.4)	0.107
Stepping time (min/day)	4.35 (14.8)	0.04 (12.0)	0.464
Nº sit to stand transitions (n/day)	0.90 (10.4)	2.60 (5.82)	0.695

PE-0, Psychoeducational 0 + Immediate Intervention group; PE-6, Psychoeducational + 6-Month Wait for Intervention group.

* Mean significant differences between assessment moments based on the paired sample T-test analysis. # significant time*group interaction effect based on ANCOVA.

Note: The model included clustering, age, sex, and BMI as covariates in the repeated measures ANCOVA.

Figure 2 highlights the differential response to the intervention amongst participants: some reduced their ST, while others maintained or even increased this behavior in both groups. A similar pattern was observed for standing time, as well as in prolonged bouts of ST.

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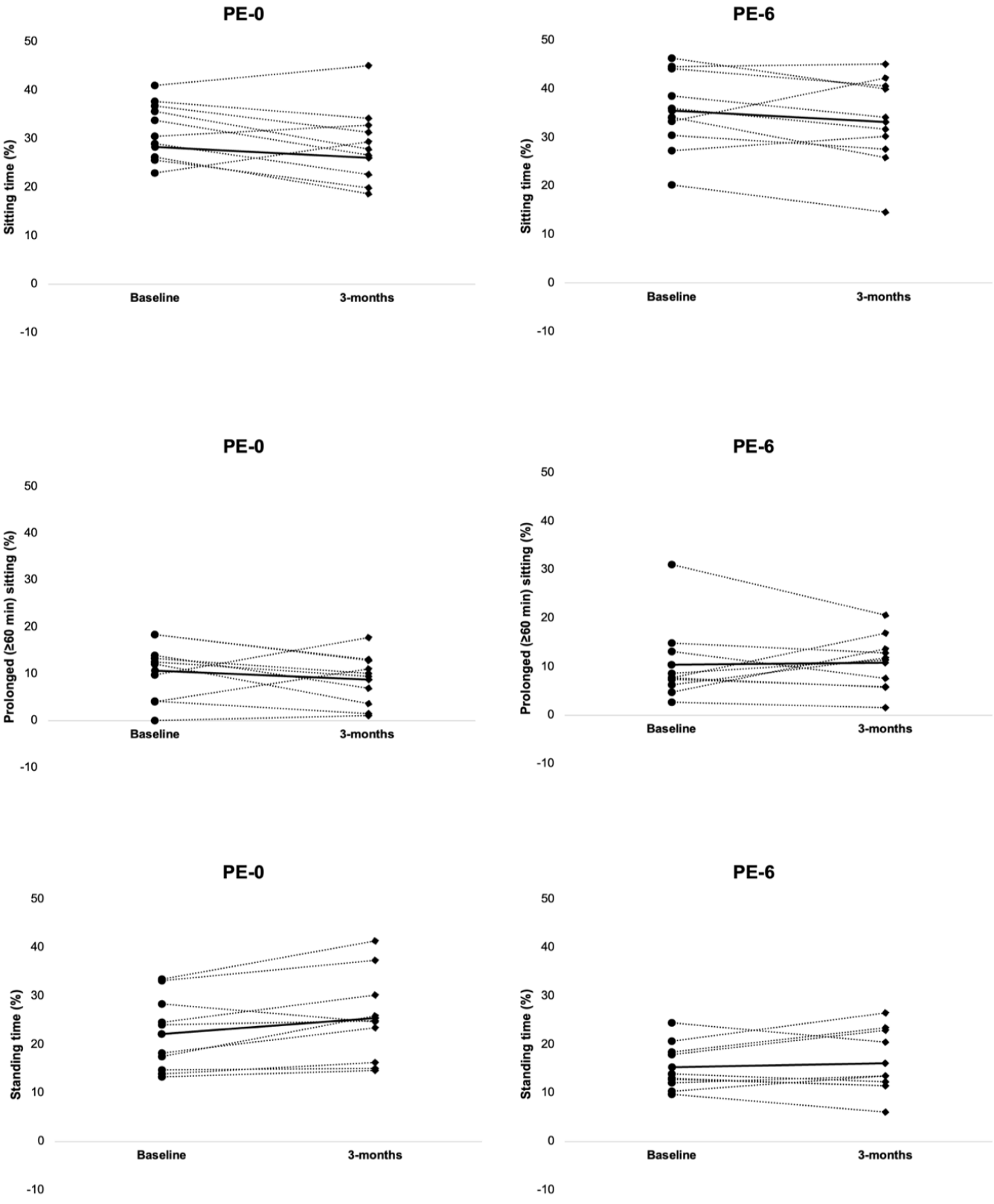

Figure 2 - Sitting time, prolonged sitting bouts (≥ 60 min) and standing time measured over 24 hours at baseline and after 3 months for the PE-0 and PE-6 groups.

4. Discussion

Effective interventions are crucial to address the increasing health problems related to excessive ST in the workplace. This study compared changes in ActivPAL-derived outcomes following a 3-month intervention using SSD preceded by a psychoeducational session or with the session being held 6 months earlier. In the latter case, the chances of participants remembering the session content are very low, which allow us, for the first time, to isolate the impact of the psychoeducational session itself without interference from prior knowledge or recall. This design offers a unique opportunity to assess the intervention's effect without the potential bias of retained information, providing a clearer understanding of the session's true impact on behavior change. We found a time*group interaction for overall ST, with the PE-0 group decreasing ST by 44.20 min/day, while the PE-6 group only reducing ST by 33.20 min/day. This result suggests that having a psychoeducational session immediately before using the SSD is different from incorporating the session months prior to the usage of SSD.

The higher reduction of ST when preceded by a psychoeducational session found in our study may be attributed to the greater awareness of health benefits which participants gained from the psychoeducational session. This awareness likely motivated more behavioral changes. However, it is important to note that motivation itself was not directly assessed in this study, so its specific role in driving behavior change remains speculative. Most of the literature supports the significant effect of SSD preceded by a psychoeducational session in reducing ST after a 3-month period, with reductions ranging from 33.50 to 117.10 min/day (Arguello et al., 2021; Dutta et al., 2014; Edwardson et al., 2022; Edwardson et al., 2018; Healy et al., 2016; MacEwen et al., 2017; Shrestha et al., 2016; Stephens et al., 2019). These results align with our study, which specifically isolated the impact of the timing of the psychoeducational session on the effectiveness of SSD interventions. The reduction in ST appears to be potentiated in the participants that recently received a psychoeducational session. However, this was the first time a comparison of the timing of the session was held, with no previous evidence on this topic, thus more studies exploring the sole impact of these psychoeducational sessions are warranted.

For the prolonged ST, the differences between groups were even higher, with the PE-0 group reducing prolonged ST (≥60 min) by 27.60 min/day, while the PE-6 group

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only reduced this deleterious behavior by 5.70 min/day. This is an interesting finding suggesting that participants that had the session months prior to the usage of SSD may still reduce overall ST, but they seem to forget the detailed information provided in the session regarding the harm associated with spending this behavior in a prolonged manner, which is more deleterious to their health.

Indeed, the reduction of prolonged ST is strongly linked to a decreased risk of non-communicable diseases, improving overall health. A systematic review conducted by Biswas et al. (2015) demonstrated that prolonged ST in adults is associated with an increase in the risk of mortality from several causes, including a 1.18 times greater likelihood of cardiovascular death, a 1.17 times higher risk of cancer mortality, a 1.91 times greater risk of diabetes, and a 1.24 times greater risk of death from all cause. In addition, reducing prolonged ST can also contribute to mental well-being and studies show that replacing ST with different intensities of physical activity is associated with a decrease in symptoms of depression and anxiety (Zhou et al., 2024). Furthermore, there is a direct association between prolonged ST and an increased prevalence of anxiety (Kim et al., 2024).

Also interesting, in the PE-6 group, standing time only increased by 11.9 min/day ($p>0.05$), while in the PE-0 group, standing time significantly increased by 47.2 min/day ($p<0.05$). Although the time*group interaction was not significant ($p>0.05$), we argue that this difference may have clinical significance. The difference of 35.3 min/day in standing time between groups may be associated with significant cardiovascular and metabolic health improvements, and there is evidence that swapping 30 minutes of ST for light physical activity (e.g., standing time) has been linked to reduced depression levels (Zhou et al., 2024). The scientific literature supports that both the reduction of ST and the increase in standing time are correlated with a lower incidence of cardiovascular diseases and type 2 diabetes (Healy et al., 2011). Moreover, these changes can improve insulin sensitivity and reduce postprandial glucose levels, decreasing the risk of diabetes (Dunstan et al., 2010).

One of the reasons why a long delay between the psychoeducational session and the main intervention can impact the intervention itself is that participants may lose focus or forget important information. This gap may weaken emotional engagement and potentially reduce the effectiveness of the intervention. Without continuous reinforcement, behaviors introduced during the psychoeducational session may not be

sustained after a few months. By contrast, delivering the session just before the intervention ensures that participants are more prepared to apply what they have learned (Hanham et al., 2023). Besides that, the immediacy of access to SSD in the PE-0 group likely improved recall of the information, leading to greater engagement and a better outcome. This immediacy also may explain the more significant reduction in ST and increase in standing time. By aligning the psychoeducational session closely with the intervention, participants were better positioned to apply the discussed strategies, thereby promoting increased adherence to the recommended practices. Moreover, the immediate application of knowledge can reinforce habit formation (Judah et al., 2018).

Several studies have demonstrated that the effectiveness of adopting SSD is significantly enhanced when psychoeducational sessions are followed by immediate access to these devices. For instance, Brierley et al. (2022) reported that a multi-component intervention substantially increased SSD usage among office workers, highlighting that immediate access after the sessions led to greater adherence to regular break recommendations. Furthermore, (Deery et al., 2024) found that participants who had access to SSD immediately after the psychoeducational session were more likely to incorporate standing into their daily routines, indicating that the immediate application of knowledge facilitates behavioral changes in naturalistic settings. In contrast, if the psychoeducational session is delivered too far in advance (as in the PE-6 group), some information may be forgotten, diminishing the intervention's impact. However, in the case of impossibility to perform this type of session due to schedule limitations or other reasons, one must be aware that there is still some effectiveness in reducing ST associated with the simple introduction of SSD. For example, a study conducted by Alkhajah et al. (2012), which only included a brief introduction to the intervention (2 min), observed a reduction of 78 min/day in ST and an increase of 83 min/day in standing time after a 3-month intervention. This highlights that even with minimal information, SSD interventions can effectively reduce ST.

4.1. Individual variability

As shown in Figure 2, individual data revealed a significant variability amongst participants. This variability in the results may be attributed to factors such as individual perception of health benefits related to reducing ST (Owen et al., 2010), the level of organizational support and workplace culture (Neuhaus, Healy, et al., 2014), the physical capabilities or limitations of participants (Mansoubi et al., 2016), as well as adjustments

made in the work environment that facilitate or hinder the use of SSD (Shrestha et al., 2018). An organizational culture that promotes regular breaks and physical activity can further support the behavioral changes initiated in the psychoeducational session. The retention of information varies among participants; those who regularly review and practice learned content achieve more lasting behavioral changes (Walsh et al., 2023). Without ongoing reinforcement, such as reminders or follow-up sessions, participants may forget crucial information, which can reduce the long-term effectiveness. Indeed, some interventions have shown that a higher impact of SSD interventions is verified in the first months, and that with time, these reductions are attenuated (Edwardson et al., 2022; Healy et al., 2016; Júdice et al., 2024). This can be explained by the vanishing of the novelty effect with time, or simply the fact that participants cannot remember and therefore are not as alert to the information and strategies delivered in the session.

4.2. Strengths and Limitations

The study compared the effectiveness of the SSD intervention with the psychoeducational session conducted immediately before the intervention versus 6-months prior, allowing for the first time, a detailed assessment of the impact of the timing of the psychoeducational session on an SSD-based intervention effectiveness. Additionally, the activPAL4 activity monitor was used to objectively measure physical behaviors providing precise data. These are the most relevant strengths of the study.

The study also has some limitations. The study included a relatively small number of participants with the majority being women, which may limit the generalizability of the results to more extensive and diverse populations. Additionally, the study had a low participation rate compared to the initial number of individuals that were recruited (i.e., 1010), which may indicate some selection bias or nonresponse bias (as observed in a similar study(Júdice et al., 2024)). This could mean that those who entered the study are possibly different from those who did not participate, potentially affecting the generalizability of the current findings. The intervention lasted 3 months, and long-term effectiveness may not have been thoroughly evaluated, necessitating more extended studies to verify the sustainability of the effects.

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4.3. Recommendations for Future Research

To enhance the effectiveness of interventions to reduce ST in the workplace, it is crucial to explore the optimal timing and frequency of psychoeducational sessions, including whether more frequent or prolonged sessions improve knowledge retention and application. Analyzing individual differences can help tailor strategies to various participants' profiles. Creating environments that support the use of adjustable workstations and promoting managerial support and a culture encouraging breaks and physical activity are essential. Future research should also assess longer interventions and control for external variables that may influence the effectiveness of strategies. These efforts aim to develop more robust and sustainable approaches, ultimately improving health and well-being of office workers.

5. Conclusion

This study demonstrates that combining a psychoeducational session with the immediate implementation of SSD significantly reduces ST compared to starting the intervention 6 months after the psychoeducational session. The intervention initiated immediately after the psychoeducational session led to more significant reductions in total ST, but more importantly prolonged sedentary bouts than the delayed start group. These findings highlight the importance of aligning psychoeducational sessions closely with the intervention's onset to maximize its effectiveness. Continuous reinforcement and personalized strategies are recommended to sustain long-term behavioral changes.

6. References

Alkhajah, T. A., Reeves, M. M., Eakin, E. G., Winkler, E. A., Owen, N., & Healy, G. N. (2012). Sit-stand workstations: a pilot intervention to reduce office sitting time. *Am J Prev Med*, *43*(3), 298-303. https://doi.org/10.1016/j.amepre.2012.05.027

Andersen, L. L., Fallentin, N., Thorsen, S. V., & Holtermann, A. (2016). Physical workload and risk of long-term sickness absence in the general working population and among blue-collar workers: prospective cohort study with register follow-up. *Occup Environ Med*, *73*(4), 246-253. https://doi.org/10.1136/oemed-2015-103314

Arguello, D., Thorndike, A. N., Cloutier, G., Morton, A., Castaneda-Sceppa, C., & John, D. (2021). Effects of an "Active-Workstation" Cluster RCT on Daily Waking

Physical Behaviors. *Med Sci Sports Exerc*, *53*(7), 1434-1445. https://doi.org/10.1249/MSS.0000000000002594

Atkin, A. J., Adams, E., Bull, F. C., & Biddle, S. J. (2012). Non-occupational sitting and mental well-being in employed adults. *Ann Behav Med*, *43*(2), 181-188. https://doi.org/10.1007/s12160-011-9320-y

Balducci, S., D'Errico, V., Haxhi, J., Sacchetti, M., Orlando, G., Cardelli, P.,…Investigators, I. D. a. E. S. I. (2019). Effect of a Behavioral Intervention Strategy on Sustained Change in Physical Activity and Sedentary Behavior in Patients With Type 2 Diabetes: The IDES_2 Randomized Clinical Trial. *JAMA*, *321*(9), 880-890. https://doi.org/10.1001/jama.2019.0922

Ball, K., Jeffery, R. W., Abbott, G., McNaughton, S. A., & Crawford, D. (2010). Is healthy behavior contagious: associations of social norms with physical activity and healthy eating. *Int J Behav Nutr Phys Act*, *7*, 86. https://doi.org/10.1186/1479-5868-7-86

Bennie, J. A., Pedisic, Z., Timperio, A., Crawford, D., Dunstan, D., Bauman, A.,…Salmon, J. (2015). Total and domain-specific sitting time among employees in desk-based work settings in Australia. *Aust N Z J Public Health*, *39*(3), 237-242. https://doi.org/10.1111/1753-6405.12293

Biddle, S. J. H., O'Connell, S. E., Davies, M. J., Dunstan, D., Edwardson, C. L., Esliger, D. W.,…Munir, F. (2020). Reducing sitting at work: process evaluation of the SMArT Work (Stand More At Work) intervention. *Trials*, *21*(1), 403. https://doi.org/10.1186/s13063-020-04300-7

Biswas, A., Oh, P. I., Faulkner, G. E., Bajaj, R. R., Silver, M. A., Mitchell, M. S., & Alter, D. A. (2015). Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Ann Intern Med*, *162*(2), 123-132. https://doi.org/10.7326/m14-1651

Blackburn, N. E., Wilson, J. J., McMullan, I. I., Caserotti, P., Giné-Garriga, M., Wirth, K.,…Tully, M. A. (2020). The effectiveness and complexity of interventions targeting sedentary behaviour across the lifespan: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*, *17*(1), 53. https://doi.org/10.1186/s12966-020-00957-0

Bora, N., K, V., Verma, A., Bharti, A. K., & Sinha, M. K. (2024). Physical activity and sedentary behavior perceptions in overweight and obese adults: A systematic

review of qualitative study. *F1000Res*, *13*, 787. https://doi.org/10.12688/f1000research.152905.1

Brierley, M. L., Smith, L. R., Bailey, D. P., Ojo, S. O., Hewson, D. J., Every, S. A.,…Chater, A. M. (2022). Evaluating a multi-component intervention to reduce and break up office workers' sitting with sit-stand desks using the APEASE criteria. *BMC Public Health*, *22*(1), 458.

Buckley, J. P., Hedge, A., Yates, T., Copeland, R. J., Loosemore, M., Hamer, M.,…Dunstan, D. W. (2015). The sedentary office: an expert statement on the growing case for change towards better health and productivity. *Br J Sports Med*, *49*(21), 1357-1362. https://doi.org/10.1136/bjsports-2015-094618

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G.,…Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. https://doi.org/10.1136/bjsports-2020-102955

Cao, C., Friedenreich, C. M., & Yang, L. (2022). Association of Daily Sitting Time and Leisure Time Physical Activity With Survival Among US Cancer Survivors. *JAMA Oncol*, *8*(3), 395-403. https://doi.org/10.1001/jamaoncol.2021.6590

Chan, C. B., & Ryan, D. A. (2009). Assessing the effects of weather conditions on physical activity participation using objective measures. *Int J Environ Res Public Health*, *6*(10), 2639-2654. https://doi.org/10.3390/ijerph6102639

Chau, J. Y., Daley, M., Dunn, S., Srinivasan, A., Do, A., Bauman, A. E., & van der Ploeg, H. P. (2014). The effectiveness of sit-stand workstations for changing office workers' sitting time: results from the Stand@Work randomized controlled trial pilot. *Int J Behav Nutr Phys Act*, *11*, 127. https://doi.org/10.1186/s12966-014-0127-7

Chau, J. Y., van der Ploeg, H. P., Merom, D., Chey, T., & Bauman, A. E. (2012). Cross-sectional associations between occupational and leisure time sitting, physical activity and obesity in working adults. *Prev Med*, *54*(3-4), 195-200. https://doi.org/10.1016/j.ypmed.2011.12.020

Chu, A. H., Ng, S. H., Tan, C. S., Win, A. M., Koh, D., & Müller-Riemenschneider, F. (2016). A systematic review and meta-analysis of workplace intervention strategies to reduce sedentary time in white-collar workers. *Obes Rev*, *17*(5), 467-481. https://doi.org/10.1111/obr.12388

Clemes, S. A., O'Connell, S. E., & Edwardson, C. L. (2014). Office workers' objectively measured sedentary behavior and physical activity during and outside working hours. *J Occup Environ Med*, *56*(3), 298-303. https://doi.org/10.1097/JOM.0000000000000101

Coenen, P., van der Molen, H. F., Burdorf, A., Huysmans, M. A., Straker, L., Frings-Dresen, M. H., & van der Beek, A. J. (2019). Associations of screen work with neck and upper extremity symptoms: a systematic review with meta-analysis. *Occup Environ Med*, *76*(7), 502-509. https://doi.org/10.1136/oemed-2018-105553

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep*, *22*(1), 7-14.

Commissaris, D. A. C. M., Huysmans, M. A., Mathiassen, S. E., Srinivasan, D., Koppes, L. L. J., & Hendriksen, I. J. M. (2016). Interventions to reduce sedentary behavior and increase physical activity during productive work: a systematic review. *Scand J Work Environ Health*, *42*(3), 181-191. https://doi.org/10.5271/sjweh.3544

Danquah, I. H., Kloster, S., Holtermann, A., Aadahl, M., Bauman, A., Ersbøll, A. K., & Tolstrup, J. S. (2017). Take a Stand!-a multi-component intervention aimed at reducing sitting time among office workers-a cluster randomized trial. *Int J Epidemiol*, *46*(1), 128-140. https://doi.org/10.1093/ije/dyw009

Deery, E., Buckley, J., Morris, M. *et al.* (2024). *Some People Sit, Some People Stand, That's Just What We Do* ": a Qualitative Exploration of Sit-Stand Desk Use in Naturalistic Settings. In. *Occup Health Sci*.

Del Pozo-Cruz, J., García-Hermoso, A., Alfonso-Rosa, R. M., Alvarez-Barbosa, F., Owen, N., Chastin, S., & Del Pozo-Cruz, B. (2018). Replacing Sedentary Time: Meta-analysis of Objective-Assessment Studies. *Am J Prev Med*, *55*(3), 395-402. https://doi.org/10.1016/j.amepre.2018.04.042

Dunstan, D. W., Barr, E. L., Healy, G. N., Salmon, J., Shaw, J. E., Balkau, B.,…Owen, N. (2010). Television viewing time and mortality: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Circulation*, *121*(3), 384-391. https://doi.org/10.1161/CIRCULATIONAHA.109.894824

Dupont, F., Léger, P. M., Begon, M., Lecot, F., Sénécal, S., Labonté-Lemoyne, E., & Mathieu, M. E. (2019). Health and productivity at work: which active workstation for which benefits: a systematic review. *Occup Environ Med*, *76*(5), 281-294. https://doi.org/10.1136/oemed-2018-105397

Dutta, N., Koepp, G. A., Stovitz, S. D., Levine, J. A., & Pereira, M. A. (2014). Using sit-stand workstations to decrease sedentary time in office workers: a randomized crossover trial. *Int J Environ Res Public Health*, *11*(7), 6653-6665. https://doi.org/10.3390/ijerph110706653

E F Graves, L., C Murphy, R., Shepherd, S. O., Cabot, J., & Hopkins, N. D. (2015). Evaluation of sit-stand workstations in an office setting: a randomised controlled trial. *BMC Public Health*, *15*, 1145. https://doi.org/10.1186/s12889-015-2469-8

Edwardson, C. L., Biddle, S. J. H., Clemes, S. A., Davies, M. J., Dunstan, D. W., Eborall, H.,…Clarke-Cornwell, A. M. (2022). Effectiveness of an intervention for reducing sitting time and improving health in office workers: three arm cluster randomised controlled trial. *BMJ*, *378*, e069288. https://doi.org/10.1136/bmj-2021-069288

Edwardson, C. L., Yates, T., Biddle, S. J. H., Davies, M. J., Dunstan, D. W., Esliger, D. W.,…Munir, F. (2018). Effectiveness of the Stand More AT (SMArT) Work intervention: cluster randomised controlled trial. *BMJ*, *363*, k3870. https://doi.org/10.1136/bmj.k3870

Ekelund, U., Brown, W. J., Steene-Johannessen, J., Fagerland, M. W., Owen, N., Powell, K. E.,…Lee, I. M. (2019). Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants. *Br J Sports Med*, *53*(14), 886-894. https://doi.org/10.1136/bjsports-2017-098963

Ekelund, U., Tarp, J., Steene-Johannessen, J., Hansen, B. H., Jefferis, B., Fagerland, M. W.,…Lee, I. M. (2019). Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis. *BMJ*, *366*, l4570. https://doi.org/10.1136/bmj.l4570

Felez-Nobrega, M., Bort-Roig, J., Briones, L., Sanchez-Niubo, A., Koyanagi, A., Puigoriol, E., & Puig-Ribera, A. (2020). Self-reported and activPAL. *J Sports Sci*, *38*(13), 1566-1574. https://doi.org/10.1080/02640414.2020.1748359

Gao, Z., & Lee, J. E. (2022). Promoting Physical Activity and Reducing Sedentary Behavior to Prevent Chronic Diseases during the COVID Pandemic and Beyond. *J Clin Med*, *11*(16). https://doi.org/10.3390/jcm11164666

Gilson, N. D., Burton, N. W., van Uffelen, J. G., & Brown, W. J. (2011). Occupational sitting time: employees' perceptions of health risks and intervention strategies. *Health Promot J Austr*, *22*(1), 38-43. https://doi.org/10.1071/he11038

Grunseit, A. C., Chau, J. Y., van der Ploeg, H. P., & Bauman, A. (2013). "Thinking on your feet": A qualitative evaluation of sit-stand desks in an Australian workplace. *BMC Public Health*, *13*, 365. https://doi.org/10.1186/1471-2458-13-365

Hadgraft, N. T., Healy, G. N., Owen, N., Winkler, E. A., Lynch, B. M., Sethi, P.,…Dunstan, D. W. (2016). Office workers' objectively assessed total and prolonged sitting time: Individual-level correlates and worksite variations. *Prev Med Rep*, *4*, 184-191. https://doi.org/10.1016/j.pmedr.2016.06.011

Hanham, J., Castro-Alonso, J. C., & Chen, O. (2023). Integrating cognitive load theory with other theories, within and beyond educational psychology. *Br J Educ Psychol*, *93 Suppl 2*, 239-250. https://doi.org/10.1111/bjep.12612

Healy, G. N., Eakin, E. G., Owen, N., Lamontagne, A. D., Moodie, M., Winkler, E. A.,…Dunstan, D. W. (2016). A Cluster Randomized Controlled Trial to Reduce Office Workers' Sitting Time: Effect on Activity Outcomes. *Med Sci Sports Exerc*, *48*(9), 1787-1797. https://doi.org/10.1249/MSS.0000000000000972

Healy, G. N., Matthews, C. E., Dunstan, D. W., Winkler, E. A., & Owen, N. (2011). Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. *Eur Heart J*, *32*(5), 590-597. https://doi.org/10.1093/eurheartj/ehq451

Henderson, B., Stuckey, R., & Keegel, T. (2018). Current and ceased users of sit stand workstations: a qualitative evaluation of ergonomics, safety and health factors within a workplace setting. *BMC Public Health*, *18*(1), 1374. https://doi.org/10.1186/s12889-018-6296-6

Hergenroeder, A., Quinn, T. D., Perdomo, S. J., Kline, C. E., & Gibbs, B. B. (2022). Effect of a 6-month sedentary behavior reduction intervention on well-being and

workplace health in desk workers with low back pain. *Work*, *71*(4), 1145-1155. https://doi.org/10.3233/WOR-205178

Ishii, K., Shibata, A., & Oka, K. (2018). Work Engagement, Productivity, and Self-Reported Work-Related Sedentary Behavior Among Japanese Adults: A Cross-Sectional Study. *J Occup Environ Med*, *60*(4), e173-e177. https://doi.org/10.1097/JOM.0000000000001270

Jochem, C., Wallmann-Sperlich, B., & Leitzmann, M. F. (2019). The Influence of Sedentary Behavior on Cancer Risk: Epidemiologic Evidence and Potential Molecular Mechanisms. *Curr Nutr Rep*, *8*(3), 167-174. https://doi.org/10.1007/s13668-019-0263-4

Judah, G., Gardner, B., Kenward, M. G., DeStavola, B., & Aunger, R. (2018). Exploratory study of the impact of perceived reward on habit formation. *BMC Psychol*, *6*(1), 62. https://doi.org/10.1186/s40359-018-0270-z

Júdice, P. B., Silva, H., Teno, S. C., & Hetherington-Rauth, M. (2024). The effectiveness of a 6-month intervention with sit-stand workstation in office workers: Results from the SUFHA cluster randomized controlled trial. *Work*. https://doi.org/10.3233/WOR-230624

Júdice, P. B., Silva, H., Teno, S. C., Monteiro, P., Silva, M. N., Carraça, E. V.,…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

Júdice, P. B., Sousa-Sá, E., & Palmeira, A. L. (2023). Discrepancies Between Self-reported and Objectively Measured Smartphone Screen Time: Before and During Lockdown. *J Prev (2022)*, *44*(3), 291-307. https://doi.org/10.1007/s10935-023-00724-4

Kazi, A., Haslam, C., Duncan, M., Clemes, S., & Twumasi, R. (2019). Sedentary behaviour and health at work: an investigation of industrial sector, job role, gender and geographical differences. *Ergonomics*, *62*(1), 21-30. https://doi.org/10.1080/00140139.2018.1489981

Keown, M. K., Skeaff, C. M., Perry, T. L., Haszard, J. J., & Peddie, M. C. (2018). Device-Measured Sedentary Behavior Patterns in Office-Based University

Employees. *J Occup Environ Med*, *60*(12), 1150-1157. https://doi.org/10.1097/JOM.0000000000001467

Kikuchi, H., Inoue, S., Sugiyama, T., Owen, N., Oka, K., Nakaya, T., & Shimomitsu, T. (2014). Distinct associations of different sedentary behaviors with health-related attributes among older adults. *Prev Med*, *67*, 335-339. https://doi.org/10.1016/j.ypmed.2014.08.011

Kim, E., Park, C. H., Lee, H. S., Lee, M. Y., & Cho, S. J. (2024). Sex Differences in the Association between Prolonged Sitting Time and Anxiety Prevalence among Korean Adults. *Brain Sci*, *14*(7). https://doi.org/10.3390/brainsci14070729

Lam, K., Baurecht, H., Pahmeier, K., Niemann, A., Romberg, C., Biermann-Stallwitz, J.,…Jochem, C. (2022). How effective and how expensive are interventions to reduce sedentary behavior? An umbrella review and meta-analysis. *Obes Rev*, *23*(5), e13422. https://doi.org/10.1111/obr.13422

Landais, L. L., Jelsma, J. G. M., Dotinga, I. R., Timmermans, D. R. M., Verhagen, E. A. L. M., & Damman, O. C. (2022). Office workers' perspectives on physical activity and sedentary behaviour: a qualitative study. *BMC Public Health*, *22*(1), 621. https://doi.org/10.1186/s12889-022-13024-z

Liu, S. H., Eaton, C. B., Driban, J. B., McAlindon, T. E., & Lapane, K. L. (2016). Comparison of self-report and objective measures of physical activity in US adults with osteoarthritis. In *Rheumatol Int* (Vol. 36, pp. 1355-1364). https://doi.org/10.1007/s00296-016-3537-9

Ma, J., Ma, D., Li, Z., & Kim, H. (2021). Effects of a Workplace Sit-Stand Desk Intervention on Health and Productivity. *Int J Environ Res Public Health*, *18*(21). https://doi.org/10.3390/ijerph182111604

MacEwen, B. T., Saunders, T. J., MacDonald, D. J., & Burr, J. F. (2017). Sit-Stand Desks To Reduce Workplace Sitting Time In Office Workers With Abdominal Obesity: A Randomized Controlled Trial. *J Phys Act Health*, *14*(9), 710-715. https://doi.org/10.1123/jpah.2016-0384

Mansfeldt, J. M., & Magkos, F. (2023). Compensatory Responses to Exercise Training As Barriers to Weight Loss: Changes in Energy Intake and Non-exercise Physical Activity. *Curr Nutr Rep*, *12*(2), 327-337. https://doi.org/10.1007/s13668-023-00467-y

Mansoubi, M., Pearson, N., Biddle, S. J., & Clemes, S. A. (2016). Using Sit-to-Stand Workstations in Offices: Is There a Compensation Effect? *Med Sci Sports Exerc*, *48*(4), 720-725. https://doi.org/10.1249/MSS.0000000000000802

Martinez-Gomez, D., Guallar-Castillon, P., Leon-Munoz, L. M., Lopez-Garcia, E., & Rodriguez-Artalejo, F. (2013). Combined impact of traditional and non-traditional health behaviors on mortality: a national prospective cohort study in Spanish older adults. *BMC Med*, *11*, 47. https://doi.org/10.1186/1741-7015-11-47

Matthews, C. E., Moore, S. C., Sampson, J., Blair, A., Xiao, Q., Keadle, S. K.,…Park, Y. (2015). Mortality Benefits for Replacing Sitting Time with Different Physical Activities. *Med Sci Sports Exerc*, *47*(9), 1833-1840. https://doi.org/10.1249/mss.0000000000000621

Mielke, G. I., da Silva, I. C., Owen, N., & Hallal, P. C. (2014). Brazilian adults' sedentary behaviors by life domain: population-based study. *PLoS One*, *9*(3), e91614. https://doi.org/10.1371/journal.pone.0091614

Mitchell, M. S., Goodman, J. M., Alter, D. A., John, L. K., Oh, P. I., Pakosh, M. T., & Faulkner, G. E. (2013). Financial incentives for exercise adherence in adults: systematic review and meta-analysis. *Am J Prev Med*, *45*(5), 658-667. https://doi.org/10.1016/j.amepre.2013.06.017

Nelson-Wong, E., Corrigan, J., Mertz, P., Kutcher, S., Carlson, I., DiRocco, T., & Hall-Nelson, B. (2021). Office-workers maintain decreased workplace sitting time long-term following participation in a sit-stand desk intervention study. *Ergonomics*, 1-9. https://doi.org/10.1080/00140139.2021.1998647

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

Neuhaus, M., Healy, G. N., Dunstan, D. W., Owen, N., & Eakin, E. G. (2014). Workplace sitting and height-adjustable workstations: a randomized controlled trial. *Am J Prev Med*, *46*(1), 30-40. https://doi.org/10.1016/j.amepre.2013.09.009

Ng, J. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Duda, J. L., & Williams, G. C. (2012). Self-Determination Theory Applied to Health

Contexts: A Meta-Analysis. *Perspect Psychol Sci*, *7*(4), 325-340. https://doi.org/10.1177/1745691612447309

Nguyen, P., Le, L. K., Nguyen, D., Gao, L., Dunstan, D. W., & Moodie, M. (2020). The effectiveness of sedentary behaviour interventions on sitting time and screen time in children and adults: an umbrella review of systematic reviews. *Int J Behav Nutr Phys Act*, *17*(1), 117. https://doi.org/10.1186/s12966-020-01009-3

Organization, W. H. (2018). G*lobal action plan on physical activity 2018-2030: more active people for a healthier world*. In (World Health Organization ed.).

Owen, N., Healy, G. N., Matthews, C. E., & Dunstan, D. W. (2010). Too much sitting: the population health science of sedentary behavior. *Exerc Sport Sci Rev*, *38*(3), 105-113. https://doi.org/10.1097/JES.0b013e3181e373a2

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D.,…Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. https://doi.org/10.1136/bmj.n71

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

Parry, S. P., Coenen, P., Shrestha, N., O'Sullivan, P. B., Maher, C. G., & Straker, L. M. (2019). Workplace interventions for increasing standing or walking for decreasing musculoskeletal symptoms in sedentary workers. *Cochrane Database Syst Rev*, *2019*(11). https://doi.org/10.1002/14651858.CD012487.pub2

Patterson, R., McNamara, E., Tainio, M., de Sá, T. H., Smith, A. D., Sharp, S. J.,…Wijndaele, K. (2018). Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *Eur J Epidemiol*, *33*(9), 811-829. https://doi.org/10.1007/s10654-018-0380-1

Pereira, M. A., Mullane, S. L., Toledo, M. J. L., Larouche, M. L., Rydell, S. A., Vuong, B.,…Buman, M. P. (2020). Efficacy of the 'Stand and Move at Work' multicomponent workplace intervention to reduce sedentary time and improve cardiometabolic risk: a group randomized clinical trial. *Int J Behav Nutr Phys Act*, *17*(1), 133. https://doi.org/10.1186/s12966-020-01033-3

Prince, S. A., Elliott, C. G., Scott, K., Visintini, S., & Reed, J. L. (2019). Device-measured physical activity, sedentary behaviour and cardiometabolic health and

fitness across occupational groups: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*, *16*(1), 30. https://doi.org/10.1186/s12966-019-0790-9

Prince, S. A., Reid, R. D., & Reed, J. L. (2019). Comparison of self-reported and objectively measured levels of sitting and physical activity and associations with markers of health in cardiac rehabilitation patients. *Eur J Prev Cardiol*, *26*(6), 653-656. https://doi.org/10.1177/2047487318806357

Renaud, L. R., Jelsma, J. G. M., Huysmans, M. A., van Nassau, F., Lakerveld, J., Speklé, E. M.,…van der Ploeg, H. P. (2020). Effectiveness of the multi-component dynamic work intervention to reduce sitting time in office workers - Results from a pragmatic cluster randomised controlled trial. *Appl Ergon*, *84*, 103027. https://doi.org/10.1016/j.apergo.2019.103027

Rhodes, R. E., Janssen, I., Bredin, S. S. D., Warburton, D. E. R., & Bauman, A. (2017). Physical activity: Health impact, prevalence, correlates and interventions. *Psychol Health*, *32*(8), 942-975. https://doi.org/10.1080/08870446.2017.1325486

Rosenkranz, S. K., Mailey, E. L., Umansky, E., Rosenkranz, R. R., & Ablah, E. (2020). Workplace Sedentary Behavior and Productivity: A Cross-Sectional Study. *Int J Environ Res Public Health*, *17*(18). https://doi.org/10.3390/ijerph17186535

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol*, *55*(1), 68-78. https://doi.org/10.1037//0003-066x.55.1.68

Sadarangani, K. P., Schuch, F. B., De Roia, G., Martínez-Gomez, D., Chávez, R., Lobo, P.,…Meyer, J. (2023). Exchanging screen for non-screen sitting time or physical activity might attenuate depression and anxiety: A cross-sectional isotemporal analysis during early pandemics in South America. *J Sci Med Sport*, *26*(6), 309-315. https://doi.org/10.1016/j.jsams.2023.04.007

Santos, A. C., Willumsen, J., Meheus, F., Ilbawi, A., & Bull, F. C. (2023). The cost of inaction on physical inactivity to public health-care systems: a population-attributable fraction analysis. *Lancet Glob Health*, *11*(1), e32-e39. https://doi.org/10.1016/S2214-109X(22)00464-8

Schwartz, B., Kapellusch, J. M., Baca, A., & Wessner, B. (2019). Medium-term effects of a two-desk sit/stand workstation on cognitive performance and workload for healthy people performing sedentary work: a secondary analysis of a

randomised controlled trial. *Ergonomics*, *62*(6), 794-810. https://doi.org/10.1080/00140139.2019.1577497

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. *Hum Factors*, *61*(5), 816-824. https://doi.org/10.1177/0018720818807043

Shrestha, B., & Dunn, L. (2020). The Declaration of Helsinki on Medical Research involving Human Subjects: A Review of Seventh Revision. *J Nepal Health Res Counc*, *17*(4), 548-552. https://doi.org/10.33314/jnhrc.v17i4.1042

Shrestha, N., Grgic, J., Wiesner, G., Parker, A., Podnar, H., Bennie, J. A.,…Pedisic, Z. (2019). Effectiveness of interventions for reducing non-occupational sedentary behaviour in adults and older adults: a systematic review and meta-analysis. *Br J Sports Med*, *53*(19), 1206-1213. https://doi.org/10.1136/bjsports-2017-098270

Shrestha, N., Ijaz, S., Kukkonen-Harjula, K. T., Kumar, S., & Nwankwo, C. P. (2015). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *1*, Cd010912. https://doi.org/10.1002/14651858.CD010912.pub2

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 Syst Rev*, *3*(3), CD010912. https://doi.org/10.1002/14651858.CD010912.pub3

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Pedisic, Z. (2018). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *6*(6), Cd010912. https://doi.org/10.1002/14651858.CD010912.pub4

Silva, H., G F Ramos, P., Teno, S. C., & Júdice, P. B. (2024). Impact of a 6-month sit-stand desk-based intervention on regional musculoskeletal discomfort and overall post-work fatigue in office workers: a cluster randomised controlled trial. *Ergonomics*, 1-14. https://doi.org/10.1080/00140139.2024.2414197

Silva, H., Ramos, P. G. F., Teno, S. C., & Júdice, P. B. (2024). The Impact of Sit-Stand Desks on Full-Day and Work-Based Sedentary Behavior of Office Workers: A Systematic Review. *Hum Factors*, 187208241305591. https://doi.org/10.1177/00187208241305591

Silva, H., Teno, S. C., & Júdice, P. B. (2024). Are there compensatory behaviors in response to a sit-stand desk intervention? *J Occup Health*. https://doi.org/10.1093/joccuh/uiae067

Stamatakis, E., Gale, J., Bauman, A., Ekelund, U., Hamer, M., & Ding, D. (2019). Sitting Time, Physical Activity, and Risk of Mortality in Adults. *J Am Coll Cardiol*, *73*(16), 2062-2072. https://doi.org/10.1016/j.jacc.2019.02.031

Stephens, S. K., Eakin, E. G., Clark, B. K., Winkler, E. A. H., Owen, N., LaMontagne, A. D.,…Healy, G. N. (2018). What strategies do desk-based workers choose to reduce sitting time and how well do they work? Findings from a cluster randomised controlled trial. *Int J Behav Nutr Phys Act*, *15*(1), 98. https://doi.org/10.1186/s12966-018-0731-z

Stephens, S. K., Winkler, E. A. H., Eakin, E. G., Clark, B. K., Owen, N., Moodie, M.,…Healy, G. N. (2019). Temporal features of sitting, standing and stepping changes in a cluster-randomised controlled trial of a workplace sitting-reduction intervention. *Int J Behav Nutr Phys Act*, *16*(1), 111. https://doi.org/10.1186/s12966-019-0879-1

Sugiyama, T., Hadgraft, N., Clark, B. K., Dunstan, D. W., & Owen, N. (2020). Sitting at work & waist circumference-A cross-sectional study of Australian workers. *Prev Med*, *141*, 106243. https://doi.org/10.1016/j.ypmed.2020.106243

Teno, S. C., Silva, M. N., & Júdice, P. B. (2024). Physical activity and sedentary behaviour-specific domains and their associations with mental health in adults: a systematic review. . In (pp. 1–28): A*dvances in Mental Health*.

Thomas, B. H., Ciliska, D., Dobbins, M., & Micucci, S. (2004). A process for systematically reviewing the literature: providing the research evidence for public health nursing interventions. *Worldviews Evid Based Nurs*, *1*(3), 176-184. https://doi.org/10.1111/j.1524-475X.2004.04006.x

Thorp, A. A., Healy, G. N., Winkler, E., Clark, B. K., Gardiner, P. A., Owen, N., & Dunstan, D. W. (2012). Prolonged sedentary time and physical activity in workplace and non-work contexts: a cross-sectional study of office, customer service and call centre employees. *Int J Behav Nutr Phys Act*, *9*, 128. https://doi.org/10.1186/1479-5868-9-128

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E.,…Participants, S. T. C. P. (2017). Sedentary Behavior Research Network

(SBRN) - Terminology Consensus Project process and outcome. *Int J Behav Nutr Phys Act*, *14*(1), 75. https://doi.org/10.1186/s12966-017-0525-8

Tremblay, M. S., Colley, R. C., Saunders, T. J., Healy, G. N., & Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Appl Physiol Nutr Metab*, *35*(6), 725-740. https://doi.org/10.1139/H10-079

Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: a systematic review. *Public Health*, *121*(12), 909-922. https://doi.org/10.1016/j.puhe.2007.04.009

Turrisi, T. B., Bittel, K. M., West, A. B., Hojjatinia, S., Mama, S. K., Lagoa, C. M., & Conroy, D. E. (2021). Seasons, weather, and device-measured movement behaviors: a scoping review from 2006 to 2020. *Int J Behav Nutr Phys Act*, *18*(1), 24. https://doi.org/10.1186/s12966-021-01091-1

van Dommelen, P., Coffeng, J. K., van der Ploeg, H. P., van der Beek, A. J., Boot, C. R., & Hendriksen, I. J. (2016). Objectively Measured Total and Occupational Sedentary Time in Three Work Settings. *PLoS One*, *11*(3), e0149951. https://doi.org/10.1371/journal.pone.0149951

Walsh, M. M., Krusmark, M. A., Jastrembski, T., Hansen, D. A., Honn, K. A., & Gunzelmann, G. (2023). Enhancing learning and retention through the distribution of practice repetitions across multiple sessions. *Mem Cognit*, *51*(2), 455-472. https://doi.org/10.3758/s13421-022-01361-8

Waters, C. N., Ling, E. P., Chu, A. H., Ng, S. H., Chia, A., Lim, Y. W., & Müller-Riemenschneider, F. (2016). Assessing and understanding sedentary behaviour in office-based working adults: a mixed-method approach. *BMC Public Health*, *16*, 360. https://doi.org/10.1186/s12889-016-3023-z

Werneck, A. O., Stubbs, B., Fernandes, R. A., Szwarcwald, C. L., & Silva, D. R. (2019). Leisure time physical activity reduces the association between TV-viewing and depressive symptoms: A large study among 59,401 Brazilian adults. *J Affect Disord*, *252*, 310-314. https://doi.org/10.1016/j.jad.2019.03.066

Zhou, L., Deng, X., Xu, M., Wu, Y., Shang, X., E, F.,…Li, X. (2023). The effects of active workstations on reducing work-specific sedentary time in office workers: a network meta-analysis of 23 randomized controlled trials. *Int J Behav Nutr Phys Act*, *20*(1), 92. https://doi.org/10.1186/s12966-023-01467-5

Zhou, Y., Huang, Z., Liu, Y., & Liu, D. (2024). The effect of replacing sedentary behavior with different intensities of physical activity on depression and anxiety in Chinese university students: an isotemporal substitution model. *BMC Public Health*, *24*(1), 1388. https://doi.org/10.1186/s12889-024-18914-y

Chapter VI
Study 4: Two-year follow-up on sit-stand desks use

Não nos tornamos aquilo que queremos, tornamo-nos aquilo que praticamos repetidamente.

Aristóteles

Chapter VI

What if you let them stand? A two-year follow-up on sit stand desk. *

Abstract

Objective: Excessive sitting-time is linked to adverse health outcomes, with sit-stand desk (SSD) emerging as effective workplace interventions. However, evidence on long-term impacts is scarce. This study evaluates the effects of SSD on physical behaviors after 18 and 24-months.

Methods: Ten office workers were analyzed: 5 after 18-months (G-18m) and 5 after 24-months (G-24m) of SSD usage. Physical behaviors—sitting, standing, stepping, and sit-to-stand transitions—were objectively measured using activPAL pre- and post-SSD implementation.

Results: Significant reductions in workplace sitting-time were observed: G-18m (-78.32min, $p=0.019$) and G-24m (-84.36min, $p<0.001$). Both groups increased standing and stepping during work hours. No changes occurred during leisure time ($p>0.05$).

Conclusion: SSD use was associated with sustained reductions in workplace sitting-time over 24-months, suggesting a potential role in long-term health promotion. These findings support SSD adoption and emphasize the need for larger-scale studies.

Keywords: Long-Term Intervention, Office Workers, Sedentary Behavior, Standing Desks, Work Setting.

*Silva, H., Teno, S. C., & Júdice, P. B. (2025). What if you let them stand? A two-year follow-up on sit stand desk. *Journal of occupational and environmental medicine*, 10.1097/JOM.0000000000003438. Advance online publication. https://doi.org/10.1097/JOM.0000000000003438

1. Introduction

Excessive sitting time (ST) is associated with adverse health outcomes such as cardiovascular disease, type II diabetes, some types of cancer, reduced cognitive function, health-related quality-of-life, depression, and even all-cause mortality (Katzmarzyk et al., 2019; Patterson et al., 2018; Saunders et al., 2020; Wang et al., 2019). Its deleterious impact seems to be independent of physical activity levels (Dogra & Stathokostas, 2012; Panahi & Tremblay, 2018). Interventions in the work environment to reduce and interrupt ST have been a common practice to find ways to diminish the burden of chronic disease in sedentary workers. These interventions can include physical environmental components (e.g., placement of sit-stand desk (SSD)), organizational components (e.g., the motivating role of management), and/or individual components (e.g., coaching) (Silva et al., 2024a; Wang et al., 2024).

We have previously reported the results of a clustered randomized controlled trial evaluating the effectiveness of a multicomponent 6-month intervention based on an adjustable SSD in the workplace (Júdice et al., 2024). On a 24 hour basis, the results indicated that the intervention group reduced ST (-44.0 min/day), prolonged sitting (>30 min) (-45.3 min/day), and increased standing time (+51.7 min/day) at 3 months. At 6 months, only the prolonged ST (>30 min) was significantly reduced by 26 min/day(Júdice et al., 2024). Furthermore, in a subsequent analysis where the ActivPAL data was analyzed during working hours and in the non-working time (i.e., leisure time) (Silva et al., 2024b), we found that in the intervention group, there was a significant reduction of ST at work by 33.0 min, along with a notable increase in standing time of 27.9 min. Moreover, a non-significant increase in ST in the leisure context of approximately 23.07 min was found after 6 months, showing that participants seem to somehow compensate the reduction during the work shift by increasing ST in the leisure time (Silva et al., 2024b).

There have been many interventions aiming to reduce ST through the usage of SSD (Nguyen et al., 2020; Shrestha et al., 2015; Shrestha et al., 2018; Zhou et al., 2023). A recent systematic review gathering information from several SSD-based interventions (Silva et al., 2024a) showed that reductions in ST at work were observed at 9 weeks (≅ 73.0 min/day), 3 months (≅ 88.0 min/day), 6 months (≅ 80.8 min/day), and 12 months (≅ 48.0 min/day), compared to the control group. However, most studies evaluated the impact of SSD during the trial period, with only a few examining the long-term effect off

*Silva, H., Teno, S. C., & Júdice, P. B. (2025). What if you let them stand? A two-year follow-up on sit stand desk. *Journal of occupational and environmental medicine*, 10.1097/JOM.0000000000003438. Advance online publication. https://doi.org/10.1097/JOM.0000000000003438

SSD, after the completion of the study and without the presence/stimulus of the researchers (i.e., phone messaging, motivational strategies). For example, in a follow-up study where the participants continued using the SSD for a year (Dutta et al., 2019), the findings for objectively measured ST at 12 months were small (-0.77 min/h, equivalent to -6.16 min/8h workday [p=0.17]) after having reached a reduction of -4.8 min/h, equivalent to -38.4 min/8h workday at the end of the intervention period [p<0.01]. Similarly, a 24-month follow-up study by(Nelson-Wong et al., 2021), carried out after the completion of the intervention period and without direct intervention or ongoing involvement from the investigators**,** reported a sustained reduction in ST during work, which at baseline was 439.5 min/day and after 24 months of follow-up, ST was 336.0 min/day.

There is a paucity of data on the long-term impact of SSD on workers physical behaviors, especially in a free-living perspective (Nguyen et al., 2020; Shrestha et al., 2018; Zhou et al., 2023), that is, following the intervention and without continued researcher involvement. Thus, the purpose of the current investigation was to assess the impact of SSD usage after a period of 12 to 18-month follow-up from the end of a 6-month SSD intervention (i.e., 18 to 24 months of SSD total usage), to determine how the presence of SSD can impact workers' physical behaviors long after participation in a SSD-based intervention. Moreover, we separated the analyses for the work setting and the leisure time, to be able to look at potential compensatory effects.

2. Method

2.1. Study design

The original study adhered to the CONSORT guidelines for cluster-randomized trials. It was designed as a parallel two-arm (1:1) randomized controlled trial with measurements taken at baseline and after 6 months of intervention. After the 6-month period, the waiting list control group started using the SSD. The entire protocol was previously published for detailed reference (Júdice et al., 2023). After the initial assessments, cluster randomization was performed using a random list generator (www.random.org) by a researcher not involved in the recruitment or data collection process. Different locations were used as units for randomization to minimize the risk of contamination. Efforts were made to balance the control and intervention groups regarding key factors such as daily ST, frequency of sit-to-stand transitions, body mass

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index (BMI), age, and gender distribution. Group allocation was communicated via email after the baseline assessments. Recruitment occurred between December 2022 and January 2023, with baseline data collected in February 2023.

This study represents a secondary analysis of the main study, using data from a subsample collected at two time points: baseline (before the implementation of SSD); and 24 months after baseline, allowing the evaluation of changes over time resulting from the use of SSD for a period of 18 months (G-18m) in half of the participants (i.e., originally from the control group), and for a period of 24 months (G-24m) in the other half of participants (i.e., originally from the intervention group).

2.2. Setting and Participants

A detailed description of the recruitment process has been provided previously (Júdice, Silva, et al., 2023). Office workers were recruited through university-wide promotions, such as banners, posters, and emails distributed within the institution. Researchers assessed the workspaces of interested participants to confirm they were appropriate for installing SSD. The inclusion criteria required participants to work at least 0.6 full-time equivalent, be over 20 years old, and spend at least 70% of their working hours in desk-related activities. Exclusion criteria consisted of workers already using an SSD; workers without a personal workspace where a SSD could be assembled; or workers with musculoskeletal disorders/health conditions inhibiting their ability to work in a standing position. Furthermore, individuals who worked from home were excluded due to the logistical complexities of providing two SSD per participant. For the follow-up phase, conducted 24 months after the initial intervention, only participants who had completed the intervention, maintained regular SSD use during that period and were available and willing to participate in the follow-up assessments were included. Participants who had discontinued SSD use or were unavailable for reassessment were excluded.

Amongst the 10 participants included in this study, the majority (6 participants) worked from 10:00 AM to 6:00 PM, while the remaining 4 worked from 9:00 AM to 5:00 PM.

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2.3. Participants that used the SSD for 24 months (G-24m)

In summary, participants in the G-24m group began the program with a psychoeducational session, followed by installing an SSD (Vinsetto, Model 923-043) at each participant's workstation. Before starting the intervention, personalized guidance was provided on how to gradually integrate the use of the SSD, including ergonomic posture recommendations and strategies to increase standing time progressively. Throughout the intervention, motivational reminders were applied to support participants in adopting and maintaining the new routine, considering challenges such as holidays. This strategy aimed to foster a sense of relatedness, competence, and autonomy, in line with the principles of Self-Determination Theory (Ryan & Deci, 2000), encouraging intrinsic motivation and promoting long-term sustainable behavioral change (Ng et al., 2012). The main goal of the session was to increase awareness and understanding of the benefits of change, as similar approaches have proven effective in facilitating behavioral modifications (Biddle et al., 2020).

After the initial 6-month intervention, participants continued using the SSD independently, without further motivational stimuli, for 18 months.

2.4. Participants that used the SSD for 18 months (G-18m)

The G-18m group participated in the same initial psychoeducational session. However, there were no changes to the work environment during the first 6 months (i.e., the group remained as a waiting list control group). After this period, participants began using the SSD. Like the G-24m group, motivational reminders were applied during the 6-month of intervention to support participants in adopting and maintaining the new routine. Following these 6 months of supervised intervention, participants continued using the SSD autonomously for an additional 12 months without any further stimuli and were evaluated at the end of this period.

2.5. Data Collection

Data on participants' sociodemographic characteristics was gathered through an online survey created using Qualtrics and all the biometric information evaluated by trained technicians as previously described (Júdice et al., 2023).

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The main outcomes from this study were assessed with an objective sensor, the ActivPAL device. In adherence to ethical guidelines, all collected data from this study is securely stored in a restricted-access folder, accessible exclusively to the research team.

2.6. Main Outcomes

The physical behaviors, including time spent sitting, standing, stepping, and transitions from sit-to-stand were objectively measured at baseline and 24-months later. Participants continuously wore the ActivPAL4 activity monitor (PAL Technologies Ltd., Glasgow, Scotland, UK) for 24 hours daily over seven consecutive days. Using a waterproof medical adhesive, a trained evaluator provided each participant with the ActivPAL device securely attached to the midpoint of their right thigh. Detailed procedures for this assessment are documented in a previous publication (Júdice, Silva, et al., 2023).

For this study, the analyses focused on five key variables: ST, standing time, stepping time, number of steps, and number of sit-to-stand transitions, assessed separately for working hours, leisure period, and for the overall 24 hours, based on valid monitored days and the specific work schedules reported by each participant.

2.7. Statistical Analyses

The statistical analyses were performed using PASW Statistics version 29.0.2.0 (SPSS Inc., an IBM Company, Chicago, IL, USA). To compare the groups at baseline (i.e., before SSD), independent-sample t-tests were employed. Repeated measures ANCOVA was performed with time (before and after SSD usage) as the within-subject factor and the intervention group (G-24m or G-18m) as the between-subject factor to evaluate the interaction effect of time and group on the measured outcomes. A significance threshold of 5% was applied to all analyses.

3. Results

Figure 1 illustrates the flow of participants throughout the study. After the initial assessments, participants were randomly allocated into two groups: the G-24m group, which began using the SSD immediately after the baseline measurement, and the G-18m group, which had no intervention (i.e., continued with their usual desk use) during the first 6 months and started using the SSD afterward. The G-24m group underwent 6

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months of intervention with prompts and 18 months of autonomous use. The G-18m group began with 6 months of using traditional desks, followed by 6 months of active prompts and SSD usage and 12 months of autonomous use.

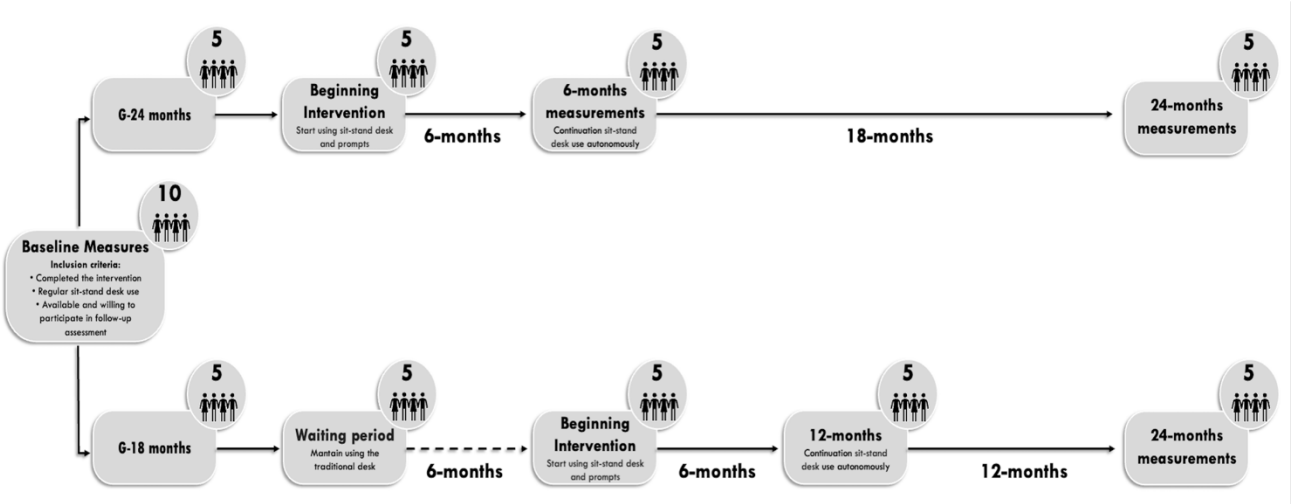

Figure 1 - Study flowchart and participant in action.

Table 1 summarizes the baseline characteristics of participants in the G-18m and G-24m groups. The sample included 10 participants (5 per group), with a mean age of 49.2 years (SD=5.4), predominantly women (90% overall). The participants had a mean of 21.8 years of service (SD=10.9) and worked an average of 8.2 hours per day (SD=1.9).

For smoking habits, 70% had never smoked, while 30% had previously smoked. Regarding the salary band, 10% reported facing very difficult conditions, 30% had sufficient income for their requirements, and 60% described their financial situation as comfortable.

In terms of education, 10% had a Ph.D., 10% held a master's degree, 40% had a bachelor's degree, and 40% had completed high school. Concerning chronic diseases, 20% of participants reported having a chronic disease, while 80% did not. The overall BMI was 30.8 kg/m² (SD=7.9). No significant differences were observed between the G-18m and G-24m groups for any variables ($p>0.05$).

Table 1 - Baseline (before SSD) characteristics by group: G-18 and G-24 months. Values are means (standard deviations), except for gender distribution.

Characteristics	G-18 months	G-24 months	Total
Sample size	(n=5)	(n=5)	(n=10)
Age (years)	52.2 (5.0)	46.2 (4.2)	49.2 (5.4)
Nº (%) women	5 (100.0%)	4 (80.0%)	9 (90.0%)
Years of Service	23.6 (13.1)	20.0 (9.5)	21.8 (10.9)
Working Hours	6.8 (0.5)	9.6 (1.8)	8.2 (1.9)
Smoking habits (%):			
Never smoked	80.0%	60.0%	70.0%
Previously smoked	20.0%	40.0%	30.0%
Salary band (%):			
Very difficult	0.0%	20.0%	10.0%
Sufficient for requirements	40.0%	20.0%	30.0%
Comfortable	60.0%	60.0%	60.0%
Education (%):			
Ph.D. Degree	0.0%	20.0%	10.0%
Master's Degree	20.0%	0.0%	10.0%
Bachelor's Degree	0.0%	80.0%	40.0%
High School	80.0%	0.0%	40.0%
Chronic Disease:			
Yes	20.0%	20.0%	20.0%
No	80.0%	80.0%	80.0%
Medication:			
Yes	40.0%	40.0%	40.0%
No	60.0%	60.0%	60.0%
Biometric measurements:			
Body weight (kg)	83.5 (18.5)	75.7 (16.5)	79.6 (19.2)
Height (m)	1.58 (0.1)	1.65 (0.1)	1.61 (0.1)
Body mass index (kg/m^2)	33.8 (7.8)	27.8 (7.5)	30.8 (7.9)

G-18 months, Group that used SSD for 18 months; G-24 months, Group that used SSD for 24 months; SSD, sit-stand desk.
Note: No differences were observed between groups ($p > 0.05$).

3.1. Changes in the workplace

The findings summarized in Table 2 reveal significant changes in sitting, standing, stepping, and transitions resulting from the use of SSD in the long-term. In the workplace, using SSD led to a substantial reduction in ST for both groups. The G-18m group reduced their ST by 78.32 min/workday (95% CI: -135.53 to -21.11; p=0.019), while the G-24m group achieved a reduction of 84.36 min/workday (95% CI: -111.49 to -57.23; p<0.001).

Standing time significantly increased in both groups. In the G-18m group, the increase was 76.46 min/workday (95% CI: 41.82 to 111.10; p=0.004), and in the G-24m group, it was 45.86 min/workday (95% CI: 3.14 to 88.58; p=0.041).

Stepping time significantly increased in both groups. In the G-18m group, there was a mean increase of 12.22 min/workday (95% CI: 0.60 to 23.84; p=0.004) corresponding to an increase in the number of steps of 1267.40 steps/work (95% CI: 31.45

to 2503.35; p=0.047), while the G-24m group showed a mean increase of 19.16 min/workday (95% CI: 3.46 to 34.86; p=0.028). Regarding the number of steps in the G-24m group, although there was an increase, it was not statistically significant (p>0.05). Additionally, no changes were found for the sit-to-stand transitions in both groups (p>0.05).

No significant differences were observed between the groups for any variables (p>0.05).

3.2. Changes in the leisure time

During the leisure time, no significant changes were observed for any of the physical behaviors, in either group (p>0.05).

No significant differences were observed between the groups for any variables (p>0.05).

3.3. Changes over 24 hours

Overall ST significantly decreased in the G-18m group, with a reduction of 83.86 min/day (95% CI: -129.45 to -38.27; p=0.007). Standing time significantly increased in the G-24m group by 61.16 min/day (95% CI: -31.90 to 90.42; p=0.004). Daily stepping significantly increased in the G-18m group by 24.84 min/day (95% CI: 12.67 to 37.02; p=0.005), corresponding to an additional 2001.42 steps/day (95% CI: -1058.32 to 2944.52; p=0.004).

No changes were observed within the groups for the other variables (p>0.05). Additionally, no differences were observed between groups for any variable, and no time × group interaction was found (p>0.05).

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Outcomes	Mean (SD) before SSD usage		Mean (SD) after long-term SSD usage		Mean Difference between moments		
	G-18 months (n=5)	G-24 months (n=5)	G-18 months (n=5)	G-24 months (n=5)	G-18 months (n=5)	Time p-value	G-24 months (n=5)
Work sitting time (min)	283.94 (66.40)	361.64 (46.48)	205.62 (87.01)	277.28 (59.09)	-78.32 (-135.53 to -21.11)	**0.019#**	-84.36 (-111.49 to -57
Work standing time (min)	159.24 (63.25)	98.66 (23.53)	235.70 (87.93)	144.52 (31.09)	76.46 (41.82 to 111.10)	**0.004#**	45.86 (3.14 to 88.5
Work stepping time (min)	55.22 (14.04)	40.90 (10.33)	67.44 (16.94)	60.06 (8.48)	12.22 (0.60 to 23.84)	**0.043#**	19.16 (3.46 to 34.8
Work number of steps	4574.10 (1112.21)	3772.20 (968.04)	5841.50 (1517.96)	5248.60 (1106.65)	1267.40 (31.45 to 2503.35)	**0.047#**	1476.40 (-595.52 t 3548.32)
Work number of sit to stand transitions	25.25 (9.83)	22.25 (2.44)	26.84 (5.88)	23.12 (4.00)	1.59 (-6.69 to 9.87)	0.622	0.87 (-5.14 to 6.88
Leisure sitting time (min)	130.76 (67.92)	132.36 (84.13)	125.22 (81.74)	98.93 (67.77)	-5.54 (-65.51 to 76.59)	0.839	-33.43 (-98.68 to 165
Leisure standing time (min)	138.57 (41.71)	143.35 (55.35)	118.20 (32.33)	158.65 (36.16)	-20.37 (-12.19 to 52.92)	0.157	15.30 (-77.09 to 46.3
Leisure stepping time (min)	30.57 (640)	56.68 (33.06)	43.19 (20.51)	49.68 (15.14)	12.64 (-32.05 to 6.80)	0.146	-7.00 (-25.00 to 39.0
Leisure number of steps	2241.10 (359.73)	4272.00 (3091.98)	2975.12 (1456.74)	4109.50 (1464.76)	734.02 (-2327.84 to 859.80)	0.270	-162.50 (-3677.51 t 4002.51)
Leisure number of sit to stand transitions	18.95 (9.40)	17.95 (3.58)	19.42 (8.14)	24.08 (7.25)	0.47 (-10.74 to 9.80)	0.905	6.13 (-14.16 to 1.90
24h sitting time (min)	414.70 (113.34)	494.00 (60.40)	330.84 (77.37)	376.21 (71.19)	-83.86 (-129.45 to -38.27)	**0.007#**	-117.79 (-260.94 to 25
24h standing time (min)	297.81 (82.20)	242.01 (34.83)	353.90 (111.50)	303.17 (23.86)	56.10 (-10.34 to 122.53)	0.079	61.16 (-31.90 to -90.
24h stepping time (min)	85.79 (16.93)	97.58 (39.99)	110.63 (24.15)	109.74 (23.02)	24.84 (12.67 to 37.02)	**0.005#**	12.16 (-26.21 to 50.3
24h number of steps	6815.20 (1448.33)	8044.20 (3624.04)	8816.62 (1947.78)	9358.10 (614.09)	2001.42 (-1058.32 to -2944.52)	**0.004#**	1313.90 (-2595.74 5223.54)
24h number of sit to stand transitions	44.20 (6.30)	40.20 (5.12)	46.26 (3.28)	47.20 (7.18)	2.06 (-5.49 to 9.61)	0.491	7.00 (-0.91 to 14.9

G-18 months, Group that used SSD for 18 months; G-24 months, Group that used SSD for 24 months; SSD, sit-stand desk.

Note: # significant time effect within group. No differences were observed between groups ($p > 0.05$).

Figures 2, 3 and 4 illustrate the individual response of participants to the long-term use of SSD, highlighting the variability in the parameters assessed, such as ST, standing time, stepping time, number of steps, and sit-to-stand transitions. Some variability was observed in the work environment, but mostly during the leisure time.

Overall, the data indicates that after 18 or 24 months of SSD use, most participants reduced their ST, with corresponding increases in standing time and, in some cases, stepping time. Nonetheless, individual changes show some variability, with some participants exhibiting modest changes or stability in their physical behaviors with time, especially in the leisure context.

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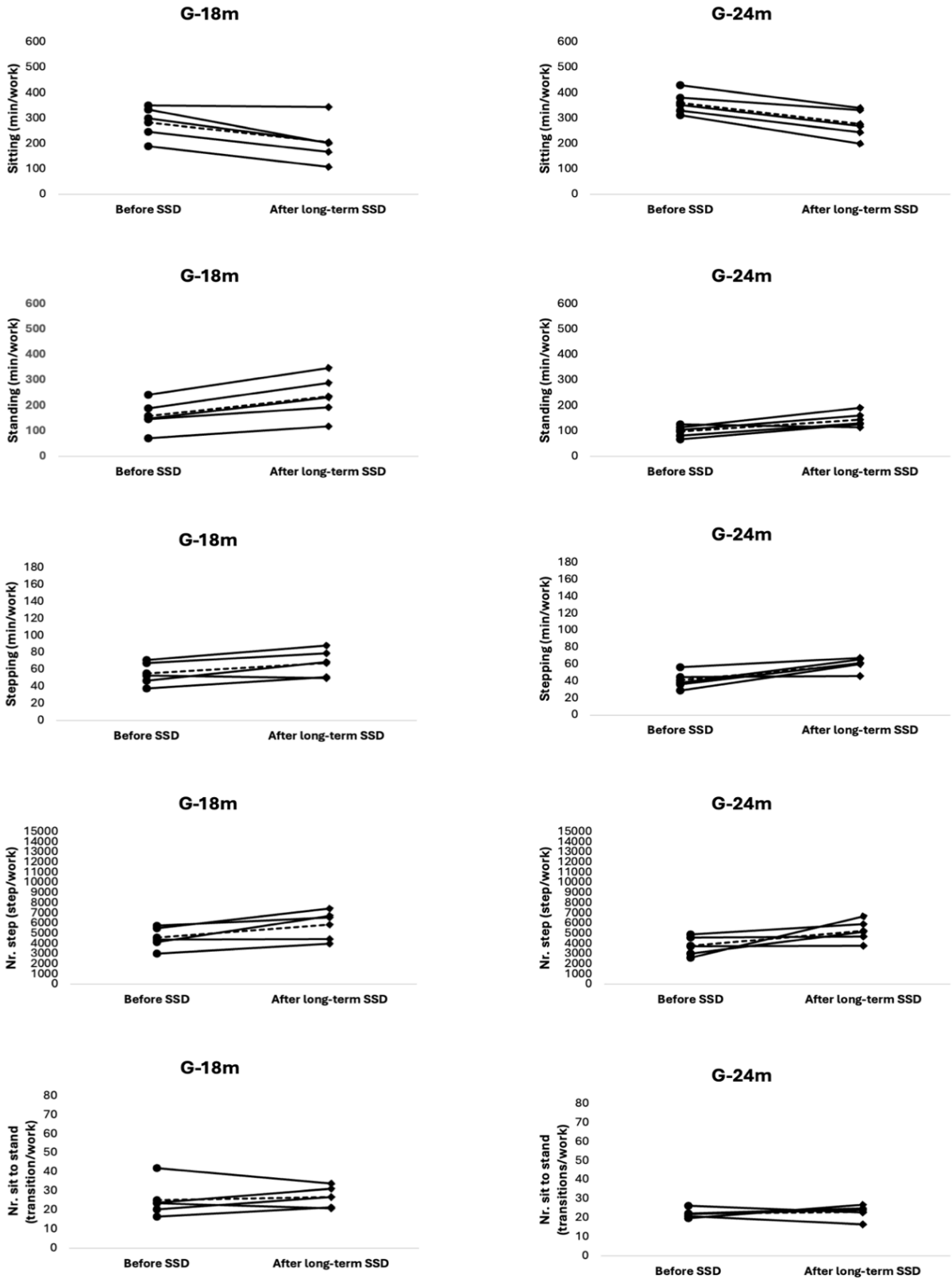

Figure 2 - Sitting time, standing time, stepping time, number of steps, and sit-to-stand transitions during working hours were assessed at baseline and after 24-months in the before SSD and after long-term SSD.

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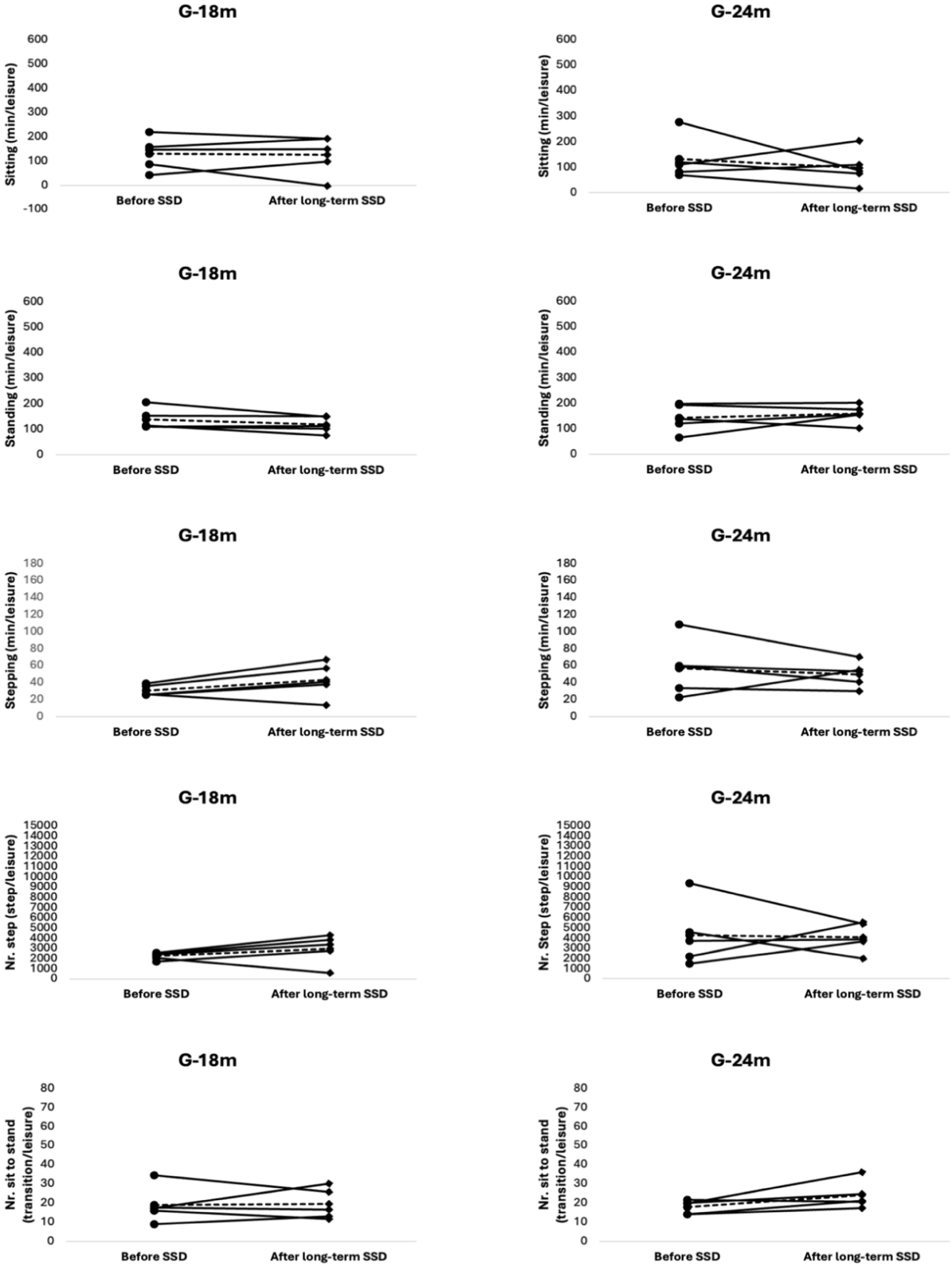

Figure 3 - Sitting time, standing time, stepping time, number of steps, and sit-to-stand transitions during leisure time were assessed at baseline and after 24-months in the before SSD and after long-term SSD.

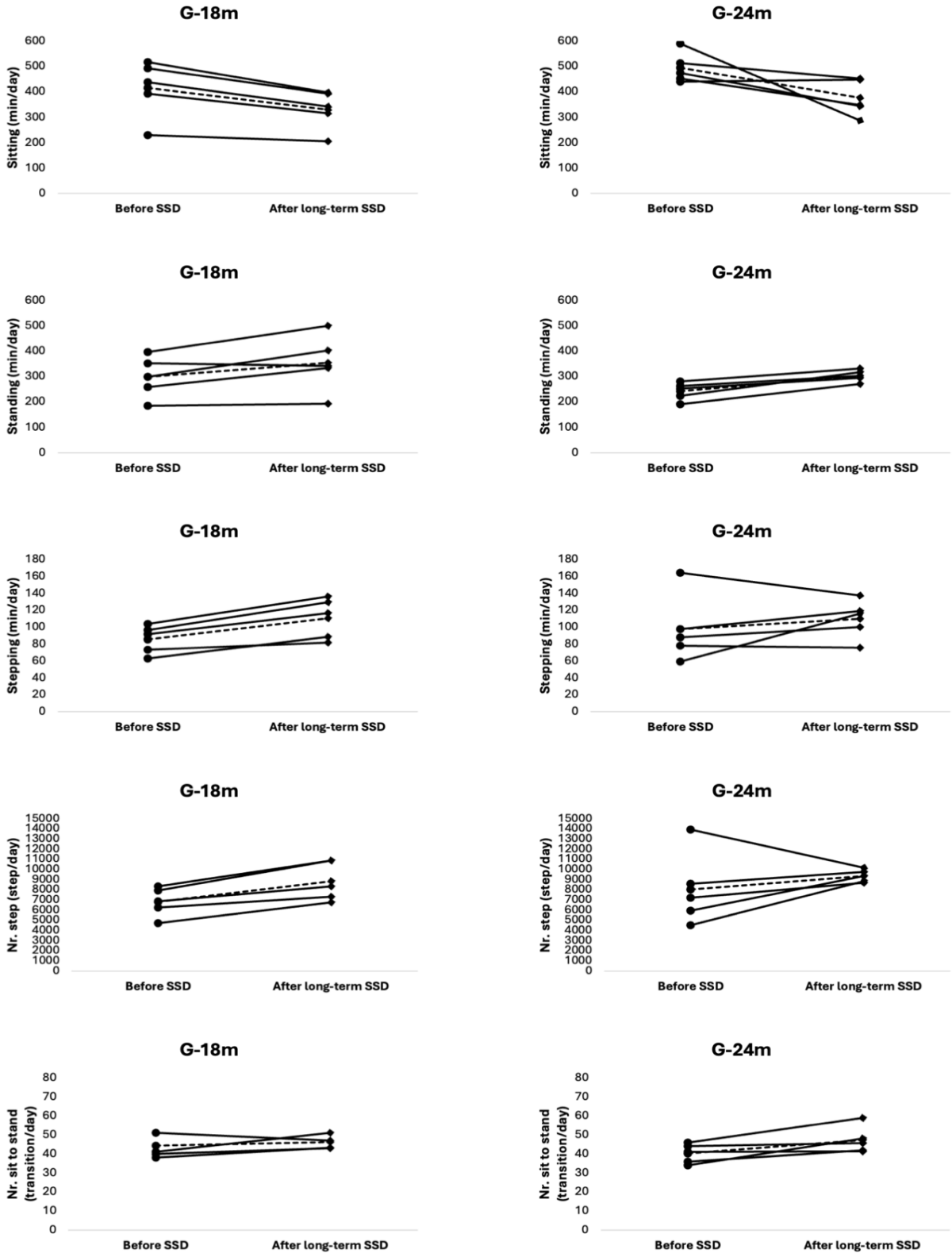

Figure 4 - Sitting time, standing time, stepping time, number of steps, and sit-to-stand transitions during 24 hours were assessed at baseline and after 24-months in the before SSD and after long-term SSD.

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4. Discussion

This study fills a critical gap in the literature by investigating the long-term effects of SSD interventions on workers' physical behaviors by considering a follow-up longer than 1-year and comparing groups that completed 18 and 24 months of SSD usage, respectively. While most research focuses on short and medium-term impact, this study provides valuable information on the sustained effects of SSD usage on physical behaviors at work, during leisure time, and over 24 hours.

Despite the small sample size, these results suggest a consistent long-term effectiveness of SSD in reducing ST and increasing physical activity in the workplace. Specifically, the G-18m group reduced ST by 78.32 min/workday, increased standing time by 76.46 min/workday, and showed modest but significant increases in stepping time (+12.22 min/workday) and the number of steps (+1267.40 steps/workday). Similarly, the G-24m group also reduced ST by 84.36 min/workday, increased standing time by 45.86 min/workday, and showed a rise in stepping time (+19.16 min/workday). These findings align with the results from medium-term interventions (until 12 months) (Dutta et al., 2019; Edwardson et al., 2022; Edwardson et al., 2018; Neuhaus, Eakin, et al., 2014; Shrestha et al., 2019; Stephens et al., 2019), that showed reductions ranging from 77 to 109.5 min/workday, confirming SSD as an effective workplace strategy to promote posture variation and reduce ST not only in the medium-term, but also when a longer period of time has passed, which is poorly explored in the literature.

Indeed, the long-term reductions in ST may reflect not only the initial novelty of the SSD but also an adaptation, as suggested by the review from Shrestha et al. (2019), which highlighted sustained behavioral changes in the few interventions exceeding 12 months. Key factors such as organizational support and individual motivation likely play crucial roles in consolidating healthier habits over time (Sharma et al., 2019; Silva et al., 2024a). Interestingly, when looking at the 6-month results from the ten participants in this study (data not presented here because part of this sample had already been analyzed in Silva, et al., (2024b)**,** our SSD-based intervention was associated with reductions in ST of 27.24 min/workday in the G-18m group and 40.24 min/workday in the G-24m group, accompanied by increases in standing time of 25.82 min/workday in the G-18m group and 39.88 min/workday in the G-24m group. These results align with those of Silva et al. (2024b), who reported a reduction in ST of 32.97 min/workday and an increase in standing time of 27.88 min/workday in the larger sample. Although the magnitude of

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changes shows slight variations, the similarity of results between this subsample and the overall sample suggest that the subsample analyzed can somehow be representative of the larger one and in this way, these findings may suggest that a longer period of time may be needed to effectively change physical behaviors of office workers, as the impact of SSD on physical behaviors after 18-24 months of SSD usage was larger than the ones at 6 months, even without interference (i.e., prompts or visits).

In contrast, SSD usage had a minimal impact on the leisure time behaviors. Neither group showed significant changes in ST, standing time, nor stepping time outside working hours, indicating that interventions focused solely on the workplace are not expected to alter physical behaviors during the leisure time, when a long-term analysis is performed. This finding corroborates previous studies encompassing a shorter period (Ball et al., 2010; Chau et al., 2012; Nguyen et al., 2020), highlighting the limitations of interventions restricted to specific contexts to change the reality in other domains. Personal routines, fatigue, and a preference for sedentary activities may contribute to the lack of changes during leisure hours. For example, in the study by Mansoubi et al. (2016), it was observed that, although SSD reduced ST during working hours, these changes did not extend to the leisure time, where compensatory ST was often adopted (Silva et al., 2024b). This highlights the challenges of promoting sustained behavioral changes outside the workplace, where personal routines, fatigue, and preferences for sedentary activities may limit the effectiveness of workplace interventions in a 24h basis. However, the good news is, that there seems to be no trend for compensatory behaviors in the leisure time, with no changes in this context.

The results over 24 hours reinforce this idea, by showing less consistent results, when compared to the one in the work setting. The G-18m group showed significant reductions in ST (-83.86 min/day) and increases in standing time (+56.10 min/day), and daily steps (+2001.42 steps/day). The G-24m group recorded a reduction in ST (-117.79 min/day), but this was not statistically significant, alongside significant increases in standing and stepping times. However, the G-24m group exhibited greater interindividual variability, reflecting a less homogeneous response to the intervention. Some participants showed ST reductions, while others experienced modest changes. Notably, the variability was also evident in the increased standing and stepping times. For example, standing time increased by 94.10 min/day in one participant, while another showed an increase of only 42.63 min/day. Similarly, stepping time changes ranged from a minimal increase of 2.46 min to a maximum of 56.41 min amongst participants. This suggests that, while some

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individuals experienced substantial improvements, others showed more discrete variations, indicating differences in the effectiveness of the intervention at an individual level (Silva et al., 2024c). This heterogeneity highlights the importance of understanding personal, environmental, and behavioral factors that may mediate individual responses to interventions, underscoring the need for tailored strategies to maximize their impact.
This context emphasizes the challenge of achieving similar levels of engagement and impact in broader, less motivated populations (Nelson-Wong et al., 2020). The evidence on the impact of SSD in periods exciding 12 months is almost non-existent, but one study conducted by Nelson-Wong et al. (2021), which also had a duration of 24 months, observed a reduction of 103.5 min/day, a result that aligns with our findings and that confirms the higher effectiveness of SSD interventions in the long-term. Conversely, the study by Konradt et al. (2022), which also had a duration of 24 months, reported that the positive effects of the SSD intervention at 6 months tended to diminish over time, indicating a possible loss of long-term impact.

As depicted in Figures 2, 3, and 4, individual variability in response to SSD interventions was evident. While several participants reduced ST, others displayed small increases, particularly during the leisure hours. Variability was also observed in standing and stepping times, emphasizing the need to explore mediators such as personal preferences, work environments, and support systems (Deery et al., 2024). Furthermore, this diversity of responses underscores the relevance of investigating additional mediators, such as individual lifestyle factors, psychological factors, and environmental conditions, which may play critical roles in modulating these outcomes (Silva et al., 2024a; Zhou et al., 2023).

Notably, in the G-18m group, there appeared to be greater interindividual variability in workplace behaviors compared to the G-24m group, indicating that behaviors or responses may take longer to stabilize. This finding is encouraging for long-term interventions, as extended exposure to SSD may lead to more consistent behavioral changes over time. Conversely, during leisure time, there appeared to be the opposite pattern; longer durations appeared to create greater variability in responses than at 18 months. In leisure settings, the G-24m group displayed more consistent trends in ST and stepping time, although variability remained when compared to workplace settings. The G-18m group showed more pronounced variability during leisure, likely influenced by unstructured environments and external barriers such as social or logistical constraints (Ojo et al., 2019). This highlights the complex nature of behavior change in unstructured

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settings and suggests that additional support or strategies may be needed to maintain consistent behavior changes during the leisure context. Future studies should aim to identify factors influencing these heterogeneous responses and develop tailored strategies to maximize benefits for diverse populations (Konradt et al., 2022; Silva et al., 2024b).

Finally, these findings reinforce the importance of adopting other strategies beyond the utilization of SSD in the workplace. Combining education with self-monitoring tools like activity trackers may help promote more active behaviors during the leisure time (Arguello et al., 2021). Tailored, comprehensive approaches but also a longer period of contact with SSD may be necessary to ensure SSD interventions achieve their full potential, thus more investigations considering SSD usage in the work setting for longer periods (i.e., 2 years or more) are needed to confirm the long-term impact of such interventions.

4.1. Strengths and Limitations

This study offers several strengths that include the objective data collection on participants' physical behavior and separation of work and non-work settings, but more important, the fact that spans a longer period of SSD usage, attaining 2 years of use. However, the study also has some limitations. Firstly, the somewhat small sample size, which may limit the robustness of the findings but also the fact that the majority were women, which limits generalizability of the results to the male population. Another important limitation is the absence of a control group at the 24-month follow-up**,** which restricts the ability to determine whether the observed effects are solely attributable to the intervention. Additionally, all participants who voluntarily participated in the follow-up were actively engaged with the intervention, which may introduce a selection bias, as those with greater motivation to continue using the SSD may have benefited more. However, as mentioned in the discussion (data not shown), the changes of this subsample at 6 months were like the ones from the larger sample, allowing to assume that these were not “a special group of workers”. Thus, despite the fragility of this study, the findings serve as a relevant indication for future studies to explore, while using a more diverse population and considering a higher sample size.

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4.2. Recommendations for Future Research

Future directions should consider the personalization of interventions, given the variability in participants' responses observed in this study. Introducing individualized strategies that consider personal preferences and each worker's challenges could improve adherence even further. Additionally, future research must investigate the mediators of this variability, such as psychosocial factors like intrinsic motivation and organizational support, to better understand the individual differences in adherence and effectiveness of SSD use. Furthermore, developing and integrating strategies to reduce ST outside of work seems crucial. Finally, more studies encompassing longer intervention/follow-up periods (i.e., > 2 years) are paramount to confirm or further extend these findings, especially in the male population.

5. Conclusion

This study suggests that the effectiveness of SSD in reducing ST and increasing standing time in the workplace can be comparable or even higher than in medium-term interventions, particularly when a period of 18 to 24 months of SSD usage was considered. These results highlight SSD as a practical and long-lasting tool for promoting occupational health and mitigating the risks of sedentary behavior. Adopting this strategy must be considered an essential part of a continuous plan to promote workplace health, but more long-term studies are needed to confirm these findings.

6. Reference

Arguello, D., Thorndike, A. N., Cloutier, G., Morton, A., Castaneda-Sceppa, C., & John, D. (2021). Effects of an "Active-Workstation" Cluster RCT on Daily Waking Physical Behaviors. *Med Sci Sports Exerc*, *53*(7), 1434-1445. https://doi.org/10.1249/MSS.0000000000002594

Ball, K., Jeffery, R. W., Abbott, G., McNaughton, S. A., & Crawford, D. (2010). Is healthy behavior contagious: associations of social norms with physical activity and healthy eating. *Int J Behav Nutr Phys Act*, *7*, 86. https://doi.org/10.1186/1479-5868-7-86

Biddle, S. J. H., O'Connell, S. E., Davies, M. J., Dunstan, D., Edwardson, C. L., Esliger, D. W.,…Munir, F. (2020). Reducing sitting at work: process evaluation of the

SMArT Work (Stand More At Work) intervention. *Trials*, *21*(1), 403. https://doi.org/10.1186/s13063-020-04300-7

Chau, J. Y., van der Ploeg, H. P., Merom, D., Chey, T., & Bauman, A. E. (2012). Cross-sectional associations between occupational and leisure time sitting, physical activity and obesity in working adults. *Prev Med*, *54*(3-4), 195-200. https://doi.org/10.1016/j.ypmed.2011.12.020

Deery, E., Buckley, J., Morris, M. *et al.* (2024). *Some People Sit, Some People Stand, That's Just What We Do* ": a Qualitative Exploration of Sit-Stand Desk Use in Naturalistic Settings. In. *Occup Health Sci*.

Dogra, S., & Stathokostas, L. (2012). Sedentary behavior and physical activity are independent predictors of successful aging in middle-aged and older adults. *J Aging Res*, *2012*, 190654. https://doi.org/10.1155/2012/190654

Dutta, N., Walton, T., & Pereira, M. A. (2019). One-year follow-up of a sit-stand workstation intervention to decrease sedentary time in office workers. *Prev Med Rep*, *13*, 277-280. https://doi.org/10.1016/j.pmedr.2019.01.008

Edwardson, C. L., Biddle, S. J. H., Clemes, S. A., Davies, M. J., Dunstan, D. W., Eborall, H.,…Clarke-Cornwell, A. M. (2022). Effectiveness of an intervention for reducing sitting time and improving health in office workers: three arm cluster randomised controlled trial. *BMJ*, *378*, e069288. https://doi.org/10.1136/bmj-2021-069288

Edwardson, C. L., Yates, T., Biddle, S. J. H., Davies, M. J., Dunstan, D. W., Esliger, D. W.,…Munir, F. (2018). Effectiveness of the Stand More AT (SMArT) Work intervention: cluster randomised controlled trial. *BMJ*, *363*, k3870. https://doi.org/10.1136/bmj.k3870

Júdice, P. B., Silva, H., Teno, S. C., & Hetherington-Rauth, M. (2024). The effectiveness of a 6-month intervention with sit-stand workstation in office workers: Results from the SUFHA cluster randomized controlled trial. *Work*. https://doi.org/10.3233/WOR-230624

Júdice, P. B., Silva, H., Teno, S. C., Monteiro, P., Silva, M. N., Carraça, E. V.,…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

Katzmarzyk, P. T., Powell, K. E., Jakicic, J. M., Troiano, R. P., Piercy, K., Tennant, B., & COMMITTEE*, P. A. G. A. (2019). Sedentary Behavior and Health: Update from the 2018 Physical Activity Guidelines Advisory Committee. *Med Sci Sports Exerc*, *51*(6), 1227-1241. https://doi.org/10.1249/MSS.0000000000001935

Konradt, U., Nath, A., Krys, S., & Heblich, F. (2022). Longitudinal Effects of a sit-stand desk intervention - persistence, Fade-Out, and psychological momentum: a Randomized Controlled Trial. *BMC Psychol*, *10*(1), 246. https://doi.org/10.1186/s40359-022-00948-9

Mansoubi, M., Pearson, N., Biddle, S. J., & Clemes, S. A. (2016). Using Sit-to-Stand Workstations in Offices: Is There a Compensation Effect? *Med Sci Sports Exerc*, *48*(4), 720-725. https://doi.org/10.1249/MSS.0000000000000802

Nelson-Wong, E., Corrigan, J., Mertz, P., Kutcher, S., Carlson, I., DiRocco, T., & Hall-Nelson, B. (2021). Office-workers maintain decreased workplace sitting time long-term following participation in a sit-stand desk intervention study. *Ergonomics*, 1-9. https://doi.org/10.1080/00140139.2021.1998647

Nelson-Wong, E., Gallagher, K., Johnson, E., Antonioli, C., Ferguson, A., Harris, S.,…Miller, J. B. (2020). Increasing standing tolerance in office workers with standing-induced back pain. *Ergonomics*, *63*(7), 804-817. https://doi.org/10.1080/00140139.2020.1761034

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

Ng, J. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Duda, J. L., & Williams, G. C. (2012). Self-Determination Theory Applied to Health Contexts: A Meta-Analysis. *Perspect Psychol Sci*, *7*(4), 325-340. https://doi.org/10.1177/1745691612447309

Nguyen, P., Le, L. K., Nguyen, D., Gao, L., Dunstan, D. W., & Moodie, M. (2020). The effectiveness of sedentary behaviour interventions on sitting time and screen time in children and adults: an umbrella review of systematic reviews. *Int J Behav Nutr Phys Act*, *17*(1), 117. https://doi.org/10.1186/s12966-020-01009-3

Ojo, S. O., Bailey, D. P., Hewson, D. J., & Chater, A. M. (2019). Perceived Barriers and Facilitators to Breaking Up Sitting Time among Desk-Based Office Workers: A

Qualitative Investigation Using the TDF and COM-B. *Int J Environ Res Public Health*, *16*(16). https://doi.org/10.3390/ijerph16162903

Panahi, S., & Tremblay, A. (2018). Sedentariness and Health: Is Sedentary Behavior More Than Just Physical Inactivity? *Front Public Health*, *6*, 258. https://doi.org/10.3389/fpubh.2018.00258

Patterson, R., McNamara, E., Tainio, M., de Sá, T. H., Smith, A. D., Sharp, S. J.,…Wijndaele, K. (2018). Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *Eur J Epidemiol*, *33*(9), 811-829. https://doi.org/10.1007/s10654-018-0380-1

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol*, *55*(1), 68-78. https://doi.org/10.1037//0003-066x.55.1.68

Saunders, T. J., McIsaac, T., Douillette, K., Gaulton, N., Hunter, S., Rhodes, R. E.,…Healy, G. N. (2020). Sedentary behaviour and health in adults: an overview of systematic reviews. *Appl Physiol Nutr Metab*, *45*(10 (Suppl. 2)), S197-S217. https://doi.org/10.1139/apnm-2020-0272

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. *Hum Factors*, *61*(5), 816-824. https://doi.org/10.1177/0018720818807043

Shrestha, N., Grgic, J., Wiesner, G., Parker, A., Podnar, H., Bennie, J. A.,…Pedisic, Z. (2019). Effectiveness of interventions for reducing non-occupational sedentary behaviour in adults and older adults: a systematic review and meta-analysis. *Br J Sports Med*, *53*(19), 1206-1213. https://doi.org/10.1136/bjsports-2017-098270

Shrestha, N., Ijaz, S., Kukkonen-Harjula, K. T., Kumar, S., & Nwankwo, C. P. (2015). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *1*, Cd010912. https://doi.org/10.1002/14651858.CD010912.pub2

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Pedisic, Z. (2018). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *6*(6), Cd010912. https://doi.org/10.1002/14651858.CD010912.pub4

Silva, H., G F Ramos, P., Teno, S. C., & Júdice, P. B. (2024c). Impact of a 6-month sit-stand desk-based intervention on regional musculoskeletal discomfort and

overall post-work fatigue in office workers: a cluster randomised controlled trial. *Ergonomics*, 1-14. https://doi.org/10.1080/00140139.2024.2414197

Silva, H., Ramos, P. G. F., Teno, S. C., & Júdice, P. B. (2024a). The Impact of Sit-Stand Desks on Full-Day and Work-Based Sedentary Behavior of Office Workers: A Systematic Review. *Hum Factors*, 187208241305591. https://doi.org/10.1177/00187208241305591

Silva, H., Teno, S. C., & Júdice, P. B. (2024b). Are there compensatory behaviors in response to a sit-stand desk intervention? *J Occup Health*. https://doi.org/10.1093/joccuh/uiae067

Stephens, S. K., Winkler, E. A. H., Eakin, E. G., Clark, B. K., Owen, N., Moodie, M.,…Healy, G. N. (2019). Temporal features of sitting, standing and stepping changes in a cluster-randomised controlled trial of a workplace sitting-reduction intervention. *Int J Behav Nutr Phys Act*, *16*(1), 111. https://doi.org/10.1186/s12966-019-0879-1

Wang, C., Lu, E. Y., Sun, W., Chang, J. R., & Tsang, H. W. H. (2024). Effectiveness of interventions on sedentary behaviors in office workers: a systematic review and meta-analysis. *Public Health*, *230*, 45-51. https://doi.org/10.1016/j.puhe.2024.02.013

Wang, X., Li, Y., & Fan, H. (2019). The associations between screen time-based sedentary behavior and depression: a systematic review and meta-analysis. *BMC Public Health*, *19*(1), 1524. https://doi.org/10.1186/s12889-019-7904-9

Zhou, L., Deng, X., Xu, M., Wu, Y., Shang, X., E, F.,…Li, X. (2023). The effects of active workstations on reducing work-specific sedentary time in office workers: a network meta-analysis of 23 randomized controlled trials. *Int J Behav Nutr Phys Act*, *20*(1), 92. https://doi.org/10.1186/s12966-023-01467-5

Chapter VII

General results and conclusion

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1. General results and conclusion

This chapter presents an integrated reflection on the main findings of this thesis, considering their theoretical, methodological, and applied contributions considering the general objectives that guided the research. To provide a coherent and critical narrative, the discussion is organized around three core analytical dimensions: (1) temporal, examining the effects of interventions over short, medium, and long-term; (2) contextual, distinguishing between work and leisure settings; and (3) strategic, exploring the impact of combining educational, behavioral, and organizational components, particularly regarding the timing of integration of psychoeducational sessions.

The discussion begins with synthesizing results from the four studies conducted: one systematic review and three experimental studies implemented in ecological settings. This structure provides a comprehensive overview of the effectiveness of sit-stand desks (SSD) in reducing sedentary behavior (SB) among office workers. It also establishes a basis for broader reflections on intervention strategies.

Study 1, the systematic review, provided the conceptual foundation for this thesis by synthesizing evidence on SSD interventions and quantifying their impact on workday and full-day SB. The meta-analytic results indicated average reductions in full-day SB of 68.7 minutes/day at 3 months, 77.7 minutes/day at 6 months, and 62.1 minutes/day at 12 months relative to control. These reductions were more substantial during working hours: 88.0 minutes/workday at 3 months and 80.8 minutes/workday at 6 months, except for the long-term, with a 48.0 minutes/workday average reduction at 12 months.

These findings are in line with previous literature demonstrating the effectiveness of SSD in promoting reductions of SB in occupational contexts (Edwardson et al., 2023; Ekelund, Tarp, et al., 2019; Shrestha et al., 2018b; Zhou et al., 2023). The findings reveal a consistent pattern: SSD interventions result in meaningful reductions in SB during working hours and, to a lesser extent, throughout the entire day, particularly in the short and medium term. The comparatively smaller reductions in overall daily SB suggest the potential presence of compensatory behaviors during non-working hours. Several studies have documented that individuals who reduce sitting time (ST) at work may subsequently increase ST during leisure hours, potentially as a form of physical or mental recovery

(Chau et al., 2014; Mansfeldt & Magkos, 2023; Neuhaus, Eakin, et al., 2014). This compensation effect may undermine the overall effectiveness of workplace interventions when SB is assessed across the full-day.

Supporting this interpretation, longitudinal evidence has shown that increased activity during working hours may be offset by prolonged sitting post-work, thereby attenuating net behavioral improvements (Mansfeldt & Magkos, 2023; Mansoubi et al., 2016). A 6-month intervention involving SSD usage confirmed this trend, emphasizing the need to consider daily activity patterns in their entirety, not just within the work domain (Compernolle et al., 2019; Silva et al., 2024b). Thus, a comprehensive, multilevel strategy is required to mitigate these compensatory effects and extend the intervention benefits beyond the workplace. At the individual level, various behavioral supports—personalized coaching, telephone-based follow-up, and motivational environmental prompts (e.g., posters, signs, reminders), may promote sustained behavior change (Zhou et al., 2023).

At the organizational level, strategies such as educational workshops, workplace visits, and physiotherapy appointments effectively create a culture of health and well-being (Edwardson et al., 2022). These organizational supports can reinforce individual efforts and promote collective engagement in health-oriented routines. Moreover, with increasing evidence that prolonged sitting is harmful regardless of physical activity levels (Buckley et al., 2015), developing sustainable, multicomponent interventions is not only timely but necessary. When strategically timed and well-integrated, psychoeducational sessions can enhance awareness, support behavior maintenance, and strengthen employee commitment.

1.1. Temporal Dimension of Intervention Effects

To address the temporal dynamics of SSD-based interventions, we structured the analysis around short (3 months), medium (6 months), and long-term (18–24 months) outcomes across three empirical studies. This approach enables a comprehensive understanding of how the effectiveness of SSD interventions evolves, as well as the persistence and variability of behavioral change.

This multi-temporal approach was particularly relevant given that results from a previous study conducted under the SUFHA project “The effectiveness of a 6-month

intervention with sit-stand workstation in office workers: Results from the SUFHA cluster randomized controlled trial", had revealed non-significant changes in 24 hour SB (Júdice et al., 2024). This prompted further investigation into whether more consistent effects could be observed during working hours and whether potential compensatory behaviors may exist during the leisure time.

Evidence from study 3, a 3-month intervention, which compared SSD interventions following psychoeducational (PE) sessions delivered either immediately before (PE-0) or 6 months earlier (PE-6), revealed a more substantial impact when the session was recent. The PE-0 group showed a 44.20 min/day reduction in ST ($p < 0.05$) compared to 33.20 min/day in the PE-6 group ($p > 0.05$). This supports the idea that the timing of informational input plays a critical role in the initial effectiveness of SSD interventions.

Moreover, reductions in prolonged ST (bouts ≥60 min) were more pronounced in the PE-0 group (-27.60 min/day, $p < 0.05$) vs. -5.70 min/day in PE-6 ($p > 0.05$), reinforcing that timely psychoeducational input may improve health outcomes by targeting the most harmful sitting patterns. Increases in standing time were also substantially higher in PE-0 (+47.2 min/day, $p < 0.05$) than in PE-6 (+11.9 min/day, $p > 0.05$), suggesting reduced ST and increased adoption of healthier alternatives.

These findings align with prior studies (Edwardson et al., 2018; MacEwen et al., 2017; Shrestha et al., 2016) and highlight the role of novelty and memory retention in short-term behavior change. Júdice et al. (2024) further confirm that significant reductions in ST can be achieved in 3 months but may not be maintained without strategic reinforcement.

As found in our study, the greater reduction in ST when preceded by a psychoeducational session may be attributed to heightened awareness of the health benefits communicated during the session, an effect likely to motivate behavioral change. Although motivation was not directly measured, its influence cannot be ruled out. Most of the literature supports the significant impact of SSD interventions preceded by psychoeducational sessions, reporting reductions in ST ranging from 33.50 to 117.10 min/day over 3-months (Arguello et al., 2021; Dutta et al., 2014; Edwardson et al., 2022; Edwardson et al., 2018; Healy et al., 2016; MacEwen et al., 2017; Shrestha et al., 2016; Stephens et al., 2019). These results align with our findings, which uniquely isolated the

effect of the timing of the psychoeducational session. The observed amplification in ST reduction among participants who received the session more recently suggests a time-sensitive mechanism. As this was the first study to test the temporal positioning of the session, further research is warranted better to understand the independent and synergistic effects of psychoeducational timing.

The effectiveness of a 6-month intervention using SSD was assessed in study 2, focusing on temporal changes in SB. The findings revealed a significant reduction in ST and a corresponding increase in standing time among participants in the intervention group ($p < 0.05$), although the time*group interaction was not statistically significant ($p > 0.05$). Nonetheless, the intervention group reduced ST by approximately 30 min/workday compared to the control group, echoing previous mid-term findings (Dutta et al., 2014; Edwardson et al., 2018). Despite the lack of significant interaction effects, these changes may still carry important clinical implications (Del Pozo-Cruz et al., 2018; Sadarangani et al., 2023).

This pattern is consistent with other SSD-based interventions of similar duration. For example, a multicomponent 6-month intervention reported by (Edwardson et al., 2018) achieved a reduction of 68.34 min/workday, although it also noted an increase in sitting during non-work hours. Similarly, Healy et al. (2016) found meaningful medium-term reductions despite the potential for behavioral compensation. Moreover, our results align with findings from Nguyen et al. (2020), whose systematic review identified average reductions of 29.96 min/day in SSD interventions over comparable time frames. These converging results suggest that SSD interventions effectively reduce ST during the medium term, though sustainability beyond this window remains a challenge.

Study 4 addressed the long-term impact of SSD interventions by examining behavioral outcomes after 18 and 24 months of continued use. This follow-up extends beyond the timeframes commonly studied in the literature, providing new evidence on the durability of SSD effects (Nelson-Wong et al., 2021; Konradt et al., 2022). Despite the small sample size, results showed that both groups G-18m and G-24m, achieved substantial and sustained reductions in ST during working hours (−78.32 and −84.36 min/day, respectively), corresponding increases in standing time. These changes exceeded those observed at 6 months (Silva et al., 2024b), suggesting that more prolonged

exposure to SSD may enhance behavior change, even in the absence of continued prompts or external reinforcement (Sharma et al., 2019; Shrestha et al., 2019).

These findings align with prior medium-term research (Dutta et al., 2014; Edwardson et al., 2018; Healy et al., 2016) but are particularly significant given the scarcity of studies extending beyond one year. They suggest SSD can support long-term improvements in occupational and physical behavior, reinforcing their value as a sustainable workplace intervention (Silva et al., 2024a; Zhou et al., 2023).

In contrast, no meaningful changes were observed during leisure time, reflecting the contextual limits of workplace-focused interventions. As seen in earlier studies (Chau et al., 2012; Mansoubi et al., 2016; Nguyen et al., 2020), leisure time behavior appears resistant to change, potentially due to factors such as fatigue, habit, or lack of environmental support (Ball et al., 2010). When analyzed over 24 hours, results were less consistent. Although G-18m showed significant reductions in total sitting and increases in daily steps, G-24m responses were more heterogeneous. This variability underscores the importance of individual, environmental, and organizational factors in shaping long-term adherence and effectiveness (Deery et al., 2024; Silva et al., 2024a).

These findings reinforce the need for personalized, multicomponent strategies that combine SSD use with behavioral supports targeting both work and leisure contexts (Arguello et al., 2021; Zhou et al., 2023). More importantly, the considerable inter-individual variability observed, evident from the divergent changes in ST and standing time among participants, confirms that a one-size-fits-all approach may not be effective. For example, trajectories in study 2 show that while some participants reduced ST markedly, others remained unchanged or even increased their ST. This diversity underscores the need to tailor interventions to individual profiles.

Recent studies by Grant et al. (2025) demonstrate that day-to-day fluctuations in ST further complicate this heterogeneity. These insights suggest that personalized strategies should be flexible and adaptive, potentially incorporating real-time feedback or digital tools that adjust goals and prompts based on an individual's daily patterns. Behavioral framework such as Self-Determination Theory (Ryan & Deci, 2000) can guide the design of such interventions by fostering autonomy, competence, and intrinsic motivation. Furthermore, compensatory behaviors during leisure time, whereby some participants offset workplace gains by increasing SB after work (Silva et al., 2024a),

highlight the importance of addressing ST across occupational and non-occupational contexts.

Extended intervention periods further support personalization: longer durations allow individuals to experiment, refine strategies, and internalize behavioral (Nelson-Wong et al., 2021; Ojo et al., 2019). Future research should validate adaptive, tailored frameworks across diverse occupational settings and populations to ensure broader applicability and sustained effectiveness.

1.2. Contextual Analysis – Critical reflection across medium and long-term

The comparative analysis between study 2 (6 months) and study 4 (18–24 months) highlights a robust and sustained impact of SSD on reducing SB during working hours. In both timeframes, participants consistently demonstrated reductions in ST and increases in standing time, benefits that not only persisted but intensified with more prolonged exposure, even without ongoing prompts (Edwardson et al., 2018; Silva et al., 2024a). This trajectory suggests that SSD interventions may foster the gradual internalization of postural change as a routine part of occupational behavior.

However, the persistent absence of effects during leisure time in both studies reveals a clear contextual boundary. These results are aligned with prior evidence showing that interventions limited to the workplace rarely generalize to unstructured, autonomous environments such as the leisure time (Ball et al., 2010; Chau et al., 2012; Nguyen et al., 2020). This points to the limits of context-specific behavior change models and underscores the role of situational affordances, environmental cues, and social modelling in shaping outcomes (Graves et al., 2015).

A more nuanced contrast emerges in compensatory behavior. In study 2, an upward trend in leisure time ST was observed (though not statistically significant), suggesting short-term compensation potentially driven by fatigue or a psychological licensing effect (Henderson et al., 2018; Mansoubi et al., 2016). In study 4, this trend was absent, indicating that long-term SSD exposure may reduce the tendency to compensate post-work. This is consistent with theories of habit formation and behavioral internalization (Gardner et al., 2014) and may reflect the transition from extrinsically regulated behaviors (prompt-driven) to more autonomous routines (Ryan & Deci, 2000).

From a Self-Determination Theory perspective, this shift could be interpreted as a gradual move toward identified or integrated regulation, in which standing and postural variation are no longer externally motivated but embedded into one's routine work identity (Deci & Deci, 2008). While these processes were not directly measured, they offer a compelling lens to interpret the sustainability of work-time changes and the reduction in leisure time compensation.

Notably, both studies highlight the absence of intentional targeting of leisure time behavior, which may explain the lack of observed changes. The interventions were not designed to extend beyond the occupational domain thus, the silence in leisure time outcomes may reflect intervention scope rather than inefficacy. As such, it remains uncertain whether changes in leisure ST could be achieved with additional environmental or behavioral strategies (Arguello et al., 2021; Zhou et al., 2023).

These findings support a dual-context approach for future interventions. Strategies might include: (a) integrating wearable self-monitoring technologies (Del Pozo-Cruz et al., 2018), (b) embedding post-work prompts, and (c) applying behavior change techniques (e.g., action planning and goal setting) that explicitly target out-of-work routines (Michie et al., 2011). Moreover, future studies should incorporate mediators and moderators, such as perceived fatigue, social norms, or motivational regulation types to better explain individual variability and behavioral spillover (Deery et al., 2024; Silva et al., 2024b).

This thesis also underscores the scientific and practical importance of acknowledging and analyzing interindividual variability in behavioral response. Across Studies 2, 3, and 4, heterogeneity in reductions of ST and changes in standing and stepping behaviors reveal that SSD interventions do not produce uniform outcomes. This variability may be influenced by a constellation of personal (e.g., motivation, beliefs, health status), organizational (e.g., leadership support, physical environment), and contextual factors (e.g., workload, schedule flexibility) (Ojo et al., 2018; Zhou et al., 2023). Future research can develop more tailored, adaptive interventions that optimize effectiveness for diverse worker profiles by identifying and studying these moderators and mediators. Such personalization is critical for ethical and inclusive practice and maximizing public health impact and resource efficiency (Deery et al., 2024; Silva et al., 2024).

Figure 1 below illustrates the spatial evolution of SSD allocation across the institution during the project. It shows the progressive dissemination of SSD over four distinct phases 0–6 months, 6–9 months, 9–24 months, and the current distribution. Initially limited to a central area of the university, SSD gradually expanded into diverse departments and buildings. This spatial transition reflects the organic growth and normalization of active workstations, reinforcing institutional adoption and equity of access.

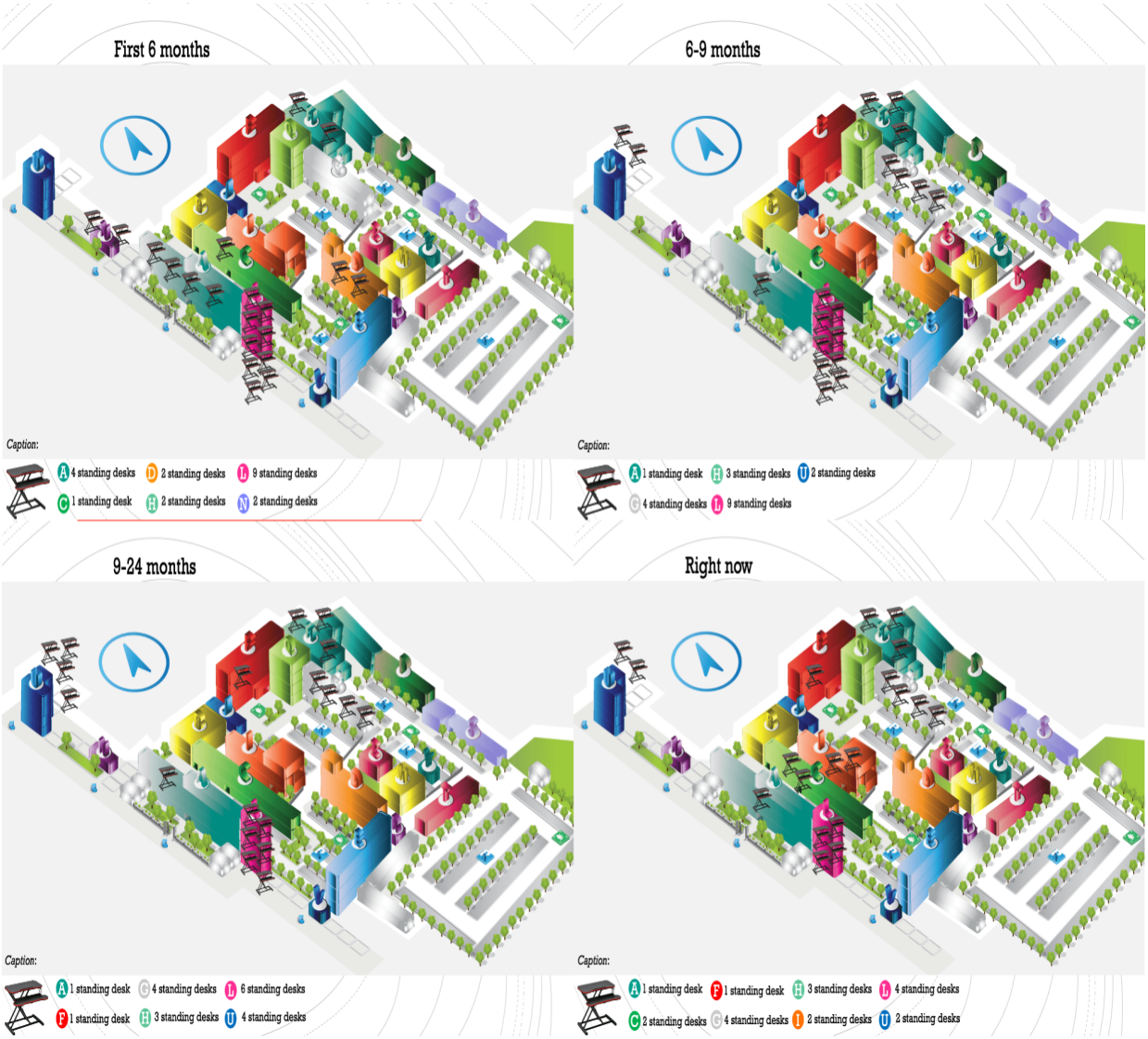

Figure 1 - Spatiotemporal deployment of SSD across the institution.

1.3. Strategic Analysis: Educational, Behavioral, and Organizational Integration

Study 3 offers a valuable opportunity to critically examine the strategic configuration of SSD interventions through the lens of educational, behavioral, and organizational components. The comparison between groups receiving a psychoeducational session immediately before (PE-0) versus six months prior (PE-6) allows for an isolated analysis of timing as a core determinant of behavioral efficacy. This study contributes to an underexplored area in the SSD literature: the temporal alignment of educational content and behavioral tools.

At the educational level**,** the findings highlight the power of knowledge timing. The superior outcomes in the PE-0 group reinforce the principle of "just-in-time" education, which enhances recall, relevance, and application (Hanham et al., 2023). These effects are consistent with the behavior change technique taxonomy, particularly mechanisms related to "instruction on how to perform the behavior," "prompting practice," and "information about health consequences" (Michie et al., 2011).

At the behavioral level, emerging literature underscores that breaking up ST through frequent interruptions yields greater cardiometabolic and psychological benefits than merely reducing the total duration of ST (Biswas et al., 2015; Zhou et al., 2023). Our findings suggest that immediate educational reinforcement may heighten awareness of the risks of uninterrupted sitting, leading to more effective disruption of prolonged bouts. Although motivation was not directly measured, the data suggest enhanced readiness to act and potentially stronger habit formation in the PE-0 group. Theoretical models like the COM-B system (Capability, Opportunity, Motivation, → Behavior) offer a valuable lens to interpret this mechanism, wherein timely education boosts both psychological capability and motivation (West et al., 2020).

From an organizational strategy standpoint, study 3 also implies that SSD interventions cannot be isolated events. Although the psychoeducational component alone can influence outcomes, its impact is significantly magnified when temporally aligned with access to the device. This calls for strategic synchronization of environmental restructuring (i.e., installing SSD) and organizational education. Interventions such as those by Brierley et al. (2022) and Deery et al. (2024) similarly report higher engagement and adherence when SSD are deployed immediately after educational workshops due to heightened salience and behavioral intent. These

observations resonate with implementation science, emphasizing the need for congruence between organizational readiness, resource allocation, and timing. Recent implementation science frameworks, such as implementation mapping, emphasize the importance of aligning organizational readiness, resource allocation, and timing to sustain workplace interventions aimed at reducing ST (Watson et al., 2022). These considerations are further supported by qualitative research showing that employees may feel uncertain about how and when to use SSD without clear organizational support and guidance. For instance, Wilkerson et al. (2021) found that employees perceived prolonged sitting as unhealthy but felt constrained by cultural or social norms, limiting their willingness to stand. Similarly, Deery et al. (2024) reported that a lack of prompts, ambiguous expectations, or perceived judgment from colleagues often influenced employees' choices to sit or stand. These insights highlight the importance of integrating educational efforts with explicit organizational signals and cultural alignment to ensure SSD are available and effectively adopted and sustained.

Importantly, this study also brings forward practical insights for policy and practice. First, it suggests that psychoeducational sessions are a valuable supplement and an essential strategic component of SSD interventions. Second, even minimal education, as shown by Alkhajah et al. (2012), who reported substantial behavioral changes following a 2-minute brief intervention can produce meaningful effects, particularly when delivered in a timely and contextually relevant manner.

However, more elaborate and proximal sessions seem to yield superior outcomes. Third, delayed delivery of educational content, as in PE-6, may still lead to behavioral improvements but fails to reach the same magnitude and depth of change, particularly in high-risk behaviors like prolonged ST.

In conclusion, integrating educational, behavioral, and organizational components in SSD interventions is not merely additive but synergistic. Timing emerges as a central strategic element that shapes health behavior change's reach, effectiveness, and sustainability. Future SSD initiatives should prioritize this alignment, ensuring that psychoeducational input is delivered near intervention onset, and should explore the inclusion of booster sessions or digital reinforcements to sustain engagement over time.

These findings contribute to the field by clarifying the boundaries of effectiveness for workplace SB interventions and emphasizing the importance of contextual and temporal tailoring in intervention design.

Each study was discussed in detail in its respective chapter. This final section aims to integrate the thesis's main empirical and conceptual contributions, reflecting on their implications for the development of effective behavioral interventions, the design of occupational health policies, and methodological advancements in the study of ST.

1.4. Implications for Practice and Future Directions

The findings from this thesis provide a significant contribution to the implementation of sustained health promotion strategies in occupational settings, with a particular focus on reducing SB among office workers. The evidence generated across the four studies demonstrates that SSD is an effective tool, particularly when integrated into multicomponent interventions tailored to each workplace's temporal, contextual, and individual specificities.

The first study, a systematic review, revealed substantial reductions in ST during working hours and throughout the day, especially within the first 6 to 12 months. These results support the importance of complementing SSD implementation with additional strategies, such as psychoeducational sessions, alerting software, or face-to-face meetings, to maximize impact. This integrated approach improves working conditions and employee well-being and represents a meaningful public health intervention opportunity. The scarcity of studies conducted in Southern European countries highlights the urgency of expanding research into more diverse cultural and organizational contexts (Silva et al., 2024b).

The second study, a six-month ecological intervention, confirmed the effectiveness of SSD in reducing ST at work but also identified a compensatory increase in SB during leisure time. This phenomenon underscores the limitation of workplace-only interventions and highlights the need for broader strategies. Integrating activity-tracking technologies, personalized movement challenges, and educational campaigns on the health risks of SB may help mitigate these compensatory effects (Arguello et al., 2021; Mansfeldt & Magkos, 2023).

The third study emphasized the strategic importance of timing in delivering psychoeducational sessions. Sessions held immediately before the provision of SSD resulted in more pronounced behavioral changes compared to those delivered several months earlier. This finding reinforces the value of "just-in-time" education, which enhances knowledge retention and application (Hanham et al., 2023). Thus, synchronizing educational, organizational, and environmental components is critical. Future research should test optimal frequency, duration, and modality (e.g., in-person, hybrid, or asynchronous) for these sessions (Michie et al., 2011).

The fourth study explored the sustainability of behavioral changes over 18 to 24 months, showing that participants maintained significant reductions in workplace SB even without continued prompts. However, interindividual variability and the lack of impact during leisure time highlight the need for personalized interventions and exploring psychosocial mediators such as intrinsic motivation and organizational support (Deery et al., 2024; Ryan & Deci, 2000).

Based on these conclusions, future interventions should focus on the following strategic axes:

1. Leadership engagement and cultural alignment: Leadership training and explicit workplace policies that support active environments are essential to legitimizing and normalizing healthy behaviors.
2. Continuous support infrastructure: Endorsement from management, peer modelling, and regular feedback loops are crucial to sustaining new habits (Sharma et al., 2019)
3. Integration beyond the workplace: Interventions effective during working hours should not be considered self-sufficient. Strategies must also promote active behaviors during non-working periods.
4. Personalization and adaptive intervention design: Given the significant variability in individual responses, it is advisable to design adaptive interventions based on continuous monitoring data. The use of digital tools, such as coaching platforms or algorithms that adjust recommendations in real time, can enhance the effectiveness of these interventions (Nahum-Shani et al., 2018).

5. Methodological rigor and long-term focus: Future studies should adopt mixed method approaches with follow-up periods longer than two years to evaluate the durability and effectiveness of interventions.
6. Geographic and cultural inclusivity: Most SSD research has been conducted in high-income, English-speaking countries. Broader applicability requires culturally sensitive adaptations in underrepresented regions, including Southern Europe and Latin America (Konradt et al., 2022).

In summary, the evidence presented in this thesis confirms that SSD-based interventions, when strategically combined with appropriate organizational, educational, and behavioral strategies, hold a high potential for promoting sustained behavior change. The next challenge lies in scaling these models into equitable, adaptable interventions that integrate health, well-being, and productivity at the core of modern organizations. This multidimensional, adaptive, and sustainable intervention paradigm may offer a foundational contribution to workplace health promotion and the advancement of occupational health policy.

1.5. Strengths and Limitations

One of the main strengths of this thesis is its methodological diversity and complementarity, combining a systematic review with a series of empirical studies. The systematic review (study 1) encompasses a broad period (2008–2024) and includes multicomponent interventions addressing environmental, organizational, and individual factors. This provided a comprehensive and integrated perspective on effective strategies to reduce SB, with special attention to a relatively unexplored dimension: the distinction between changes during working hours and compensatory patterns during leisure time.

In the empirical studies (Studies 2, 3, and 4), another strength is the usage of objective measurement tools (ActivPAL4), which ensure high precision and reliability when assessing physical behaviors. The ecological validity of these studies, implemented in a real workplace environment, reinforces the practical relevance of the findings and enhances their translational potential for policy and organizational application.

A particularly innovative contribution is found in study 3, which examined the timing of the psychoeducational component. The results revealed that interventions delivered

closer to the behavioral change phase had more substantial impact, providing actionable insights for optimizing health promotion programs. Study 4 further distinguishes itself by including a long-term follow-up of up to 24 months, addressing a critical gap in a field primarily focused on short and medium-term outcomes.

Another transversal strength is the explicit acknowledgment of interindividual variability in response to interventions. The research emphasizes the importance of personalized strategies by recognizing differences in baseline behaviors, motivational readiness, job demands, and environmental constraints. This supports the move toward adaptive, multicomponent interventions, which can be dynamically adjusted to suit each participant's characteristics, preferences, and contexts, potentially including ergonomic customizations, behavioral prompts, and digital feedback systems.

Additionally, the thesis stands out for being one of the few studies conducted in a Portuguese-speaking context, contributing novel data to an underrepresented population in the literature and expanding the global relevance of findings in ST intervention research.

Despite its contributions, the thesis presents several limitations. In study 1, the heterogeneity of included studies, in terms of design, duration, sample characteristics, and outcomes, prevented a formal meta-analysis, limiting the statistical synthesis of evidence.

In study 3, the short intervention duration (three months) restricted the ability to evaluate sustainability of behavior change over time. Although study 4 partially addressed this with a long-term design, but the small sample size and predominantly female composition constrain the generalizability of results, particularly for male-dominated professions or work settings with different sociodemographic profiles.

Another limitation stems from the recruitment context: all participants worked in a university setting, which may not reflect broader occupational environments. In many shared offices, only one participant per room was included, limiting SSD use due to social and spatial constraints. Additionally, some tasks involving extensive paperwork were not easily compatible with the SSD surface, reducing the desk’s functional applicability for specific job roles.

Temporal factors must also be considered. The 6-month intervention spanned different seasons, which may have influenced behavior due to environmental factors such

as temperature, daylight hours, or holidays. While the control group helps account for these effects, seasonality remains a potential confounding variable.

Finally, although changes during working hours were consistently observed, ST during the leisure time remained largely unaffected, underscoring the contextual specificity of the intervention and the importance of promoting ST reduction across the full-day.

2. References

Alkhajah, T. A., Reeves, M. M., Eakin, E. G., Winkler, E. A., Owen, N., & Healy, G. N. (2012). Sit-stand workstations: a pilot intervention to reduce office sitting time. *Am J Prev Med*, *43*(3), 298-303. https://doi.org/10.1016/j.amepre.2012.05.027

Arguello, D., Thorndike, A. N., Cloutier, G., Morton, A., Castaneda-Sceppa, C., & John, D. (2021). Effects of an "Active-Workstation" Cluster RCT on Daily Waking Physical Behaviors. *Med Sci Sports Exerc*, *53*(7), 1434-1445. https://doi.org/10.1249/MSS.0000000000002594

Ball, K., Jeffery, R. W., Abbott, G., McNaughton, S. A., & Crawford, D. (2010). Is healthy behavior contagious: associations of social norms with physical activity and healthy eating. *Int J Behav Nutr Phys Act*, *7*, 86. https://doi.org/10.1186/1479-5868-7-86

Biswas, A., Oh, P. I., Faulkner, G. E., Bajaj, R. R., Silver, M. A., Mitchell, M. S., & Alter, D. A. (2015). Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Ann Intern Med*, *162*(2), 123-132. https://doi.org/10.7326/M14-1651

Brierley, M. L., Smith, L. R., Bailey, D. P., Ojo, S. O., Hewson, D. J., Every, S. A.,…Chater, A. M. (2022). Evaluating a multi-component intervention to reduce and break up office workers' sitting with sit-stand desks using the APEASE criteria. *BMC Public Health*, *22*(1), 458.

Buckley, J. P., Hedge, A., Yates, T., Copeland, R. J., Loosemore, M., Hamer, M.,…Dunstan, D. W. (2015). The sedentary office: an expert statement on the growing case for change towards better health and productivity. *Br J Sports Med*, *49*(21), 1357-1362. https://doi.org/10.1136/bjsports-2015-094618

Chastin, S., Gardiner, P. A., Harvey, J. A., Leask, C. F., Jerez-Roig, J., Rosenberg, D.,…Skelton, D. A. (2021). Interventions for reducing sedentary behaviour in community-dwelling older adults. *Cochrane Database Syst Rev*, *6*(6), Cd012784. https://doi.org/10.1002/14651858.CD012784.pub2

Chau, J. Y., Daley, M., Dunn, S., Srinivasan, A., Do, A., Bauman, A. E., & van der Ploeg, H. P. (2014). The effectiveness of sit-stand workstations for changing office workers' sitting time: results from the Stand@Work randomized controlled trial pilot. *Int J Behav Nutr Phys Act*, *11*, 127. https://doi.org/10.1186/s12966-014-0127-7

Chau, J. Y., van der Ploeg, H. P., Merom, D., Chey, T., & Bauman, A. E. (2012). Cross-sectional associations between occupational and leisure time sitting, physical activity and obesity in working adults. *Prev Med*, *54*(3-4), 195-200. https://doi.org/10.1016/j.ypmed.2011.12.020

Commissaris, D. A. C. M., Huysmans, M. A., Mathiassen, S. E., Srinivasan, D., Koppes, L. L. J., & Hendriksen, I. J. M. (2016). Interventions to reduce sedentary behavior and increase physical activity during productive work: a systematic review. *Scand J Work Environ Health*, *42*(3), 181-191. https://doi.org/10.5271/sjweh.3544

Compernolle, S., DeSmet, A., Poppe, L., Crombez, G., De Bourdeaudhuij, I., Cardon, G.,…Van Dyck, D. (2019). Effectiveness of interventions using self-monitoring to reduce sedentary behavior in adults: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*, *16*(1), 63. https://doi.org/10.1186/s12966-019-0824-3

Deci, E. L., & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. In (Vol. *49 (3)*, pp. 182–185). *Canadian Psychology*: *Psychologie canadienne*.

Deery, E., Buckley, J., Morris, M. *et al.* (2024). *Some People Sit, Some People Stand, That's Just What We Do* ": a Qualitative Exploration of Sit-Stand Desk Use in Naturalistic Settings. In. *Occup Health Sci*.

Del Pozo-Cruz, J., García-Hermoso, A., Alfonso-Rosa, R. M., Alvarez-Barbosa, F., Owen, N., Chastin, S., & Del Pozo-Cruz, B. (2018). Replacing Sedentary Time: Meta-analysis of Objective-Assessment Studies. *Am J Prev Med*, *55*(3), 395-402. https://doi.org/10.1016/j.amepre.2018.04.042

Dutta, N., Koepp, G. A., Stovitz, S. D., Levine, J. A., & Pereira, M. A. (2014). Using sit-stand workstations to decrease sedentary time in office workers: a randomized crossover trial. *Int J Environ Res Public Health*, *11*(7), 6653-6665. https://doi.org/10.3390/ijerph110706653

E F Graves, L., C Murphy, R., Shepherd, S. O., Cabot, J., & Hopkins, N. D. (2015). Evaluation of sit-stand workstations in an office setting: a randomised controlled trial. *BMC Public Health*, *15*, 1145. https://doi.org/10.1186/s12889-015-2469-8

Edwardson, C. L., Biddle, S. J. H., Clemes, S. A., Davies, M. J., Dunstan, D. W., Eborall, H.,…Clarke-Cornwell, A. M. (2022). Effectiveness of an intervention for reducing sitting time and improving health in office workers: three arm cluster randomised controlled trial. *Bmj*, *378*, e069288. https://doi.org/10.1136/bmj-2021-069288

Edwardson, C. L., Maylor, B. D., Biddle, S. J., Clemes, S. A., Cox, E., Davies, M. J.,…Clarke-Cornwell, A. M. (2023). A multicomponent intervention to reduce daily sitting time in office workers: the SMART Work & Life three-arm cluster RCT. *Public Health Res (Southampt)*, *11*(6), 1-229. https://doi.org/10.3310/DNYC2141

Edwardson, C. L., Yates, T., Biddle, S. J. H., Davies, M. J., Dunstan, D. W., Esliger, D. W.,…Munir, F. (2018). Effectiveness of the Stand More AT (SMArT) Work intervention: cluster randomised controlled trial. *BMJ*, *363*, k3870. https://doi.org/10.1136/bmj.k3870

Ekelund, U., Tarp, J., Steene-Johannessen, J., Hansen, B. H., Jefferis, B., Fagerland, M. W.,…Lee, I. M. (2019). Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis. *BMJ*, *366*, l4570. https://doi.org/10.1136/bmj.l4570

Gardner, B., Thuné-Boyle, I., Iliffe, S., Fox, K. R., Jefferis, B. J., Hamer, M.,…Wardle, J. (2014). 'On Your Feet to Earn Your Seat', a habit-based intervention to reduce sedentary behaviour in older adults: study protocol for a randomized controlled trial. *Trials*, *15*, 368. https://doi.org/10.1186/1745-6215-15-368

Hanham, J., Castro-Alonso, J. C., & Chen, O. (2023). Integrating cognitive load theory with other theories, within and beyond educational psychology. *Br J Educ Psychol*, *93 Suppl 2*, 239-250. https://doi.org/10.1111/bjep.12612

Healy, G. N., Eakin, E. G., Owen, N., Lamontagne, A. D., Moodie, M., Winkler, E. A.,…Dunstan, D. W. (2016). A Cluster Randomized Controlled Trial to Reduce Office Workers' Sitting Time: Effect on Activity Outcomes. *Med Sci Sports Exerc*, *48*(9), 1787-1797. https://doi.org/10.1249/mss.0000000000000972

Henderson, B., Stuckey, R., & Keegel, T. (2018). Current and ceased users of sit stand workstations: a qualitative evaluation of ergonomics, safety and health factors within a workplace setting. *BMC Public Health*, *18*(1), 1374. https://doi.org/10.1186/s12889-018-6296-6

Júdice, P. B., Silva, H., Teno, S. C., & Hetherington-Rauth, M. (2024). The effectiveness of a 6-month intervention with sit-stand workstation in office workers: Results from the SUFHA cluster randomized controlled trial. *Work*. https://doi.org/10.3233/WOR-230624

Konradt, U., Nath, A., Krys, S., & Heblich, F. (2022). Longitudinal Effects of a sit-stand desk intervention - persistence, Fade-Out, and psychological momentum: a Randomized Controlled Trial. *BMC Psychol*, *10*(1), 246. https://doi.org/10.1186/s40359-022-00948-9

MacEwen, B. T., Saunders, T. J., MacDonald, D. J., & Burr, J. F. (2017). Sit-Stand Desks To Reduce Workplace Sitting Time In Office Workers With Abdominal Obesity: A Randomized Controlled Trial. *J Phys Act Health*, *14*(9), 710-715. https://doi.org/10.1123/jpah.2016-0384

Mansfeldt, J. M., & Magkos, F. (2023). Compensatory Responses to Exercise Training As Barriers to Weight Loss: Changes in Energy Intake and Non-exercise Physical Activity. *Curr Nutr Rep*, *12*(2), 327-337. https://doi.org/10.1007/s13668-023-00467-y

Mansoubi, M., Pearson, N., Biddle, S. J., & Clemes, S. A. (2016). Using Sit-to-Stand Workstations in Offices: Is There a Compensation Effect? *Med Sci Sports Exerc*, *48*(4), 720-725. https://doi.org/10.1249/MSS.0000000000000802

Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement Sci*, *6*, 42. https://doi.org/10.1186/1748-5908-6-42

Nahum-Shani, I., Smith, S. N., Spring, B. J., Collins, L. M., Witkiewitz, K., Tewari, A., & Murphy, S. A. (2018). Just-in-Time Adaptive Interventions (JITAIs) in Mobile Health: Key Components and Design Principles for Ongoing Health Behavior Support. *Ann Behav Med*, *52*(6), 446-462. https://doi.org/10.1007/s12160-016-9830-8

Nelson-Wong, E., Corrigan, J., Mertz, P., Kutcher, S., Carlson, I., DiRocco, T., & Hall-Nelson, B. (2021). Office-workers maintain decreased workplace sitting time long-term following participation in a sit-stand desk intervention study. *Ergonomics*, 1-9. https://doi.org/10.1080/00140139.2021.1998647

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

Nguyen, P., Le, L. K., Nguyen, D., Gao, L., Dunstan, D. W., & Moodie, M. (2020). The effectiveness of sedentary behaviour interventions on sitting time and screen time in children and adults: an umbrella review of systematic reviews. *Int J Behav Nutr Phys Act*, *17*(1), 117. https://doi.org/10.1186/s12966-020-01009-3

Ojo, S. O., Bailey, D. P., Hewson, D. J., & Chater, A. M. (2019). Perceived Barriers and Facilitators to Breaking Up Sitting Time among Desk-Based Office Workers: A Qualitative Investigation Using the TDF and COM-B. *Int J Environ Res Public Health*, *16*(16). https://doi.org/10.3390/ijerph16162903

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol*, *55*(1), 68-78. https://doi.org/10.1037//0003-066x.55.1.68

Sadarangani, K. P., Schuch, F. B., De Roia, G., Martínez-Gomez, D., Chávez, R., Lobo, P.,…Meyer, J. (2023). Exchanging screen for non-screen sitting time or physical activity might attenuate depression and anxiety: A cross-sectional isotemporal analysis during early pandemics in South America. *J Sci Med Sport*, *26*(6), 309-315. https://doi.org/10.1016/j.jsams.2023.04.007

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. *Hum Factors*, *61*(5), 816-824. https://doi.org/10.1177/0018720818807043

Shrestha, N., Grgic, J., Wiesner, G., Parker, A., Podnar, H., Bennie, J. A.,…Pedisic, Z. (2019). Effectiveness of interventions for reducing non-occupational sedentary behaviour in adults and older adults: a systematic review and meta-analysis. *Br J Sports Med*, *53*(19), 1206-1213. https://doi.org/10.1136/bjsports-2017-098270

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 Syst Rev*, *3*(3), Cd010912. https://doi.org/10.1002/14651858.CD010912.pub3

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Pedisic, Z. (2018). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *6*(6), Cd010912. https://doi.org/10.1002/14651858.CD010912.pub4

Silva, H., Ramos, P. G. F., Teno, S. C., & Júdice, P. B. (2024a). The Impact of Sit-Stand Desks on Full-Day and Work-Based Sedentary Behavior of Office Workers: A Systematic Review. *Hum Factors*, 187208241305591. https://doi.org/10.1177/00187208241305591

Silva, H., Teno, S. C., & Júdice, P. B. (2024b). Are there compensatory behaviors in response to a sit-stand desk intervention? *J Occup Health*. https://doi.org/10.1093/joccuh/uiae067

Stephens, S. K., Winkler, E. A. H., Eakin, E. G., Clark, B. K., Owen, N., Moodie, M.,…Healy, G. N. (2019). Temporal features of sitting, standing and stepping changes in a cluster-randomised controlled trial of a workplace sitting-reduction intervention. *Int J Behav Nutr Phys Act*, *16*(1), 111. https://doi.org/10.1186/s12966-019-0879-1

Walsh, M. M., Krusmark, M. A., Jastrembski, T., Hansen, D. A., Honn, K. A., & Gunzelmann, G. (2023). Enhancing learning and retention through the distribution of practice repetitions across multiple sessions. *Mem Cognit*, *51*(2), 455-472. https://doi.org/10.3758/s13421-022-01361-8

Watson, A. K., Hernandez, B. F., Kolodny-Goetz, J., Walker, T. J., Lamont, A., Imm, P.,…Fernandez, M. E. (2022). Using Implementation Mapping to Build Organizational Readiness. *Front Public Health*, *10*, 904652. https://doi.org/10.3389/fpubh.2022.904652

West, J. T., Miller, W. M., Jeon, S., & Ye, X. (2020). The Effects of a Preconditioning Rolling Session on Subsequent Eccentric Exercise-Induced Muscle Damage. *J Strength Cond Res*, *34*(8), 2112-2119. https://doi.org/10.1519/jsc.0000000000003678

Wilkerson, A. H., Bhochhibhoya, S., & Dragicevic, A. (2021). "It Feels Unhealthy to be Sitting for 40 hours a Week": A Qualitative Analysis of Employee Perceptions of Standing Desk Use in the Workplace. *J Occup Environ Med*, *63*(4), 322-328. https://doi.org/10.1097/JOM.0000000000002128

Zhou, L., Deng, X., Xu, M., Wu, Y., Shang, X., E, F.,…Li, X. (2023). The effects of active workstations on reducing work-specific sedentary time in office workers: a network meta-analysis of 23 randomized controlled trials. *Int J Behav Nutr Phys Act*, *20*(1), 92. https://doi.org/10.1186/s12966-023-01467-5

Chapter VIII

Bibliography

1. References

Alkhajah, T. A., Reeves, M. M., Eakin, E. G., Winkler, E. A., Owen, N., & Healy, G. N. (2012). Sit-stand workstations: a pilot intervention to reduce office sitting time. *Am J Prev Med*, *43*(3), 298-303. https://doi.org/10.1016/j.amepre.2012.05.027

Andersen, L. L., Fallentin, N., Thorsen, S. V., & Holtermann, A. (2016). Physical workload and risk of long-term sickness absence in the general working population and among blue-collar workers: prospective cohort study with register follow-up. *Occup Environ Med*, *73*(4), 246-253. https://doi.org/10.1136/oemed-2015-103314

Arguello, D., Thorndike, A. N., Cloutier, G., Morton, A., Castaneda-Sceppa, C., & John, D. (2021). Effects of an "Active-Workstation" Cluster RCT on Daily Waking Physical Behaviors. *Med Sci Sports Exerc*, *53*(7), 1434-1445. https://doi.org/10.1249/MSS.0000000000002594

Atkin, A. J., Adams, E., Bull, F. C., & Biddle, S. J. (2012). Non-occupational sitting and mental well-being in employed adults. *Ann Behav Med*, *43*(2), 181-188. https://doi.org/10.1007/s12160-011-9320-y

Balducci, S., D'Errico, V., Haxhi, J., Sacchetti, M., Orlando, G., Cardelli, P.,…Investigators, I. D. a. E. S. I. (2019). Effect of a Behavioral Intervention Strategy on Sustained Change in Physical Activity and Sedentary Behavior in Patients With Type 2 Diabetes: The IDES_2 Randomized Clinical Trial. *JAMA*, *321*(9), 880-890. https://doi.org/10.1001/jama.2019.0922

Ball, K., Jeffery, R. W., Abbott, G., McNaughton, S. A., & Crawford, D. (2010). Is healthy behavior contagious: associations of social norms with physical activity and healthy eating. *Int J Behav Nutr Phys Act*, *7*, 86. https://doi.org/10.1186/1479-5868-7-86

Bennie, J. A., Pedisic, Z., Timperio, A., Crawford, D., Dunstan, D., Bauman, A.,…Salmon, J. (2015). Total and domain-specific sitting time among employees in desk-based work settings in Australia. *Aust N Z J Public Health*, *39*(3), 237-242. https://doi.org/10.1111/1753-6405.12293

Biddle, S. J. H., O'Connell, S. E., Davies, M. J., Dunstan, D., Edwardson, C. L., Esliger, D. W.,…Munir, F. (2020). Reducing sitting at work: process evaluation of the SMArT Work (Stand More At Work) intervention. *Trials*, *21*(1), 403. https://doi.org/10.1186/s13063-020-04300-7

Biswas, A., Oh, P. I., Faulkner, G. E., Bajaj, R. R., Silver, M. A., Mitchell, M. S., & Alter, D. A. (2015). Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Ann Intern Med*, *162*(2), 123-132. https://doi.org/10.7326/m14-1651

Blackburn, N. E., Wilson, J. J., McMullan, I. I., Caserotti, P., Giné-Garriga, M., Wirth, K.,…Tully, M. A. (2020). The effectiveness and complexity of interventions targeting sedentary behaviour across the lifespan: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*, *17*(1), 53. https://doi.org/10.1186/s12966-020-00957-0

Bora, N., K, V., Verma, A., Bharti, A. K., & Sinha, M. K. (2024). Physical activity and sedentary behavior perceptions in overweight and obese adults: A systematic review of qualitative study. *F1000Res*, *13*, 787. https://doi.org/10.12688/f1000research.152905.1

Brierley, M. L., Smith, L. R., Bailey, D. P., Ojo, S. O., Hewson, D. J., Every, S. A.,…Chater, A. M. (2022). Evaluating a multi-component intervention to reduce and break up office workers' sitting with sit-stand desks using the APEASE criteria. *BMC Public Health*, *22*(1), 458.

Buckley, J. P., Hedge, A., Yates, T., Copeland, R. J., Loosemore, M., Hamer, M.,…Dunstan, D. W. (2015). The sedentary office: an expert statement on the growing case for change towards better health and productivity. *Br J Sports Med*, *49*(21), 1357-1362. https://doi.org/10.1136/bjsports-2015-094618

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G.,…Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. https://doi.org/10.1136/bjsports-2020-102955

Cao, C., Friedenreich, C. M., & Yang, L. (2022). Association of Daily Sitting Time and Leisure Time Physical Activity With Survival Among US Cancer Survivors. *JAMA Oncol*, *8*(3), 395-403. https://doi.org/10.1001/jamaoncol.2021.6590

Chan, C. B., & Ryan, D. A. (2009). Assessing the effects of weather conditions on physical activity participation using objective measures. *Int J Environ Res Public Health*, *6*(10), 2639-2654. https://doi.org/10.3390/ijerph6102639

Chastin, S., Gardiner, P. A., Harvey, J. A., Leask, C. F., Jerez-Roig, J., Rosenberg, D.,…Skelton, D. A. (2021). Interventions for reducing sedentary behaviour in

community-dwelling older adults. *Cochrane Database Syst Rev*, *6*(6), Cd012784. https://doi.org/10.1002/14651858.CD012784.pub2

Chau, J. Y., Daley, M., Dunn, S., Srinivasan, A., Do, A., Bauman, A. E., & van der Ploeg, H. P. (2014). The effectiveness of sit-stand workstations for changing office workers' sitting time: results from the Stand@Work randomized controlled trial pilot. *Int J Behav Nutr Phys Act*, *11*, 127. https://doi.org/10.1186/s12966-014-0127-7

Chau, J. Y., van der Ploeg, H. P., Merom, D., Chey, T., & Bauman, A. E. (2012). Cross-sectional associations between occupational and leisure time sitting, physical activity and obesity in working adults. *Prev Med*, *54*(3-4), 195-200. https://doi.org/10.1016/j.ypmed.2011.12.020

Chu, A. H., Ng, S. H., Tan, C. S., Win, A. M., Koh, D., & Müller-Riemenschneider, F. (2016). A systematic review and meta-analysis of workplace intervention strategies to reduce sedentary time in white-collar workers. *Obes Rev*, *17*(5), 467-481. https://doi.org/10.1111/obr.12388

Clemes, S. A., O'Connell, S. E., & Edwardson, C. L. (2014). Office workers' objectively measured sedentary behavior and physical activity during and outside working hours. *J Occup Environ Med*, *56*(3), 298-303. https://doi.org/10.1097/JOM.0000000000000101

Coenen, P., van der Molen, H. F., Burdorf, A., Huysmans, M. A., Straker, L., Frings-Dresen, M. H., & van der Beek, A. J. (2019). Associations of screen work with neck and upper extremity symptoms: a systematic review with meta-analysis. *Occup Environ Med*, *76*(7), 502-509. https://doi.org/10.1136/oemed-2018-105553

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep*, *22*(1), 7-14.

Commissaris, D. A. C. M., Huysmans, M. A., Mathiassen, S. E., Srinivasan, D., Koppes, L. L. J., & Hendriksen, I. J. M. (2016). Interventions to reduce sedentary behavior and increase physical activity during productive work: a systematic review. *Scand J Work Environ Health*, *42*(3), 181-191. https://doi.org/10.5271/sjweh.3544

Compernolle, S., DeSmet, A., Poppe, L., Crombez, G., De Bourdeaudhuij, I., Cardon, G.,…Van Dyck, D. (2019). Effectiveness of interventions using self-monitoring

to reduce sedentary behavior in adults: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*, *16*(1), 63. https://doi.org/10.1186/s12966-019-0824-3

Danquah, I. H., Kloster, S., Holtermann, A., Aadahl, M., Bauman, A., Ersbøll, A. K., & Tolstrup, J. S. (2017). Take a Stand!-a multi-component intervention aimed at reducing sitting time among office workers-a cluster randomized trial. *Int J Epidemiol*, *46*(1), 128-140. https://doi.org/10.1093/ije/dyw009

Deci, E. L., & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. In (Vol. *49 (3)*, pp. 182–185). *Canadian Psychology*: *Psychologie canadienne*.

Deery, E., Buckley, J., Morris, M. *et al.* (2024). *Some People Sit, Some People Stand, That's Just What We Do* ": a Qualitative Exploration of Sit-Stand Desk Use in Naturalistic Settings. In. *Occup Health Sci*.

Del Pozo-Cruz, J., García-Hermoso, A., Alfonso-Rosa, R. M., Alvarez-Barbosa, F., Owen, N., Chastin, S., & Del Pozo-Cruz, B. (2018). Replacing Sedentary Time: Meta-analysis of Objective-Assessment Studies. *Am J Prev Med*, *55*(3), 395-402. https://doi.org/10.1016/j.amepre.2018.04.042

Dogra, S., & Stathokostas, L. (2012). Sedentary behavior and physical activity are independent predictors of successful aging in middle-aged and older adults. *J Aging Res*, *2012*, 190654. https://doi.org/10.1155/2012/190654

Dunstan, D. W., Barr, E. L., Healy, G. N., Salmon, J., Shaw, J. E., Balkau, B.,…Owen, N. (2010). Television viewing time and mortality: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Circulation*, *121*(3), 384-391. https://doi.org/10.1161/CIRCULATIONAHA.109.894824

Dupont, F., Léger, P. M., Begon, M., Lecot, F., Sénécal, S., Labonté-Lemoyne, E., & Mathieu, M. E. (2019). Health and productivity at work: which active workstation for which benefits: a systematic review. *Occup Environ Med*, *76*(5), 281-294. https://doi.org/10.1136/oemed-2018-105397

Dutta, N., Koepp, G. A., Stovitz, S. D., Levine, J. A., & Pereira, M. A. (2014). Using sit-stand workstations to decrease sedentary time in office workers: a randomized crossover trial. *Int J Environ Res Public Health*, *11*(7), 6653-6665. https://doi.org/10.3390/ijerph110706653

Dutta, N., Walton, T., & Pereira, M. A. (2019). One-year follow-up of a sit-stand workstation intervention to decrease sedentary time in office workers. *Prev Med Rep*, *13*, 277-280. https://doi.org/10.1016/j.pmedr.2019.01.008

E F Graves, L., C Murphy, R., Shepherd, S. O., Cabot, J., & Hopkins, N. D. (2015). Evaluation of sit-stand workstations in an office setting: a randomised controlled trial. *BMC Public Health*, *15*, 1145. https://doi.org/10.1186/s12889-015-2469-8

Edwardson, C. L., Biddle, S. J. H., Clemes, S. A., Davies, M. J., Dunstan, D. W., Eborall, H.,…Clarke-Cornwell, A. M. (2022). Effectiveness of an intervention for reducing sitting time and improving health in office workers: three arm cluster randomised controlled trial. *BMJ*, *378*, e069288. https://doi.org/10.1136/bmj-2021-069288

Edwardson, C. L., Maylor, B. D., Biddle, S. J., Clemes, S. A., Cox, E., Davies, M. J.,…Clarke-Cornwell, A. M. (2023). A multicomponent intervention to reduce daily sitting time in office workers: the SMART Work & Life three-arm cluster RCT. *Public Health Res (Southampt)*, *11*(6), 1-229. https://doi.org/10.3310/DNYC2141

Edwardson, C. L., Yates, T., Biddle, S. J. H., Davies, M. J., Dunstan, D. W., Esliger, D. W.,…Munir, F. (2018). Effectiveness of the Stand More AT (SMArT) Work intervention: cluster randomised controlled trial. *Bmj*, *363*, k3870. https://doi.org/10.1136/bmj.k3870

Ekelund, U., Brown, W. J., Steene-Johannessen, J., Fagerland, M. W., Owen, N., Powell, K. E.,…Lee, I. M. (2019). Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants. *Br J Sports Med*, *53*(14), 886-894. https://doi.org/10.1136/bjsports-2017-098963

Ekelund, U., Tarp, J., Steene-Johannessen, J., Hansen, B. H., Jefferis, B., Fagerland, M. W.,…Lee, I. M. (2019). Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis. *BMJ*, *366*, l4570. https://doi.org/10.1136/bmj.l4570

Felez-Nobrega, M., Bort-Roig, J., Briones, L., Sanchez-Niubo, A., Koyanagi, A., Puigoriol, E., & Puig-Ribera, A. (2020). Self-reported and activPAL. *J Sports Sci*, *38*(13), 1566-1574. https://doi.org/10.1080/02640414.2020.1748359

Gao, Z., & Lee, J. E. (2022). Promoting Physical Activity and Reducing Sedentary Behavior to Prevent Chronic Diseases during the COVID Pandemic and Beyond. *J Clin Med*, *11*(16). https://doi.org/10.3390/jcm11164666

Gardner, B., Thuné-Boyle, I., Iliffe, S., Fox, K. R., Jefferis, B. J., Hamer, M.,…Wardle, J. (2014). 'On Your Feet to Earn Your Seat', a habit-based intervention to reduce sedentary behaviour in older adults: study protocol for a randomized controlled trial. *Trials*, *15*, 368. https://doi.org/10.1186/1745-6215-15-368

Gilson, N. D., Burton, N. W., van Uffelen, J. G., & Brown, W. J. (2011). Occupational sitting time: employees' perceptions of health risks and intervention strategies. *Health Promot J Austr*, *22*(1), 38-43. https://doi.org/10.1071/he11038

Grunseit, A. C., Chau, J. Y., van der Ploeg, H. P., & Bauman, A. (2013). "Thinking on your feet": A qualitative evaluation of sit-stand desks in an Australian workplace. *BMC Public Health*, *13*, 365. https://doi.org/10.1186/1471-2458-13-365

Hadgraft, N. T., Healy, G. N., Owen, N., Winkler, E. A., Lynch, B. M., Sethi, P.,…Dunstan, D. W. (2016). Office workers' objectively assessed total and prolonged sitting time: Individual-level correlates and worksite variations. *Prev Med Rep*, *4*, 184-191. https://doi.org/10.1016/j.pmedr.2016.06.011

Hanham, J., Castro-Alonso, J. C., & Chen, O. (2023). Integrating cognitive load theory with other theories, within and beyond educational psychology. *Br J Educ Psychol*, *93 Suppl 2*, 239-250. https://doi.org/10.1111/bjep.12612

Healy, G. N., Eakin, E. G., Owen, N., Lamontagne, A. D., Moodie, M., Winkler, E. A.,…Dunstan, D. W. (2016). A Cluster Randomized Controlled Trial to Reduce Office Workers' Sitting Time: Effect on Activity Outcomes. *Med Sci Sports Exerc*, *48*(9), 1787-1797. https://doi.org/10.1249/MSS.0000000000000972

Healy, G. N., Matthews, C. E., Dunstan, D. W., Winkler, E. A., & Owen, N. (2011). Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. *Eur Heart J*, *32*(5), 590-597. https://doi.org/10.1093/eurheartj/ehq451

Henderson, B., Stuckey, R., & Keegel, T. (2018). Current and ceased users of sit stand workstations: a qualitative evaluation of ergonomics, safety and health factors within a workplace setting. *BMC Public Health*, *18*(1), 1374. https://doi.org/10.1186/s12889-018-6296-6

Hergenroeder, A., Quinn, T. D., Perdomo, S. J., Kline, C. E., & Gibbs, B. B. (2022). Effect of a 6-month sedentary behavior reduction intervention on well-being and workplace health in desk workers with low back pain. *Work*, *71*(4), 1145-1155. https://doi.org/10.3233/WOR-205178

Ishii, K., Shibata, A., & Oka, K. (2018). Work Engagement, Productivity, and Self-Reported Work-Related Sedentary Behavior Among Japanese Adults: A Cross-

Sectional Study. *J Occup Environ Med*, *60*(4), e173-e177. https://doi.org/10.1097/JOM.0000000000001270

Jochem, C., Wallmann-Sperlich, B., & Leitzmann, M. F. (2019). The Influence of Sedentary Behavior on Cancer Risk: Epidemiologic Evidence and Potential Molecular Mechanisms. *Curr Nutr Rep*, *8*(3), 167-174. https://doi.org/10.1007/s13668-019-0263-4

Judah, G., Gardner, B., Kenward, M. G., DeStavola, B., & Aunger, R. (2018). Exploratory study of the impact of perceived reward on habit formation. *BMC Psychol*, *6*(1), 62. https://doi.org/10.1186/s40359-018-0270-z

Júdice, P. B., Silva, H., Teno, S. C., & Hetherington-Rauth, M. (2024). The effectiveness of a 6-month intervention with sit-stand workstation in office workers: Results from the SUFHA cluster randomized controlled trial. *Work*. https://doi.org/10.3233/WOR-230624

Júdice, P. B., Silva, H., Teno, S. C., Monteiro, P., Silva, M. N., Carraça, E. V.,…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

Júdice, P. B., Sousa-Sá, E., & Palmeira, A. L. (2023). Discrepancies Between Self-reported and Objectively Measured Smartphone Screen Time: Before and During Lockdown. *J Prev (2022)*, *44*(3), 291-307. https://doi.org/10.1007/s10935-023-00724-4

Katzmarzyk, P. T., Powell, K. E., Jakicic, J. M., Troiano, R. P., Piercy, K., Tennant, B., & COMMITTEE*, P. A. G. A. (2019). Sedentary Behavior and Health: Update from the 2018 Physical Activity Guidelines Advisory Committee. *Med Sci Sports Exerc*, *51*(6), 1227-1241. https://doi.org/10.1249/MSS.0000000000001935

Kazi, A., Haslam, C., Duncan, M., Clemes, S., & Twumasi, R. (2019). Sedentary behaviour and health at work: an investigation of industrial sector, job role, gender and geographical differences. *Ergonomics*, *62*(1), 21-30. https://doi.org/10.1080/00140139.2018.1489981

Keown, M. K., Skeaff, C. M., Perry, T. L., Haszard, J. J., & Peddie, M. C. (2018). Device-Measured Sedentary Behavior Patterns in Office-Based University Employees. *J Occup Environ Med*, *60*(12), 1150-1157. https://doi.org/10.1097/JOM.0000000000001467

Kikuchi, H., Inoue, S., Sugiyama, T., Owen, N., Oka, K., Nakaya, T., & Shimomitsu, T. (2014). Distinct associations of different sedentary behaviors with health-related attributes among older adults. *Prev Med*, *67*, 335-339. https://doi.org/10.1016/j.ypmed.2014.08.011

Kim, E., Park, C. H., Lee, H. S., Lee, M. Y., & Cho, S. J. (2024). Sex Differences in the Association between Prolonged Sitting Time and Anxiety Prevalence among Korean Adults. *Brain Sci*, *14*(7). https://doi.org/10.3390/brainsci14070729

Konradt, U., Nath, A., Krys, S., & Heblich, F. (2022). Longitudinal Effects of a sit-stand desk intervention - persistence, Fade-Out, and psychological momentum: a Randomized Controlled Trial. *BMC Psychol*, *10*(1), 246. https://doi.org/10.1186/s40359-022-00948-9

Lam, K., Baurecht, H., Pahmeier, K., Niemann, A., Romberg, C., Biermann-Stallwitz, J.,…Jochem, C. (2022). How effective and how expensive are interventions to reduce sedentary behavior? An umbrella review and meta-analysis. *Obes Rev*, *23*(5), e13422. https://doi.org/10.1111/obr.13422

Landais, L. L., Jelsma, J. G. M., Dotinga, I. R., Timmermans, D. R. M., Verhagen, E. A. L. M., & Damman, O. C. (2022). Office workers' perspectives on physical activity and sedentary behaviour: a qualitative study. *BMC Public Health*, *22*(1), 621. https://doi.org/10.1186/s12889-022-13024-z

Liu, S. H., Eaton, C. B., Driban, J. B., McAlindon, T. E., & Lapane, K. L. (2016). Comparison of self-report and objective measures of physical activity in US adults with osteoarthritis. In *Rheumatol Int* (Vol. 36, pp. 1355-1364). https://doi.org/10.1007/s00296-016-3537-9

Ma, J., Ma, D., Li, Z., & Kim, H. (2021). Effects of a Workplace Sit-Stand Desk Intervention on Health and Productivity. *Int J Environ Res Public Health*, *18*(21). https://doi.org/10.3390/ijerph182111604

MacEwen, B. T., Saunders, T. J., MacDonald, D. J., & Burr, J. F. (2017). Sit-Stand Desks To Reduce Workplace Sitting Time In Office Workers With Abdominal Obesity: A Randomized Controlled Trial. *J Phys Act Health*, *14*(9), 710-715. https://doi.org/10.1123/jpah.2016-0384

Mansfeldt, J. M., & Magkos, F. (2023). Compensatory Responses to Exercise Training As Barriers to Weight Loss: Changes in Energy Intake and Non-exercise Physical Activity. *Curr Nutr Rep*, *12*(2), 327-337. https://doi.org/10.1007/s13668-023-00467-y

Mansoubi, M., Pearson, N., Biddle, S. J., & Clemes, S. A. (2016). Using Sit-to-Stand Workstations in Offices: Is There a Compensation Effect? *Med Sci Sports Exerc*, *48*(4), 720-725. https://doi.org/10.1249/MSS.0000000000000802

Martinez-Gomez, D., Guallar-Castillon, P., Leon-Munoz, L. M., Lopez-Garcia, E., & Rodriguez-Artalejo, F. (2013). Combined impact of traditional and non-traditional health behaviors on mortality: a national prospective cohort study in Spanish older adults. *BMC Med*, *11*, 47. https://doi.org/10.1186/1741-7015-11-47

Matthews, C. E., Moore, S. C., Sampson, J., Blair, A., Xiao, Q., Keadle, S. K.,…Park, Y. (2015). Mortality Benefits for Replacing Sitting Time with Different Physical Activities. *Med Sci Sports Exerc*, *47*(9), 1833-1840. https://doi.org/10.1249/mss.0000000000000621

Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement Sci*, *6*, 42. https://doi.org/10.1186/1748-5908-6-42

Mielke, G. I., da Silva, I. C., Owen, N., & Hallal, P. C. (2014). Brazilian adults' sedentary behaviors by life domain: population-based study. *PLoS One*, *9*(3), e91614. https://doi.org/10.1371/journal.pone.0091614

Mitchell, M. S., Goodman, J. M., Alter, D. A., John, L. K., Oh, P. I., Pakosh, M. T., & Faulkner, G. E. (2013). Financial incentives for exercise adherence in adults: systematic review and meta-analysis. *Am J Prev Med*, *45*(5), 658-667. https://doi.org/10.1016/j.amepre.2013.06.017

Nahum-Shani, I., Smith, S. N., Spring, B. J., Collins, L. M., Witkiewitz, K., Tewari, A., & Murphy, S. A. (2018). Just-in-Time Adaptive Interventions (JITAIs) in Mobile Health: Key Components and Design Principles for Ongoing Health Behavior Support. *Ann Behav Med*, *52*(6), 446-462. https://doi.org/10.1007/s12160-016-9830-8

Nelson-Wong, E., Corrigan, J., Mertz, P., Kutcher, S., Carlson, I., DiRocco, T., & Hall-Nelson, B. (2021). Office-workers maintain decreased workplace sitting time long-term following participation in a sit-stand desk intervention study. *Ergonomics*, 1-9. https://doi.org/10.1080/00140139.2021.1998647

Nelson-Wong, E., Gallagher, K., Johnson, E., Antonioli, C., Ferguson, A., Harris, S.,…Miller, J. B. (2020). Increasing standing tolerance in office workers with standing-induced back pain. *Ergonomics*, *63*(7), 804-817. https://doi.org/10.1080/00140139.2020.1761034

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

Neuhaus, M., Healy, G. N., Dunstan, D. W., Owen, N., & Eakin, E. G. (2014). Workplace sitting and height-adjustable workstations: a randomized controlled trial. *Am J Prev Med*, *46*(1), 30-40. https://doi.org/10.1016/j.amepre.2013.09.009

Ng, J. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Duda, J. L., & Williams, G. C. (2012). Self-Determination Theory Applied to Health Contexts: A Meta-Analysis. *Perspect Psychol Sci*, *7*(4), 325-340. https://doi.org/10.1177/1745691612447309

Nguyen, P., Le, L. K., Nguyen, D., Gao, L., Dunstan, D. W., & Moodie, M. (2020). The effectiveness of sedentary behaviour interventions on sitting time and screen time in children and adults: an umbrella review of systematic reviews. *Int J Behav Nutr Phys Act*, *17*(1), 117. https://doi.org/10.1186/s12966-020-01009-3

Ojo, S. O., Bailey, D. P., Hewson, D. J., & Chater, A. M. (2019). Perceived Barriers and Facilitators to Breaking Up Sitting Time among Desk-Based Office Workers: A Qualitative Investigation Using the TDF and COM-B. *Int J Environ Res Public Health*, *16*(16). https://doi.org/10.3390/ijerph16162903

Organization, W. H. (2018). G*lobal action plan on physical activity 2018-2030: more active people for a healthier world*. In (World Health Organization ed.).

Owen, N., Healy, G. N., Matthews, C. E., & Dunstan, D. W. (2010). Too much sitting: the population health science of sedentary behavior. *Exerc Sport Sci Rev*, *38*(3), 105-113. https://doi.org/10.1097/JES.0b013e3181e373a2

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D.,…Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. https://doi.org/10.1136/bmj.n71

Panahi, S., & Tremblay, A. (2018). Sedentariness and Health: Is Sedentary Behavior More Than Just Physical Inactivity? *Front Public Health*, *6*, 258. https://doi.org/10.3389/fpubh.2018.00258

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

Parry, S. P., Coenen, P., Shrestha, N., O'Sullivan, P. B., Maher, C. G., & Straker, L. M. (2019). Workplace interventions for increasing standing or walking for decreasing musculoskeletal symptoms in sedentary workers. *Cochrane Database Syst Rev*, *2019*(11). https://doi.org/10.1002/14651858.CD012487.pub2

Patterson, R., McNamara, E., Tainio, M., de Sá, T. H., Smith, A. D., Sharp, S. J.,…Wijndaele, K. (2018). Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *Eur J Epidemiol*, *33*(9), 811-829. https://doi.org/10.1007/s10654-018-0380-1

Pereira, M. A., Mullane, S. L., Toledo, M. J. L., Larouche, M. L., Rydell, S. A., Vuong, B.,…Buman, M. P. (2020). Efficacy of the 'Stand and Move at Work' multicomponent workplace intervention to reduce sedentary time and improve cardiometabolic risk: a group randomized clinical trial. *Int J Behav Nutr Phys Act*, *17*(1), 133. https://doi.org/10.1186/s12966-020-01033-3

Prince, S. A., Elliott, C. G., Scott, K., Visintini, S., & Reed, J. L. (2019). Device-measured physical activity, sedentary behaviour and cardiometabolic health and fitness across occupational groups: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*, *16*(1), 30. https://doi.org/10.1186/s12966-019-0790-9

Prince, S. A., Reid, R. D., & Reed, J. L. (2019). Comparison of self-reported and objectively measured levels of sitting and physical activity and associations with markers of health in cardiac rehabilitation patients. *Eur J Prev Cardiol*, *26*(6), 653-656. https://doi.org/10.1177/2047487318806357

Renaud, L. R., Jelsma, J. G. M., Huysmans, M. A., van Nassau, F., Lakerveld, J., Speklé, E. M.,…van der Ploeg, H. P. (2020). Effectiveness of the multi-component dynamic work intervention to reduce sitting time in office workers - Results from a pragmatic cluster randomised controlled trial. *Appl Ergon*, *84*, 103027. https://doi.org/10.1016/j.apergo.2019.103027

Rhodes, R. E., Janssen, I., Bredin, S. S. D., Warburton, D. E. R., & Bauman, A. (2017). Physical activity: Health impact, prevalence, correlates and interventions. *Psychol Health*, *32*(8), 942-975. https://doi.org/10.1080/08870446.2017.1325486

Rosenkranz, S. K., Mailey, E. L., Umansky, E., Rosenkranz, R. R., & Ablah, E. (2020). Workplace Sedentary Behavior and Productivity: A Cross-Sectional Study. *Int J Environ Res Public Health*, *17*(18). https://doi.org/10.3390/ijerph17186535

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol*, *55*(1), 68-78. https://doi.org/10.1037//0003-066x.55.1.68

Sadarangani, K. P., Schuch, F. B., De Roia, G., Martínez-Gomez, D., Chávez, R., Lobo, P.,…Meyer, J. (2023). Exchanging screen for non-screen sitting time or physical activity might attenuate depression and anxiety: A cross-sectional isotemporal analysis during early pandemics in South America. *J Sci Med Sport*, *26*(6), 309-315. https://doi.org/10.1016/j.jsams.2023.04.007

Santos, A. C., Willumsen, J., Meheus, F., Ilbawi, A., & Bull, F. C. (2023). The cost of inaction on physical inactivity to public health-care systems: a population-attributable fraction analysis. *Lancet Glob Health*, *11*(1), e32-e39. https://doi.org/10.1016/S2214-109X(22)00464-8

Saunders, T. J., McIsaac, T., Douillette, K., Gaulton, N., Hunter, S., Rhodes, R. E.,…Healy, G. N. (2020). Sedentary behaviour and health in adults: an overview of systematic reviews. *Appl Physiol Nutr Metab*, *45*(10 (Suppl. 2)), S197-S217. https://doi.org/10.1139/apnm-2020-0272

Schwartz, B., Kapellusch, J. M., Baca, A., & Wessner, B. (2019). Medium-term effects of a two-desk sit/stand workstation on cognitive performance and workload for healthy people performing sedentary work: a secondary analysis of a randomised controlled trial. *Ergonomics*, *62*(6), 794-810. https://doi.org/10.1080/00140139.2019.1577497

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. *Hum Factors*, *61*(5), 816-824. https://doi.org/10.1177/0018720818807043

Shrestha, B., & Dunn, L. (2020). The Declaration of Helsinki on Medical Research involving Human Subjects: A Review of Seventh Revision. *J Nepal Health Res Counc*, *17*(4), 548-552. https://doi.org/10.33314/jnhrc.v17i4.1042

Shrestha, N., Grgic, J., Wiesner, G., Parker, A., Podnar, H., Bennie, J. A.,…Pedisic, Z. (2019). Effectiveness of interventions for reducing non-occupational sedentary behaviour in adults and older adults: a systematic review and meta-analysis. *Br J Sports Med*, *53*(19), 1206-1213. https://doi.org/10.1136/bjsports-2017-098270

Shrestha, N., Ijaz, S., Kukkonen-Harjula, K. T., Kumar, S., & Nwankwo, C. P. (2015). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *1*, Cd010912. https://doi.org/10.1002/14651858.CD010912.pub2

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 Syst Rev*, *3*(3), CD010912. https://doi.org/10.1002/14651858.CD010912.pub3

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Pedisic, Z. (2018). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *6*(6), Cd010912. https://doi.org/10.1002/14651858.CD010912.pub4

Silva, H., G F Ramos, P., Teno, S. C., & Júdice, P. B. (2024c). Impact of a 6-month sit-stand desk-based intervention on regional musculoskeletal discomfort and overall post-work fatigue in office workers: a cluster randomised controlled trial. *Ergonomics*, 1-14. https://doi.org/10.1080/00140139.2024.2414197

Silva, H., Ramos, P. G. F., Teno, S. C., & Júdice, P. B. (2024a). The Impact of Sit-Stand Desks on Full-Day and Work-Based Sedentary Behavior of Office Workers: A Systematic Review. *Hum Factors*, 187208241305591. https://doi.org/10.1177/00187208241305591

Silva, H., Teno, S. C., & Júdice, P. B. (2024b). Are there compensatory behaviors in response to a sit-stand desk intervention? *J Occup Health*. https://doi.org/10.1093/joccuh/uiae067

Stamatakis, E., Gale, J., Bauman, A., Ekelund, U., Hamer, M., & Ding, D. (2019). Sitting Time, Physical Activity, and Risk of Mortality in Adults. *J Am Coll Cardiol*, *73*(16), 2062-2072. https://doi.org/10.1016/j.jacc.2019.02.031

Stephens, S. K., Eakin, E. G., Clark, B. K., Winkler, E. A. H., Owen, N., LaMontagne, A. D.,…Healy, G. N. (2018). What strategies do desk-based workers choose to reduce sitting time and how well do they work? Findings from a cluster randomised controlled trial. *Int J Behav Nutr Phys Act*, *15*(1), 98. https://doi.org/10.1186/s12966-018-0731-z

Stephens, S. K., Winkler, E. A. H., Eakin, E. G., Clark, B. K., Owen, N., Moodie, M.,…Healy, G. N. (2019). Temporal features of sitting, standing and stepping changes in a cluster-randomised controlled trial of a workplace sitting-reduction

intervention. *Int J Behav Nutr Phys Act*, *16*(1), 111. https://doi.org/10.1186/s12966-019-0879-1

Sugiyama, T., Hadgraft, N., Clark, B. K., Dunstan, D. W., & Owen, N. (2020). Sitting at work & waist circumference-A cross-sectional study of Australian workers. *Prev Med*, *141*, 106243. https://doi.org/10.1016/j.ypmed.2020.106243

Teno, S. C., Silva, M. N., & Júdice, P. B. (2024). Physical activity and sedentary behaviour-specific domains and their associations with mental health in adults: a systematic review. . In (pp. 1–28): A*dvances in Mental Health*.

Thomas, B. H., Ciliska, D., Dobbins, M., & Micucci, S. (2004). A process for systematically reviewing the literature: providing the research evidence for public health nursing interventions. *Worldviews Evid Based Nurs*, *1*(3), 176-184. https://doi.org/10.1111/j.1524-475X.2004.04006.x

Thorp, A. A., Healy, G. N., Winkler, E., Clark, B. K., Gardiner, P. A., Owen, N., & Dunstan, D. W. (2012). Prolonged sedentary time and physical activity in workplace and non-work contexts: a cross-sectional study of office, customer service and call centre employees. *Int J Behav Nutr Phys Act*, *9*, 128. https://doi.org/10.1186/1479-5868-9-128

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E.,…Participants, S. T. C. P. (2017). Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. *Int J Behav Nutr Phys Act*, *14*(1), 75. https://doi.org/10.1186/s12966-017-0525-8

Tremblay, M. S., Colley, R. C., Saunders, T. J., Healy, G. N., & Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Appl Physiol Nutr Metab*, *35*(6), 725-740. https://doi.org/10.1139/H10-079

Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: a systematic review. *Public Health*, *121*(12), 909-922. https://doi.org/10.1016/j.puhe.2007.04.009

Turrisi, T. B., Bittel, K. M., West, A. B., Hojjatinia, S., Mama, S. K., Lagoa, C. M., & Conroy, D. E. (2021). Seasons, weather, and device-measured movement behaviors: a scoping review from 2006 to 2020. *Int J Behav Nutr Phys Act*, *18*(1), 24. https://doi.org/10.1186/s12966-021-01091-1

van Dommelen, P., Coffeng, J. K., van der Ploeg, H. P., van der Beek, A. J., Boot, C. R., & Hendriksen, I. J. (2016). Objectively Measured Total and Occupational

Sedentary Time in Three Work Settings. *PLoS One*, *11*(3), e0149951. https://doi.org/10.1371/journal.pone.0149951

Walsh, M. M., Krusmark, M. A., Jastrembski, T., Hansen, D. A., Honn, K. A., & Gunzelmann, G. (2023). Enhancing learning and retention through the distribution of practice repetitions across multiple sessions. *Mem Cognit*, *51*(2), 455-472. https://doi.org/10.3758/s13421-022-01361-8

Wang, C., Lu, E. Y., Sun, W., Chang, J. R., & Tsang, H. W. H. (2024). Effectiveness of interventions on sedentary behaviors in office workers: a systematic review and meta-analysis. *Public Health*, *230*, 45-51. https://doi.org/10.1016/j.puhe.2024.02.013

Wang, X., Li, Y., & Fan, H. (2019). The associations between screen time-based sedentary behavior and depression: a systematic review and meta-analysis. *BMC Public Health*, *19*(1), 1524. https://doi.org/10.1186/s12889-019-7904-9

Waters, C. N., Ling, E. P., Chu, A. H., Ng, S. H., Chia, A., Lim, Y. W., & Müller-Riemenschneider, F. (2016). Assessing and understanding sedentary behaviour in office-based working adults: a mixed-method approach. *BMC Public Health*, *16*, 360. https://doi.org/10.1186/s12889-016-3023-z

Watson, A. K., Hernandez, B. F., Kolodny-Goetz, J., Walker, T. J., Lamont, A., Imm, P.,…Fernandez, M. E. (2022). Using Implementation Mapping to Build Organizational Readiness. *Front Public Health*, *10*, 904652. https://doi.org/10.3389/fpubh.2022.904652

Werneck, A. O., Stubbs, B., Fernandes, R. A., Szwarcwald, C. L., & Silva, D. R. (2019). Leisure time physical activity reduces the association between TV-viewing and depressive symptoms: A large study among 59,401 Brazilian adults. *J Affect Disord*, *252*, 310-314. https://doi.org/10.1016/j.jad.2019.03.066

West, J. T., Miller, W. M., Jeon, S., & Ye, X. (2020). The Effects of a Preconditioning Rolling Session on Subsequent Eccentric Exercise-Induced Muscle Damage. *J Strength Cond Res*, *34*(8), 2112-2119. https://doi.org/10.1519/jsc.0000000000003678

Wilkerson, A. H., Bhochhibhoya, S., & Dragicevic, A. (2021). "It Feels Unhealthy to be Sitting for 40hours a Week": A Qualitative Analysis of Employee Perceptions of Standing Desk Use in the Workplace. *J Occup Environ Med*, *63*(4), 322-328. https://doi.org/10.1097/JOM.0000000000002128

Zhou, L., Deng, X., Xu, M., Wu, Y., Shang, X., E, F.,…Li, X. (2023). The effects of active workstations on reducing work-specific sedentary time in office workers: a network meta-analysis of 23 randomized controlled trials. *Int J Behav Nutr Phys Act*, *20*(1), 92. https://doi.org/10.1186/s12966-023-01467-5

Zhou, Y., Huang, Z., Liu, Y., & Liu, D. (2024). The effect of replacing sedentary behavior with different intensities of physical activity on depression and anxiety in Chinese university students: an isotemporal substitution model. *BMC Public Health*, *24*(1), 1388. https://doi.org/10.1186/s12889-024-18914-y

Annexes

Annex I: Questionnaire applied to participants within the scope of the SUFHA study.

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Questionário SUFHA

Consentimento

Caro/a participante do SUFHA,

Desde já agradecemos o seu interesse em participar neste estudo científico. É objetivo deste estudo perceber, de que forma a alteração no contexto laboral poderá impactar ao nível do comportamento e escolhas alimentares, bem-estar e qualidade de vida, nível de fadiga e dor musculoesquelética e ainda em termos de produtividade. Tal permitirá não só o avanço do conhecimento, mas também o desenvolvimento de melhores práticas de promoção de saúde no contexto laboral, que podem ser posteriormente alargadas a uma escala maior.

Neste âmbito, pedimos-lhe p.f. que preencha um breve questionário online (demora cerca de 20 minutos), de forma a aferirmos alguns dos seus comportamentos de saúde. Não há respostas certas ou erradas. Pedimos-lhe apenas que responda com verdade, de forma ponderada e tão completa quanto possível. As suas respostas serão codificadas cumprindo a legislação aplicável em matéria de proteção de dados: os dados recolhidos são anónimos, confidenciais, protegidos de forma segura e acessíveis apenas à equipa de investigação. As respostas serão analisadas de forma agrupada, e nunca de forma individual. A sua participação neste questionário é totalmente voluntária.

Agradecemos desde já a sua colaboração, a sua participação é muito importante!

Declaro que li e...

- ○ ACEITO as condições da minha participação
- ○ NÃO ACEITO as condições da minha participação

Pedimos que coloque aqui o seu código de identificação (por exemplo, suf01)

Pedimos que coloque aqui o seu peso medido*

40 62 84 106 128 150

Kilogramas

Pedimos que coloque aqui a sua altura medida*

140 150 160 170 180 190 200

Centímetros

Pedimos que coloque aqui o seu perímetro de cintura medido*

30 40 50 60 70 80 90 100 110 120 130

Centímetros

Qual é a sua idade, em anos?

18 30 43 55 68 80

Idade

Sexo

- ○ Feminino
- ○ Masculino
- ○ Outro / Prefiro não dizer

Qual a sua nacionalidade?

_____

Qual a sua naturalidade?

_____

Profissão / Função dentro da ULHT

- ○ Serviços Académicos e Administrativos (p. ex: SATA, PUI, Suporte adicional, Serviços académicos, Recursos humanos)
- ○ Serviços Financeiros (p. ex: Direção financeira, Tesouraria)
- ○ Serviços de Gestão e Administração (p. ex: DMK, DGPA, Reitoria, Administração)
- ○ Outra. Qual? _____

Tempo de serviço / Há quantos anos trabalha nesta instituição?

1 10 18 27 35

Anos de trabalho 

Em média, quantas horas trabalha por dia?

▼ 1 hora por dia ... 24 horas por dia

Qual o nível de escolaridade mais elevado que concluiu?

- ○ Não concluiu a Instrução Primária
- ○ Instrução Primária
- ○ Ensino Básico (9º ano)
- ○ Ensino Secundário (12º ano)
- ○ Licenciatura
- ○ Mestrado
- ○ Doutoramento

Como classifica a sua situação financeira atual?

- ○ Muito difícil
- ○ Difícil
- ○ Suficiente para as necessidades
- ○ Confortável
- ○ Muito confortável

Como é que se desloca? Qual a sua forma mais habitual de se deslocar entre lugares (p.ex. entre casa e a universidade)?

- ○ A pé ou de bicicleta (não elétrica)
- ○ Bicicleta ou trotinete (elétrica)
- ○ Transportes públicos
- ○ Carro ou mota

Atualmente fuma?

- ○ Não e nunca fumei
- ○ Não, mas já fumei
- ○ Fumo ocasionalmente
- ○ Fumo diariamente

Quantos cigarros fuma, em média, por dia?

	1 7 14 20
Nº de cigarros	

Tem alguma doença crónica (física ou psíquica) ou incapacidade diagnosticada por um médico?

- ○ Não
- ○ Sim. Qual/quais? _____

Toma algum tipo de medicação?

- ○ Não
- ○ Sim. Qual/quais? _____

A Universidade Lusófona preocupa-se em promover comportamentos saudáveis (p.ex. atividade física e alimentação).

- ○ Discordo totalmente
- ○ Discordo parcialmente
- ○ Não concordo nem discordo
- ○ Concordo parcialmente
- ○ Concordo totalmente

Costuma praticar atividade física estruturada (p.ex., corrida, caminhada, exercício no ginásio, dança ou atividades desportivas)?

- ○ SIM, costumo praticar atividade física estruturada
- ○ NÃO, não costumo praticar atividade física estruturada

Indique quão frequentemente, no último mês...

	Nunca	Poucas vezes	Algumas vezes	Muitas vezes	Sempre que possível
1.Subiu escadas em vez de utilizar elevadores ou escadas rolantes (p.ex. no seu prédio, em centros comerciais, no local de trabalho etc.).	○	○	○	○	○
2. Escolheu estar em pé em situações em que podia estar sentado (p.ex. enquanto fala ao telefone, enquanto espera em locais públicos ou pelo transporte etc.).	○	○	○	○	○

As próximas questões referem-se ao tempo que passa sentado(a) / reclinado(a) / deitado(a), diariamente, na universidade, em casa, no trabalho, nos transportes ou outros contextos e durante os tempos livres (não inclua o tempo que passa a dormir).

Quanto tempo esteve sentado/a num dia típico de semana?

Horas/minutos

▼ 30 minutos ... 20 horas

Quanto tempo esteve sentado/a num dia típico de fim de semana?

Horas/minutos

▼ 30 minutos ... 20 horas

Habitualmente, quando está sentado, quão frequentemente se costuma levantar?

- ○ Estou mais de 3 horas sem me levantar
- ○ Estou mais de 1 hora sem me levantar
- ○ Levanto-me de hora em hora
- ○ Levanto-me, pelo menos de meia em meia hora

Fadiga geral e no trabalho

Em baixo irá encontrar um conjunto de afirmações que poderão descrever a sua situação. Para cada uma das seguintes frases **indique como se sente, no geral**, utilizando a seguinte escala de resposta:

	Nada	Um pouco	Moderadamente	Muito	Extremamente
1.Não me sinto com energia.	○	○	○	○	○
2.Tudo o que eu faço requer esforço.	○	○	○	○	○
3.Sinto-me fraco em determinadas partes do meu corpo.	○	○	○	○	○
4.Sinto as minhas pernas ou os meus braços pesados.	○	○	○	○	○
5.Sinto-me cansado sem motivo aparente.	○	○	○	○	○
6.Tenho vontade de me deitar para descansar.	○	○	○	○	○
7.Tenho dificuldades em concentrar me.	○	○	○	○	○
8.Sinto-me cansado, pesado e rígido.	○	○	○	○	○

NFR (RecScale)

Para cada uma das questões que se seguem, assinale a opção que melhor descrever a sua **situação atual**.

	Não	Sim
1. É difícil relaxar no final de um dia ocupado.	○	○
2. No final de um dia ocupado, sinto-me esgotado(a).	○	○
3. Devido às minhas atividades, no final do dia, sinto-me exausto(a).	○	○
4. Depois de jantar, sinto-me em boa forma.	○	○
5. Só começo a sentir-me relaxado(a) ao 2º dia de descanso.	○	○
6. Tenho dificuldade em concentrar-me no meu tempo livre, depois do trabalho ou tarefas diárias.	○	○
7. Quando chego a casa do trabalho ou após as minhas tarefas diárias, não consigo ter vontade de estar com outras pessoas.	○	○
8. Depois do trabalho ou das minhas tarefas diárias, preciso de pelo menos uma hora para me sentir completamente recuperado(a).	○	○
9. Quando chego a casa do trabalho ou após as minhas tarefas diárias, preciso que "me deixem em paz" durante algum tempo.	○	○
10. Depois de um dia de trabalho ou outros deveres, sinto-me tão cansado(a) que não consigo fazer mais nada.	○	○
11. A sensação de cansaço que tenho impede-me de fazer, ao mesmo ritmo, o meu trabalho ou outras tarefas diárias ao longo do dia.	○	○

Nas **duas últimas semanas,** por quanto tempo teve **dificuldade ou incapacidade** nas seguintes situações:

	Nada	Um pouco	Moderadamente	Muito	Extremamente
1. Trabalhar as horas que me são solicitadas.	○	○	○	○	○
2. Começar as suas tarefas assim que chega ao trabalho.	○	○	○	○	○
3. Fazer os mesmos movimentos, repetidamente durante o trabalho.	○	○	○	○	○
4. Utilizar o equipamento de trabalho (i.e.: telefone, caneta, teclado, rato...).	○	○	○	○	○
5. Concentrar-se no trabalho.	○	○	○	○	○
6. Ajudar os outros a acabar o trabalho.	○	○	○	○	○
7. Desenvolver a quantidade de trabalho queme é solicitada.	○	○	○	○	○
8. Sentir que devia ter feito aquilo que sou capaz de fazer.	○	○	○	○	○

Qualidade de vida - EUROHIS-QOL-8

As próximas questões procuram conhecer a sua **qualidade de vida, saúde e outras áreas da sua vida**. Por favor, responda a todas as perguntas, optando sempre pela opção que lhe parecer mais apropriada.

Tendo em conta as **duas últimas semanas:**

	Muito má	Má	Nem boa nem má	Boa	Muito boa
Como avalia a sua qualidade de vida?	○	○	○	○	○

Tendo em conta as **duas últimas semanas**:

	Nada	Pouco	Moderadamente	Bastante	Completamente
Tem energia suficiente para a sua vida diária?	○	○	○	○	○
Tem dinheiro suficiente para satisfazer as suas necessidades?	○	○	○	○	○

Tendo em conta as **duas últimas semanas**:

	Muito insatisfeito	Insatisfeito	Nem satisfeito nem insatisfeito	Satisfeito	Muito satisfeito
Até que ponto está satisfeito(a) com a sua saúde?	○	○	○	○	○
Até que ponto está satisfeito(a) com a sua capacidade para desempenhar as atividades do seu dia-a-dia?	○	○	○	○	○
Até que ponto está satisfeito(a) consigo próprio(a)?	○	○	○	○	○
Até que ponto está satisfeito(a) com as suas relações pessoais?	○	○	○	○	○
Até que ponto está satisfeito(a) com as condições do lugar em que vive?	○	○	○	○	○

Bem-estar - WHO-5

Indique, por favor, para cada uma das cinco afirmações, a opção que mais se aproxima do **modo como se tem sentido nas últimas 2 semanas**.

Exemplo: Se se sentiu alegre e bem-disposto(a), durante mais da metade do tempo, assinale na 1ª linha a opção na 5ª coluna.

Durante as últimas 2 semanas...

	Algumas vezes	Menos da metade do tempo	Mais da metade do tempo	Maior parte do tempo	Todo o tempo
1. Senti-me alegre e bem-disposto(a).	○	○	○	○	○
2. Senti-me calmo(a) e tranquilo(a).	○	○	○	○	○
3. Senti-me ativo(a) e enérgico(a).	○	○	○	○	○
4. Acordei e senti-me fresco(a) e repousado(a).	○	○	○	○	○
5. O meu dia-a-dia tem sido preenchido com coisas que me interessam.	○	○	○	○	○

UWES-9

As seguintes afirmações referem-se ao **modo como se sente no trabalho**. Por favor, leia as mesmas com atenção e pense se alguma vez se sente assim em relação ao seu trabalho. Se nunca teve esta sensação, por favor assinale "nunca" na escala. Se já teve esta sensação, assinale a frequência com que a sente, entre "algumas vezes ao longo do ano ou menos" e "todos os dias", que melhor descreve a sua situação.

	Nunca	Algumas vezes por ano ou menos	Uma vez por mês	Algumas vezes por mês	Uma vez por semana	Algumas vezes por semana	Todos os dias
1. No meu trabalho sinto-me cheio(a) de energia.	○	○	○	○	○	○	○
2. No meu trabalho sinto-me com força e energia.	○	○	○	○	○	○	○
3. Estou entusiasmado(a) com o meu trabalho.	○	○	○	○	○	○	○
4. O meu trabalho inspira-me.	○	○	○	○	○	○	○
5. Quando me levanto de manhã apetece-me ir trabalhar	○	○	○	○	○	○	○
6. Sinto-me feliz quando estou a trabalhar intensamente.	○	○	○	○	○	○	○

7. Estou orgulhoso(a) do que faço neste trabalho.	○	○	○	○	○	○	○
8. Estou imerso(a) no meu trabalho.	○	○	○	○	○	○	○
9. "Deixo-me ir" quando estou a trabalhar	○	○	○	○	○	○	○

Adesão à Dieta Mediterrânica

Com que **frequência** consome...

Cereais não refinados (pão integral/de mistura, massa e arroz integral, etc.)
1 porção equivale a 1 fatia de pão/1 bola, ½ chávena de arroz ou massa.

- ○ Nunca
- ○ 1-6 porções regulares por semana
- ○ 7-12 porções regulares por semana
- ○ 13-18 porções regulares por semana
- ○ 19-31 porções regulares por semana
- ○ >=32 porções regulares por semana

Batatas
1 porção equivale a ½ chávena de batata cozida/puré, 1 chávena de batatas fritas, 1,5 batatas cruas.

- ○ Nunca
- ○ 1-2 porções regulares por semana
- ○ 3 porções regulares por semana
- ○ 4 porções regulares por semana
- ○ >=5 porções regulares por semana

Fruta
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.

- ○ Nunca
- ○ 1-4 porções regulares por semana

- ○ 5-8 porções regulares por semana
- ○ 9-15 porções regulares por semana
- ○ 16-21 porções regulares por semana
- ○ >=22 porções regulares por semana

Hortícolas (crus ou cozinhados)
1 porção equivale a 1 chávena almoçadeira de hortícolas crus e ½ chávena cozinhados.

- ○ Nunca
- ○ 1-6 porções regulares por semana
- ○ 7-12 porções regulares por semana
- ○ 13-20 porções regulares por semana
- ○ 21-32 porções regulares por semana
- ○ >=33 porções regulares por semana

Leguminosas (grão, feijão, ervilhas, etc.)
1 porção equivale a 1 chávena.

- ○ Nunca
- ○ 1-2 porções regulares por semana
- ○ 3-4 porções regulares por semana
- ○ 5-6 porções regulares por semana
- ○ >=7 porções regulares por semana

Peixe (e derivados do mar)
1 porção equivale a 120g de peixe cozinhado.

- ○ Nunca
- ○ < 1 porção regular por semana
- ○ 1-2 porções regulares por semana
- ○ 3-4 porções regulares por semana
- ○ 5-6 porções regulares por semana
- ○ >=7 porções regulares por semana

Carnes vermelhas e produtos de charcutaria

1 porção equivale a 120g de carne cozinhada

- ○ ≤1 porção regular por semana
- ○ 2-3 porções regulares por semana
- ○ 4-5 porções regulares por semana
- ○ 6-7 porções regulares por semana
- ○ 8-10 porções regulares por semana
- ○ >=11 porções regulares por semana

Carnes brancas (de aves)

1 porção equivale a 120g de carne cozinhada

- ○ ≤ 3 porções regulares por semana
- ○ 4 porções regulares por semana
- ○ 5-6 porções regulares por semana
- ○ 7-8 porções regulares por semana
- ○ 9-10 porções regulares por semana
- ○ ≥ 11 porções regulares por semana

Lacticínios gordos (queijo, iogurte, leite)
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 porções regulares por semana.

- ○ ≤10 porções regulares por semana
- ○ 11-15 porções regulares por semana
- ○ 16-20 porções regulares por semana

- ○ 21-28 porções regulares por semana
- ○ 29-30 porções regulares por semana
- ○ >=31 porções regulares por semana

Uso de azeite na confeção

- ○ Nunca
- ○ Raramente
- ○ 1-3 vezes por semana
- ○ 3-5 vezes por semana
- ○ Diariamente

Bebidas alcoólicas
1 copo de vinho = 100ml

- ○ 0 ml/dia
- ○ 300 ml/dia
- ○ 400 ml/dia
- ○ 500 ml/dia
- ○ 600 ml/dia
- ○ >=700 ml/dia

Numa semana típica, quantas vezes...

	Nunca	1-2 vezes	3-5 vezes	6 ou mais vezes
1. Toma pequeno-almoço?	○	○	○	○
2. Salta refeições principais (almoço/jantar)?	○	○	○	○
3. Come refeições caseiras confecionadas por si/familiares/amigos?	○	○	○	○
4. Come em restaurantes/bares/cafés ou encomenda comida (*take away*)?	○	○	○	○
5. Come refeições rápidas (*fast food*)?	○	○	○	○

Para cada afirmação que se segue, indique **quão verdadeira/aplicável** é para si...

	Nada verdadeiro no meu caso	Um pouco verdadeiro no meu caso	Às vezes	Muito verdadeiro no meu caso	Totalmente verdadeiro no meu caso
1. Dou por mim a comer quando me sinto mais ansioso(a), depressivo(a) ou triste, mesmo que não esteja fisicamente com fome.	○	○	○	○	○
2. Recuso comidas ou bebidas porque controlo o meu peso.	○	○	○	○	○
3. Como menos do que habitualmente quando comi demasiado na véspera.	○	○	○	○	○
4. Vigio exatamente o que como.	○	○	○	○	○
5. Eu confio no meu corpo para me alertar quando devo comer.	○	○	○	○	○
6. Eu confio no meu corpo para me alertar da quantidade que devo comer.	○	○	○	○	○
7. Habitualmente, escolho alimentos que ajudam o meu corpo a funcionar melhor.	○	○	○	○	○
8. Por vezes, quando começo a comer não consigo parar.	○	○	○	○	○
9. Estar com alguém que está a comer, faz-me querer comer também.	○	○	○	○	○
10. Quando vejo um prato com aspeto delicioso ou sinto o cheiro de comida apetitosa não resisto a comer, mesmo que tenha acabado há pouco tempo uma refeição.	○	○	○	○	○

Desconforto musculoesquelético

Por favor, responda a cada questão assinalando a opção mais apropriada. Marque apenas uma opção por cada questão. Não deixe nenhuma questão em branco, mesmo se não tiver nenhum problema em qualquer parte do corpo. Para responder, considere as regiões do corpo conforme ilustra a figura abaixo.

Teve algum problema nos **<u>últimos 7 dias</u>**, nas seguintes regiões:

Pescoço?

○ Não

○ Sim

	1	2	3	4	5	6	7	8	9	10	11	
Sem dor	○	○	○	○	○	○	○	○	○	○	○	Dor máxima

Ombros?

○ Não

○ Sim

Em que região?

○, no ombro direito

○, no ombro esquerdo

○, em ambos

	1	2	3	4	5	6	7	8	9	10	11	
Sem dor	○	○	○	○	○	○	○	○	○	○	○	Dor máxima

Cotovelo?

○ Não

○ Sim

○, no cotovelo direito

○, no cotovelo esquerdo

○, em ambos

	1	2	3	4	5	6	7	8	9	10	11	
Sem dor	○	○	○	○	○	○	○	○	○	○	○	Dor máxima

Punho/mãos?

○ Não

○ Sim

○, no punho/mãos direitos

○, no punho/mãos esquerdo

○, em ambos

	1	2	3	4	5	6	7	8	9	10	11	
Sem dor	○	○	○	○	○	○	○	○	○	○	○	Dor máxima

Região Torácica?

○ Não

○ Sim

	1	2	3	4	5	6	7	8	9	10	11	
Sem dor	○	○	○	○	○	○	○	○	○	○	○	Dor máxima

Região Lombar?

○ Não

○ Sim

	1	2	3	4	5	6	7	8	9	10	11	
Sem dor	○	○	○	○	○	○	○	○	○	○	○	Dor máxima

Ancas/coxas?

○ Não

○ Sim

○, na anca/coxa direita

○, na anca/coxa esquerda

○, em ambos

	1	2	3	4	5	6	7	8	9	10	11	
Sem dor	○	○	○	○	○	○	○	○	○	○	○	Dor máxima

Nota metodológica: O preenchimento do questionário foi realizado integralmente na presença do investigador, o que permitiu garantir a clareza das instruções, a padronização do processo e a fidelidade dos dados recolhidos. Esta abordagem contribuiu para reduzir ambiguidades, facilitar a compreensão por parte dos participantes e assegurar a qualidade e consistência da informação registada.

Os dados assinalados com um asterisco (*) referem-se a itens preenchidos diretamente pelo investigador, após a realização das medições correspondentes, sempre com o participante presente, de forma a garantir a precisão e exatidão dos registos.

Annex II: Opinion of the ethics committee of the Faculty of Physical Education and Sports within the scope of the SUFHA study.

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UNIVERSIDADE LUSÓFONA
I Faculdade de Educação Física e Desporto

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)

Annex III: Scientific production complementary to the work integrated into the thesis

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Article published as first author in *Ergonomics*, October 2024.

Impact of a 6-month sit-stand desk-based intervention on regional musculoskeletal discomfort and overall post-work fatigue in office workers: a cluster randomized controlled trial.

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Abstract

Purpose: Evaluate the impact of a 6-month sit-stand desk (SSD) intervention on office workers' regional musculoskeletal discomfort (MD) and overall post-work fatigue (PWF) compared to a control group.

Methods: A two-arm (1:1) clustered randomized controlled trial including 38 participants (aged 24-60 years, 77% women) assigned to intervention or control groups. The intervention, spanning 6 months, involved psychoeducation, motivational prompts, and SSD. The control group maintained standard working conditions. MD was assessed using the Nordic Musculoskeletal Questionnaire, and PWF with the Need for Recovery Scale. ANCOVA was employed to compare groups, adjusting for covariates, with 5% significance.

Results: The intervention group reduced overall MD ($p=0.018$) and PWF ($p=0.013$), while the control group showed no changes. However, no time*group interactions were found ($p>0.05$).

Conclusion: A 6-month SSD intervention alleviated office workers' MD and PWF, suggesting benefits from increasing standing time by at least 30 minutes/day. Future investigations must explore individual heterogeneity in response to SSD.

Keywords: musculoskeletal discomfort; office workers; sedentary behavior; sit-stand desk.

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1. Introduction

Sedentary behavior (SB) (i.e., any task performed while awake, in a sitting, lying, or reclining posture with an energy expenditure of ≤ 1.5 metabolic equivalents (METs)) has been increasing in the past decades, and there is an estimated 1.9 million deaths worldwide accountable to this risk factor (Tremblay et al., 2017). Extended periods of SB (defined as uninterrupted periods exceeding 30 minutes) have been linked to an amplified likelihood of chronic illnesses such as cardiovascular disease and type 2 diabetes, as well as early death (Patterson et al., 2018). Additionally, engaging in excessive SB (ranging from 7.5 to 9.5 hours or more) has been correlated with an elevated risk of mortality (Ekelund, Brown, et al., 2019).

SB is particularly concerning since adults in developed countries spend more than 60% of their waking time sitting at the workplace (Bennie et al., 2015; Colley et al., 2011). According to the World Health Organization (WHO), workers represent approximately half of the global population, and for SB to be reduced, sitting at work must be regularly replaced by standing or other active breaks (Buckley et al., 2015). Office workers spend long periods with static neck postures and repetitive hand/wrist movements, often with awkward back postures (Neupane et al., 2017). These factors increase the chance of developing musculoskeletal discomfort (MD) or pain, resulting in reduced work performance (Neupane et al., 2017).

Musculoskeletal symptoms of discomfort are prevalent among sedentary workers, with 90% of office workers reporting events of pain associated with work posture(Parry et al., 2019). Prolonged keyboard and mouse use, high mental workload, and stress contribute to musculoskeletal symptoms in sedentary office workers (Coenen et al., 2019). Available evidence suggests that prolonged sitting at work may correlate with neck and lower limb discomfort, while upper extremity issues may be linked to computer usage (Andersen et al., 2016; Bennie et al., 2015; Sterud, 2014). Prolonged sitting, particularly when coupled with poor postures such as forward-leaning positions, can exacerbate lower back discomfort (Biswas et al., 2015). Office-based workers typically spend a significant portion of their workday seated, with approximately 75% of their time being sedentary, often in extended bouts lasting 30 minutes or more without interruption (Chau et al., 2013). The most common musculoskeletal complaints among desk workers are neck, shoulder, and lower back pain (Katzmarzyk et al., 2019).

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Reducing sitting time may alleviate MD through regular interruption of static postures and reducing the slumped posture of the lumbar spine that can occur (Karakolis & Callaghan, 2014). However, it is essential to note that prolonged periods of static standing can also harm musculoskeletal health (Coenen et al., 2017). Conflicting evidence exists regarding sitting reduction-based interventions' impact on MD (Karakolis & Callaghan, 2014; Neuhaus, Eakin, et al., 2014; Shrestha et al., 2018a). Studies evaluating sitting interventions in the workplace have reported improvements, worsening, or no change in musculoskeletal outcomes (Agarwal et al., 2018; Karakolis & Callaghan, 2014; Neuhaus, Eakin, et al., 2014; Shrestha et al., 2018a). Also, evidence indicates inconsistent findings according to the analyzed body region.

In addition to musculoskeletal discomfort, the occupational balance between SB and physical activity (PA) is linked to the need for recovery after work (NFR) (Karihtala et al., 2023). Specific physical exposures at work, such as bending or twisting the back, working with arms at or above shoulder height, pushing/pulling/lifting/carrying, squatting or kneeling, neck flexion, repetitive hand/arm movement, and prolonged standing, are commonly associated with physically demanding occupations and have been well-documented as risk factors for musculoskeletal disorders (Punnett & Wegman, 2004). However, despite being less physically intense, sedentary jobs, particularly those involving prolonged sitting, repetitive hand and arm movements, or sustained improper postures, can similarly contribute to the development of musculoskeletal pain and disorders. The cumulative effects of these subtle yet repetitive exposures in office settings underscore the importance of ergonomic interventions, as even low-intensity tasks performed over extended periods can induce significant biomechanical strain. These exposures predict long-term sickness absence, musculoskeletal pain, and related disorders (Andersen et al., 2016; de Cássia Pereira Fernandes et al., 2016; Punnett & Wegman, 2004; Sterud, 2014), often worsening after work. Fatigue after work is shared among workers engaged in physical labor (Bláfoss, Sundstrup, et al., 2019), characterized by tiredness, lack of energy, and exhaustion (Shen et al., 2006). Engaging in PA can help reduce general and work-related fatigue, with higher levels of fatigue associated with lower PA levels and vice versa (de Vries et al., 2016; de Vries et al., 2017; Puetz, 2006). Recent studies (Bláfoss, Micheletti, et al., 2019; Karihtala et al., 2023) suggest that interrupting sedentary work with short PA intervals can reduce NFR levels. These

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findings emphasize the importance of promoting a balanced approach between SB and PA in occupational settings to mitigate adverse health outcomes.

The substantial amount of SB spent at work and its associated health risks emphasize the need to comprehend the development of musculoskeletal symptoms in sedentary workers. Thus, our study aimed to investigate the impact of a 6-month sit-stand desk (SSD) based intervention in the presence and intensity of overall MD and NFR and investigate regional changes in MD of office workers.

2. Method

2.1. Study design

This trial followed the CONSORT standard for cluster randomized clinical trials and is a two-arm (1:1) randomized controlled trial conducted in parallel. Measurements occurred at baseline and six months later. The entire protocol for more detail has been previously published (Júdice et al., 2023). Briefly, after baseline measurements, cluster randomization was performed using a list randomizer (www.random.org) by a researcher not involved in the data collection or recruitment. The allocation procedure took into account various sites as units for randomization to minimize the possibility of contamination. Measures were taken to ensure that both the control and intervention groups were equated concerning essential factors like daily duration of sitting, frequency of transitions from sitting to standing, body mass index (BMI), age, and gender distribution. Participants were grouped and randomized as a cluster when they faced each other from their workstations. Participants were informed about their group allocation by email after the initial assessments. Recruitment took place between December 2022 and January 2023, with initial data collection in February 2023 and follow-up data collection in August 2023.

2.2. Setting and participants

Recruitment of office workers was conducted through university advertisements (banners, posters) and institutional emails. Individuals who indicated interest and fulfilled the inclusion criteria were invited to take part in the study. A dedicated website (https://sufha.ulusofona.pt) was created to inform participants about the trial, assessments, expectations, and tools to promote SSD use during the intervention. Researchers assessed the suitability of participants' workspaces for installing SSD during

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visits to those who expressed an interest. Inclusion criteria included working at least 0.6 full-time, over 20 years old, and spending at least 70% of a week on desk-related activities. Exclusion criteria included the current use of an SSD, lack of personal space to set up a desk, and musculoskeletal disorders or health conditions that would make standing intolerable (e.g., rheumatic diseases, neuromuscular diseases, fibromyalgia, chronic low back pain, autoimmune diseases, osteoporosis, and recent orthopedic surgeries within the past year). Additionally, individuals who worked from home were excluded due to the logistical challenge of assembling two SSD for each participant.

2.3. Data Collection

An online questionnaire was employed to gather information on participants' sociodemographic details, health status, and occupational characteristics. To comply with ethical standards, the data from this study has been securely stored in a folder accessible only to the research team members. Participant consent was not extended to the public sharing of this data.

2.4. Nordic Musculoskeletal Questionnaire

We used the Nordic Musculoskeletal Questionnaire to assess MD in several body regions participants experienced the previous week. This questionnaire covers and scores discomfort in nine different body regions (i.e., neck, shoulders, elbows, hands/wrists, thorax, lower back, hips/thighs, knees, and ankles/feet). Participants rated the discomfort in each body region on a scale from zero (no discomfort) to nine (as much discomfort as possible) (Andersen et al., 2008). An overall discomfort score was calculated by summing the different body regions' scores. The higher the score, the more MD the participants felt.

2.5. NFR Scale

The NFR scale assessed the need to recover after work (van Veldhoven & Broersen, 2003). The questionnaire presents 11 items with dichotomic answers 0 ("no") and 1 ("yes"). The items mentioned in the questionnaire are: 1. I find it difficult to relax at the end of a working day; 2. By the end of the working day, I feel really worn out; 3. Because of my job, at the end of the working day, I feel rather exhausted; 4. After the

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evening meal, I generally feel in good shape; 5. In general, I only start to feel relaxed on the second non-working day; 6. I find it difficult to concentrate in my free time after work; 7. I cannot really show any interest in other people when I have just come home myself; 8. Generally, I need more than an hour before I feel completely recuperated after work; 9. When I get home from work, I need to be left in peace for a while; 10. Often, after a day's work I feel so tired that I cannot get involved in other activities; 11. A feeling of tiredness prevents me from doing my work as well as I normally would during the last part of the working day. A higher total NFR score indicates that the worker needs greater recovery time from their work tasks, thus more post-work fatigue (PWF).

2.6. Physical Behaviors

The physical behaviors (e.g., sitting time, standing time) were objectively assessed at both baseline and six months, where participants were asked to continuously wear an activPAL4 activity monitor (manufactured by PAL Technologies Ltd., Glasgow, Scotland, UK) for 24 hours over 7 days. More details on this evaluation have been previously described (Júdice et al., 2023). Five variables were considered from the ActivPAL data. The variables include the mean time spent sitting per day, mean time spent in prolonged sitting per day (categorized into bouts of 30 minutes or more and bouts of over 60 minutes), mean time spent standing per day, mean time spent stepping per day, and mean number of valid days.

2.7. Assessment Procedures

After providing instructions on using the ActivPAL, participants received the device, which was affixed to the right thigh's midpoint using a waterproof pharmacological dressing by a trained evaluator. Participants were informed that the device should be worn continuously for seven consecutive days, without removal, starting from the assessment day. One day before the device's return, participants received an email indicating the location and time for retrieval. Subsequently, participants completed an online questionnaire, with immediate assistance from a trained evaluator for any queries. The questionnaire, created using Qualtrics online software, covered various themes as previously outlined (Júdice et al., 2023).

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2.8. Control Group

The waiting-list control group attended a psychoeducational session about the independent benefits of reducing and interrupting sitting time with standing. However, there were no contextual changes during the 6-month intervention, meaning no access to SSD or any other prompts. This session aimed to raise awareness and literacy, as it has been shown to facilitate behavior change in a similar setting (Biddle et al., 2020). After the intervention, the waiting-list control group had access to the SSD.

2.9. Intervention Group

Intervention details were published before (Júdice, et al., 2023). Briefly, the intervention group attended the initial psychoeducational session and received an SSD (Vinsetto, Model 923-043) for their workplace. In addition to the initial session, the intervention involved assembling SSD at participants' workplaces before the intervention began. Desk mounts included a device installed on conventional workplace desks using a clamping arm. This device facilitated seamless transitions between sitting and standing postures, primarily during computer-based activities. Participants were also given a demonstration of how to use their SSD, personalized information on correct ergonomic posture, and individualized guidance on gradually increasing standing time.

Recognizing that temporary context changes, such as holidays, may disrupt new routines, like standing more often in the workplace, motivational nudges were incorporated throughout the intervention. These nudges were delivered via email and SUFHA's website in various formats. They included animated short videos with tips on breaking up sitting time and testimonials from participants sharing their experiences using the desk. These nudges aimed to support relatedness, perceived competence, and autonomy according to the Self-Determination Theory (Ryan & Deci, 2000), promoting autonomous motivation for sustained behavioral change (Ng et al., 2012).

Lastly, monthly emails were sent to intervention group participants, allowing them to reflect on the previous month and provide detailed feedback on several aspects, such as SSD usage, strategies to reduce sitting time, barriers, the need for more information, and the alignment of desk use with personal expectations.

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2.10. Statistical Analysis

We conducted statistical analyses using PASW Statistics version 29.0.2.0 (SPSS Inc., an IBM Company, Chicago, IL, USA). Paired-sample t-tests assessed differences between baseline and 6-month follow-up within each group. In instances where exploratory analysis indicated non-normally distributed variables, non-parametric tests were used. A repeated measures ANCOVA, considering the time (baseline, 6-month follow-up) as the within-subjects factor and the intervention group as the between-subjects factor, was performed to evaluate the intervention's effect on the outcomes. Adjustments were made for age, sex, clustering, and BMI. The threshold for statistical significance was set at 5%.

3. Results

As illustrated in a previous publication(Júdice, Silva, et al., 2023), initially, 40 participants were recruited and assessed at baseline. However, one participant withdrew from the study due to health problems. We then randomized 27 office clusters, allocating 15 clusters (20 participants) to the intervention group and 12 clusters (19 participants) to the control group. No participants withdrew from the study after randomization. However, of the 39 participants who completed the study, one participant from the intervention group was excluded from the analyses due to pregnancy during the intervention period. Therefore, 38 participants (19 in each group) were included in the final analyses.

Table 1 shows the baseline characteristics of the SUFHA participants. The age range of the study participants was 24 to 60 years, with a mean age of 43.8 years (SD=8.0). The mean BMI was 28.8 kg/m² (SD=6.9). The sample was 76.3% female (n=29). Educational qualifications varied, with 28.4% having completed high school, 45.8% having completed a bachelor's degree, 12.9% having completed a master's degree, and 12.9% having completed a doctorate. No significant differences were observed between the intervention and control groups at baseline ($p>0.05$).

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Table 1 - Baseline characteristics according to randomized groups: usual practice (control) and SUFHA intervention. Values are means (standard deviations) unless stated otherwise.

Characteristics	Control	Intervention	Total
Sample size	(n=19)	(n=19)	(n=38)
Age (years)	42.3 (9.5)	45.3 (6.0)	43.8 (8.0)
Nº (%) women	14 (73.3%)	16 (80.0%)	30 (76.6%)
Service Time	14.6 (11.5)	15.8 (9.9)	15.2 (10.6)
Biometric measurements			
Body mass index (kg/m^2)	30.5 (7.4)	27.2 (6.1)	28.8 (6.9)
Body weight (kg)	82.3 (21.1)	72.0 (16.5)	77.0 (19.4)
Height (m)	1.64 (0.1)	1.63 (0.1)	1.63 (0.1)
ActivPAL outcomes			
Sitting time (min/day)	475.9 (130.4)	469.0 (70.5)	472.4 (102.7)
Prolonged (≥30 min) sitting (min/day)	266.7 (118.7)	276.1 (93.8)	271.5 (105.4)
Prolonged (≥60 min) sitting (min/day)	125.6 (104.9)	145.0 (86.7)	135.5 (95.2)
Standing time (min/day)	248.4 (82.2)	274.2 (92.5)	261.6 (87.5)
Stepping time (min/day)	81.5 (23.3)	99.9 (27.3)	91.0 (26.8)
Nº of valid days	6.0 (0.0)	6.0 (0.0)	6.0 (0.0)

Table 2 demonstrates that the intervention group experienced significant reductions in overall MD and PWF scores ($p<0.05$). Additionally, there was a notable trend towards reduced shoulder pain (-1.16, 95% CI: -2.41 to 0.90, $p=0.067$) and low back pain (-1.05, 95% CI: -2.14 to 0.31, $p=0.056$) within the intervention group. Notably, no significant time*group interactions were observed for any outcome ($p>0.05$).

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Table 2 - Pain intensity in the neck, shoulders, upper back, elbows, lower back, wrist/hand, hip/thigh, at two assessment times: baseline and 6 months, in the control group (CG) and the intervention group (IG).

	Mean (SD) at baseline		**Mean (SD) at 6 months**		**p**	**Mean difference from baseline to 6 months (95% CI)**			
	CG (n=19)	IG (n=19)	CG (n=19)	IG (n=19)	Time*group p-value	CG[2] (n=19)	Time p-value	IG (n=19)	Time p-value
Neck	2.58 (3.47)	2.47 (3.37)	1.95 (3.24)	1.74 (2.85)	0.937	-0.63 (-2.74 to 1.48)	0.537	-0.74 (-2.52 to 1.04)	0.396
Shoulder	1.37 (2.73)	2.21 (3.15)	0.79 (2.51)	1.05 (2.27)	0.441	-0.58 (-1.52 to 0.36)	0.213	-1.16 (-2.41 to 0.90)	0.067
Upper back	0.63 (2.31)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.242	-0.63 (-1.75 to 0.48)	0.250	0.00 (0.00 to 0.00)	1.000
Elbow	0.00 (0.00)	0.90 (2.69)	0.00 (0.00)	0.90 (2.42)	1.00	0.00 (0.00 to 0.00)	1.000	0.00 (-0.32 to 0.32)	1.000
Hand/wrist	0.63 (2.01)	2.00 (3.43)	0.42 (1.84)	1.00 (2.00)	0.403	-0.21 (-1.57 to 1.15)	0.749	-1.00 (-2.52 to 0.52)	0.185
Low back	3.26 (3.26)	3.68 (3.16)	2.00 (2.69)	2.63 (3.25)	0.807	-1.26 (-2.70 to 0.17)	0.081	-1.05 (-2.14 to 0.31)	0.056
Hip/thigh	0.84 (2.12)	2.53 (3.61)	0.16 (0.69)	1.63 (3.00)	0.806	-0.68 (-1.79 to 0.42)	0.209	-0.90 (-2.3 to 0.51)	0.199
Score muskoskeletal discomfort	9.32 (10.31)	13.79 (13.95)	5.32 (6.46)	8.90 (10.70)	0.752	-4.00 (-8.36 to 0.36)	0.070	-4.89 (-8.86 to -0.93)	**0.018***
Score NFR	6.11 (2.96)	4.74 (3.12)	5.05 (3.49)	3.05 (2.84)	0.486	-1.05(-2.44 to 0.33)	0.128	-1.68 (-2.96 to -0.41)	**0.013***

Abbreviations: NFR, Need for Recovery Scale; CG, Control group; IG, Intervention group.
Note: The model included clustering, age, sex, and BMI as covariates in the repeated measures ANCOVA. * Mean significant time effect within group.

While the time*group effect on MD across various body regions did not reach statistical significance, Figure 1 effectively illustrates the temporal dynamics of overall musculoskeletal discomfort, neck pain, and shoulder pain within both the intervention and control groups.

Further analysis revealed no significant temporal changes in MD levels across elbow, wrist/hand, and upper back regions (Fig. 2), as well as the hip/thigh, for both the intervention and control groups ($p>0.05$). However, there was a reduction in shoulder pain (Fig.1) and low back pain (Fig.3) that approached significance between baseline and 6 months. This reduction was particularly evident in the intervention group. Additionally, the NFR score (Fig. 3) demonstrated discernible variations between baseline and 6 months across groups, with a statistically significant difference between baseline and 6 months observed within the intervention group ($p=0.013$).

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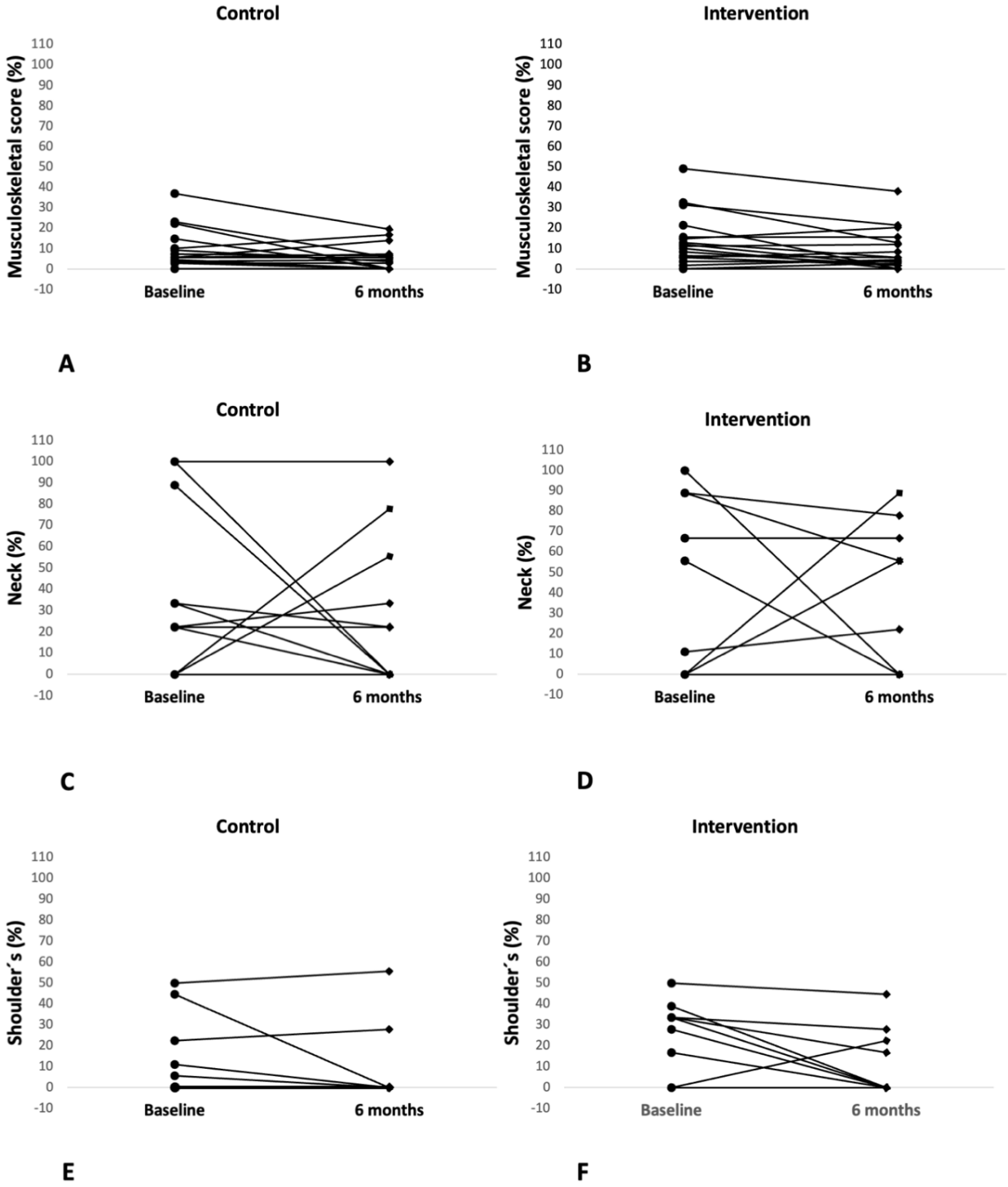

Figure 1 - Inter-individual Change in score musculoskeletal pain, neck, and shoulders among participants in the control and intervention groups.

Silva, H., G F Ramos, P., Teno, S. C., & Júdice, P. B. (2024). Impact of a 6-month sit-stand desk-based intervention on regional musculoskeletal discomfort and overall post-work fatigue in office workers: a cluster randomised controlled trial. *Ergonomics*, 1–14. https://doi.org/10.1080/00140139.2024.2414197

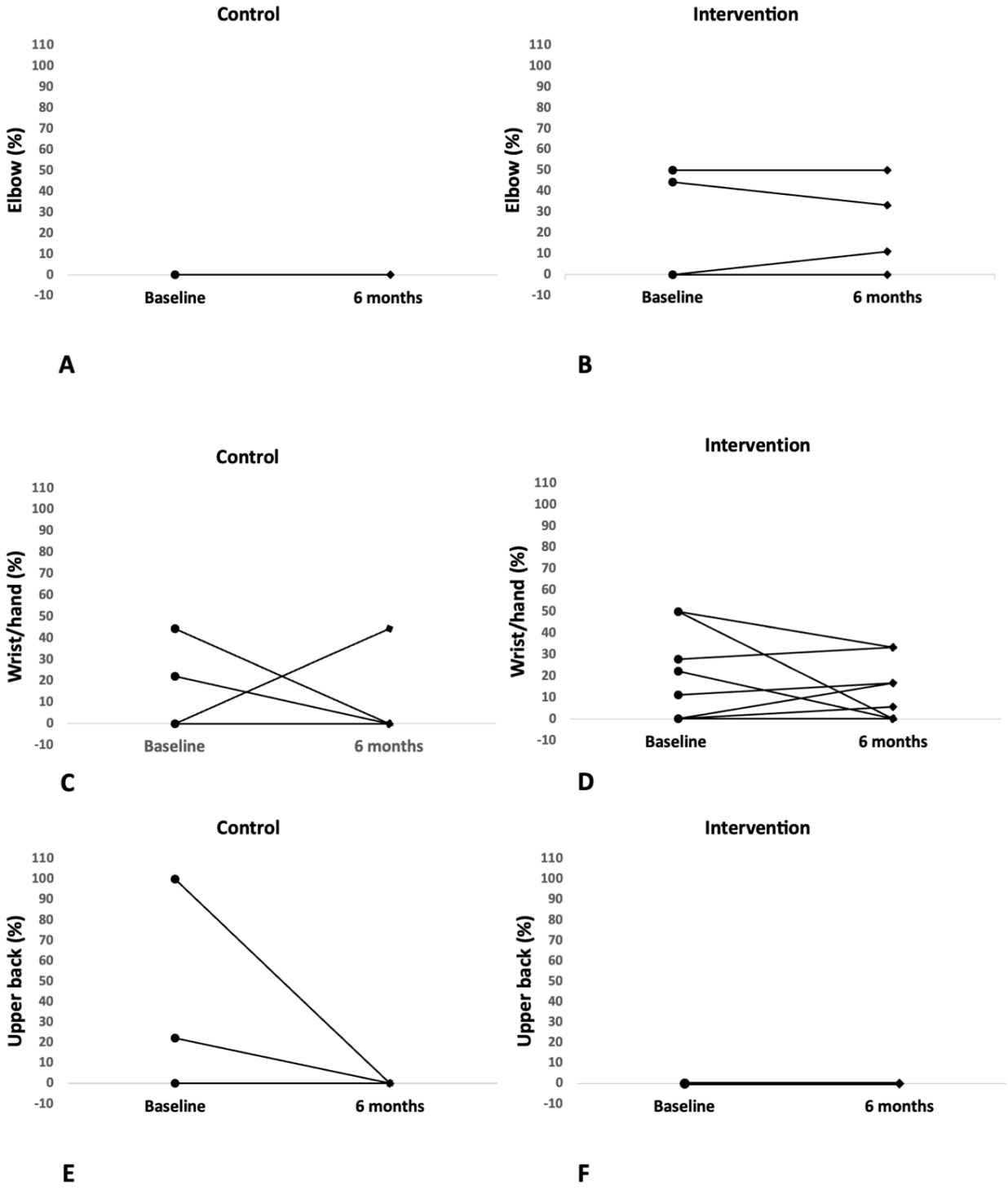

Figure 2 - Inter-individual change in elbow, wrist/hand, and upper back pain among participants in the control and intervention groups.

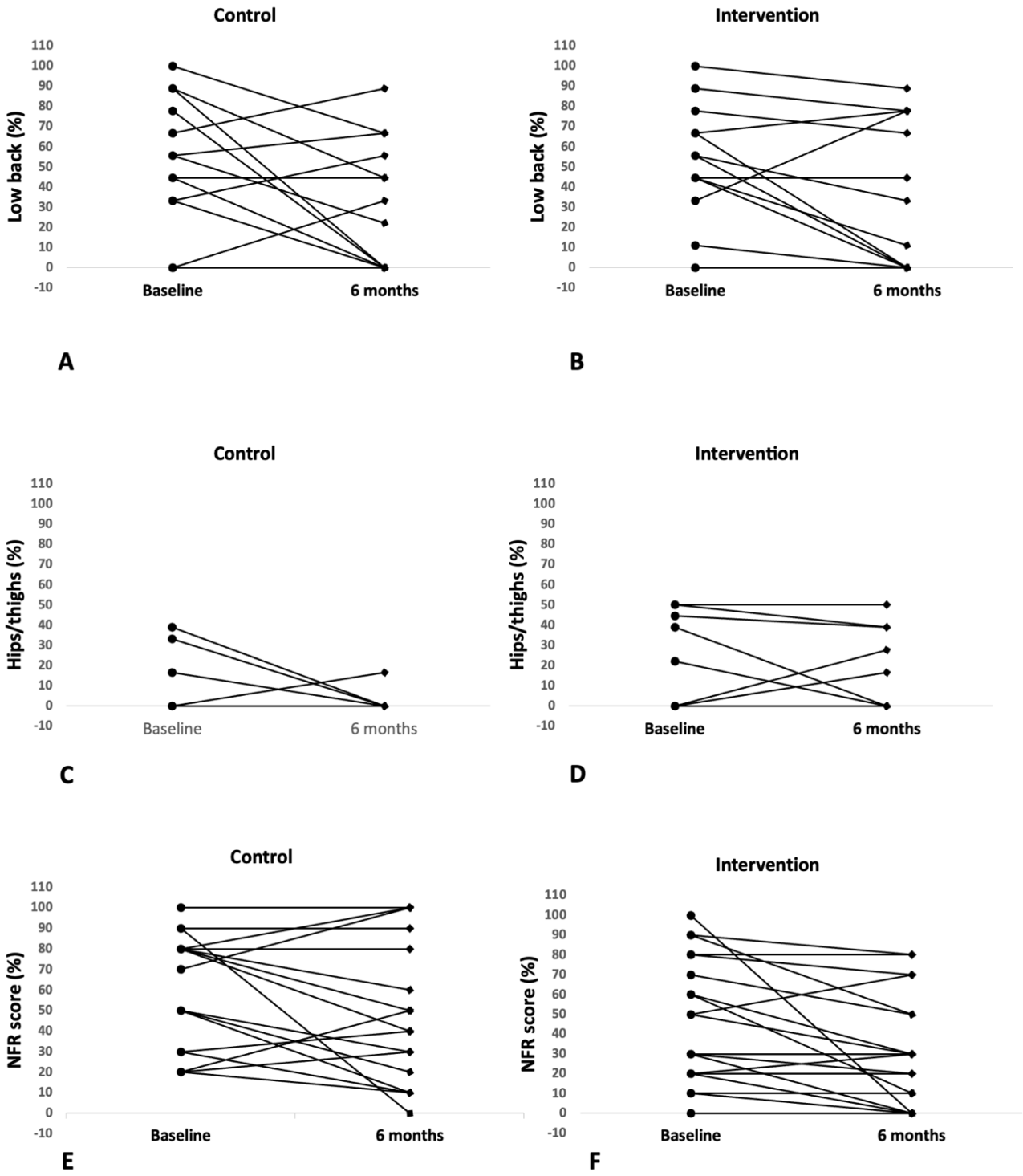

Figure 3 - Inter-individual Change in low back, hips/thighs pain, and NFR score among participants in the control and intervention groups.

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4. Discussion

This study compared the changes in the intensity of overall and regional MD and PWF, in office workers participating in a 6-month SSD-based intervention. The intervention led to almost significant reductions in shoulder and lower back pain and significant improvements in overall MD and PWF over the 6 months. However, no significant differences between groups were observed.

Although there are plausible arguments that improving postural variation by interrupting prolonged periods of sitting with ergonomically appropriate alternatives may benefit the musculoskeletal health of office workers (Karakolis et al., 2016; Mclean et al., 2001), the literature on the effects of interventions to reduce sitting time on MD is sparse (Neuhaus, Eakin, et al., 2014; Shrestha et al., 2016). This evidence is insufficient and mostly from low-quality studies (Neuhaus, Eakin, et al., 2014; Shrestha et al., 2016), which, aligned with inconsistencies between interventions and body areas (Agarwal et al., 2018), makes it difficult to compare our findings. A systematic review of interventions aimed at reducing sitting time in the workplace found inconclusive evidence regarding their impact on musculoskeletal discomfort, since the studies reported varied in their findings, including slight improvements, worsening of symptoms, or no noticeable change (Shrestha et al., 2016). Our results are more in line with the ones suggesting no impact of these interventions on musculoskeletal discomfort, as no time*group interactions were found for any outcome. Regardless, it is essential to mention that we found time differences in the intervention group for the overall MD score, while no differences were found in the control group.

In the context of our study, several reasons can explain the lack of effect of the intervention in reducing musculoskeletal discomfort. Our findings indicate that, after 6 months, there was no significant difference in total sitting time between the control and intervention groups (Júdice et al., 2024). However, a significant decrease in prolonged sitting time was observed in the intervention group. These findings align with (Renaud et al., 2020) study, which found no differences in sitting time reduction between the intervention and control groups. Despite slight improvements in MD in various body regions, these improvements did not reach statistical significance, which is consistent with the results of our study. Findings from Nguyen et al. (2021) revealed a negative correlation between standing/walking and musculoskeletal pain among office workers,

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suggesting that transitioning from a seated to a standing or walking position during work may reduce the risks of musculoskeletal injuries (Barone Gibbs et al., 2018; Ognibene et al., 2016). However, reducing sitting time alone may not be sufficient to promote significant improvements in muscle pain symptoms (Parry et al., 2019). Instead, interventions that simultaneously decrease sitting time and increase other types of PA, such as walking, may be necessary. For example, incorporating specific exercises, such as stretching, flexibility, strengthening, and muscle activation targeted at particular areas of pain, may prove beneficial in alleviating muscle symptoms (Andersen et al., 2011). Another possible reason may be the increased workload in the second evaluation moment compared to the baseline. This workload increase may have led office workers to spend more time sitting, thus softening the potential reduction in musculoskeletal obtained during the intervention period. This hypothesis is supported by the self-reported data obtained through the monthly questionnaire and by a study carried out by (Brierley et al., 2022), which had the same problem. Some studies (Baek et al., 2018; Barbieri et al., 2012; Zaidel et al., 2021) have identified that prolonged exposure to high physical and psychosocial demands in the workplace and extended periods of computer use without adequate breaks for rest and recovery can significantly increase muscle tension and fatigue. These combined factors have been associated with the development of musculoskeletal disorders, highlighting the importance of implementing workload management strategies and promoting regular breaks to reduce the risk of injuries and occupational health problems.

One possible reason for the non-significant difference in musculoskeletal pain may be the initial conditions of the sample, given that these areas of the body did not present pain in either the intervention or control group. In the review conducted by Parry et al. (2019), it was observed that the initial characteristics of participants regarding musculoskeletal symptoms can bias the results. Therefore, conducting more extensive randomized clinical trials is suggested, as well as recruiting participants with initial musculoskeletal symptoms and assessing long-term outcomes. This approach would allow to understand whether interventions to increase standing time or walking activity can alleviate musculoskeletal symptoms among sedentary workers and maintain efficacy over time.

Regarding PWF, as mentioned earlier, the high workload repetition faced by workers during the 6-month measurement period, mainly due to the intense academic

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season, may justify the limited reduction in sitting time. The strong association between fatigue and pain is well-established (Fishbain et al., 2003). A study conducted by Bláfoss, et al. (2019)revealed that physical exposures during work, such as prolonged standing, repetitive movements, and adopting postures involving bending or twisting the back, are associated with increased self-reported fatigue. Additionally, a systematic review conducted by Fishbain et al. (2003) found associations between pain and fatigue, suggesting that fatigue is related to the development of pain. It seems plausible that sustained muscular activity during work, both in physical and sedentary jobs, contributes to muscular fatigue, which, in turn, may result in the onset of pain. This vicious cycle, in which fatigue leads to pain and vice versa, can be a significant component of workers' experiences.

Finally, the lack of significant differences between the control and intervention groups may be attributed to the absence of a more intensive individual follow-up routine. For instance, personal sessions and multiple phone calls per week could have contributed to a higher effectiveness of the intervention (Renaud et al., 2020). This point is supported by a study by Zhou et al. (2023), which demonstrated that multi-component interventions, including the SSD + promotion, were more likely to become the ideal intervention. Interestingly, in an intervention like ours (Graves et al., 2015), the outcome of an active intervention solely at the workstation may diminish after the participants' initial novelty period wears off. This wear-off effect could influence the results regarding musculoskeletal pain and PWF.

When analyzing the inter-individual variability, particularly in different regions of the body such as the neck, shoulder, chest, elbow, hand/wrist, lower back and thigh, it was observed that the intervention had a more pronounced effect in specific areas, such as the shoulder and lower back (Fig. 1F and Fig. 3B), where there was a significant trend towards MD reduction. Although these differences did not reach significance, they suggest that individuals respond differently to the intervention, which highlights the importance of considering heterogeneity in the individual response to the intervention. Furthermore, by considering the overall MD and NFR, which demonstrated significant results in the intervention group over time, we can discern additional patterns of response that may inform future intervention strategies and the personalization of interventions. This more detailed analysis of the results highlights the complexity of the relationship

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between workplace interventions, individual responses, and clinical outcomes. It suggests promising areas for future research and refinement of intervention approaches.

4.1. Strengths and Limitations

This study has several strengths, such as an objective measurement of time spent standing and sitting, using validated questionnaires, and adopting a controlled and randomized study design. However, it is essential to acknowledge some limitations. Firstly, the questionnaires are based on self-reports, such as the Nordic Musculoskeletal Questionnaire and the NFR. In the case of the MD questionnaire, these do not allow for a precise distinction between the origin of the pain, as participants may report pain related to muscles and joints or even due to unrelated events, such as sports-related injuries. Despite the associated biasing risks, self-report questionnaires are widely adopted in this study due to their ease of application and cost-effectiveness. Secondly, another limitation of this study is the broad age range of participants, ranging from 24 to 60 years. The mixing of young and middle-aged workers, without a detailed analysis by age groups, compromises the generalization of results. Age diversity may influence responses to interventions, as factors such as physical fitness, adaptability, and work preferences vary substantially among these groups. Thus, it is essential for future research to analyze the effects of interventions by age group, allowing for a deeper and more targeted understanding of the dynamics affecting different age groups. The option of not depicting the analyses based on the age group was due to the limited sample size. Furthermore, it is relevant to consider that our intervention focused on office workers in the university setting, consisted of predominantly women, and participants were not randomized according to the degree of musculoskeletal pain or PWF, as it was not the focus of the primary study.

4.2.Implications for Practice

Based on the results of this study, we recommend implementing SSD interventions for office workers, complemented with multicomponent strategies (e.g., delivering of pedometers) and active workstations (e.g., treadmill desk) to improve PA (Arguello et al., 2021). These strategies may include educational sessions, in-person meetings, alert software, or other alert techniques. Literature reports that this combination has effectively reduced SB in the short, medium, and long term (3, 6, and 12 months). Additional

strategies should be developed to enhance the effectiveness of interventions, such as physical exercises to improve physical capacity and effective measures to alleviate pain, optimizing outcomes. These interventions are expected to yield crucial health benefits, encouraging companies and governments to invest in these novel approaches and promote sustainable implementation of preventive interventions tailored to the work context. Ultimately, this will enhance PA levels and well-being of workers, helping to mitigate the rise of non-communicable diseases and associated healthcare costs. Future research should aim to identify and test the most effective workplace intervention approaches, depending on the initial state of each participant, the so called, individualized medicine or treatment.

5. Conclusion

Reducing sedentarism among office workers requires innovative, evidence-based interventions to help decrease SB and increase PA. Our 6-month SSD-based intervention has proven effective in reducing MD and PWF among office workers in the intervention group. However, the psychoeducation session alone has some favorable effects on these outcomes (i.e., control group). These results suggest that reducing SB in the workplace may benefit workers' MD and PWF, as well as other proven health benefits when adjusted for participants' initial degree of pain and fatigue. Further investment in SSD interventions is needed to identify the most effective strategies for reducing SB and, consequently, relieving MD and NFR.

6. References

Agarwal, S., Steinmaus, C., & Harris-Adamson, C. (2018). Sit-stand workstations and impact on low back discomfort: a systematic review and meta-analysis. *Ergonomics*, *61*(4), 538-552. https://doi.org/10.1080/00140139.2017.1402960

Alkhajah, T. A., Reeves, M. M., Eakin, E. G., Winkler, E. A., Owen, N., & Healy, G. N. (2012). Sit-stand workstations: a pilot intervention to reduce office sitting time. *Am J Prev Med*, *43*(3), 298-303. https://doi.org/10.1016/j.amepre.2012.05.027

Andersen, K., Weinberger, M. H., Egan, B., Constance, C. M., Ali, M. A., Jin, J., & Keefe, D. L. (2008). Comparative efficacy and safety of aliskiren, an oral direct renin inhibitor, and ramipril in hypertension: a 6-month, randomized, double-

blind trial. *J Hypertens*, *26*(3), 589-599. https://doi.org/10.1097/HJH.0b013e3282f3ad9a

Andersen, L. L., Fallentin, N., Thorsen, S. V., & Holtermann, A. (2016). Physical workload and risk of long-term sickness absence in the general working population and among blue-collar workers: prospective cohort study with register follow-up. *Occup Environ Med*, *73*(4), 246-253. https://doi.org/10.1136/oemed-2015-103314

Andersen, L. L., Saervoll, C. A., Mortensen, O. S., Poulsen, O. M., Hannerz, H., & Zebis, M. K. (2011). Effectiveness of small daily amounts of progressive resistance training for frequent neck/shoulder pain: randomised controlled trial. *Pain*, *152*(2), 440-446. https://doi.org/10.1016/j.pain.2010.11.016

Arguello, D., Thorndike, A. N., Cloutier, G., Morton, A., Castaneda-Sceppa, C., & John, D. (2021). Effects of an "Active-Workstation" Cluster RCT on Daily Waking Physical Behaviors. *Med Sci Sports Exerc*, *53*(7), 1434-1445. https://doi.org/10.1249/MSS.0000000000002594

Atkin, A. J., Adams, E., Bull, F. C., & Biddle, S. J. (2012). Non-occupational sitting and mental well-being in employed adults. *Ann Behav Med*, *43*(2), 181-188. https://doi.org/10.1007/s12160-011-9320-y

Baek, K., Yang, S., Lee, M., & Chung, I. (2018). The Association of Workplace Psychosocial Factors and Musculoskeletal Pain Among Korean Emotional Laborers. *Saf Health Work*, *9*(2), 216-223. https://doi.org/10.1016/j.shaw.2017.09.004

Balducci, S., D'Errico, V., Haxhi, J., Sacchetti, M., Orlando, G., Cardelli, P.,…Investigators, I. D. a. E. S. I. (2019). Effect of a Behavioral Intervention Strategy on Sustained Change in Physical Activity and Sedentary Behavior in Patients With Type 2 Diabetes: The IDES_2 Randomized Clinical Trial. *JAMA*, *321*(9), 880-890. https://doi.org/10.1001/jama.2019.0922

Ball, K., Jeffery, R. W., Abbott, G., McNaughton, S. A., & Crawford, D. (2010). Is healthy behavior contagious: associations of social norms with physical activity and healthy eating. *Int J Behav Nutr Phys Act*, *7*, 86. https://doi.org/10.1186/1479-5868-7-86

Barbieri, D. F., Nogueira, H. C., Bergamin, L. J., & Oliveira, A. B. (2012). Physical and psychosocial indicators among office workers from public sector with and

without musculoskeletal symptoms. *Work*, *41 Suppl 1*, 2461-2466. https://doi.org/10.3233/WOR-2012-0481-2461

Barone Gibbs, B., Hergenroeder, A. L., Perdomo, S. J., Kowalsky, R. J., Delitto, A., & Jakicic, J. M. (2018). Reducing sedentary behaviour to decrease chronic low back pain: the stand back randomised trial. *Occup Environ Med*, *75*(5), 321-327. https://doi.org/10.1136/oemed-2017-104732

Bennie, J. A., Pedisic, Z., Timperio, A., Crawford, D., Dunstan, D., Bauman, A.,…Salmon, J. (2015). Total and domain-specific sitting time among employees in desk-based work settings in Australia. *Aust N Z J Public Health*, *39*(3), 237-242. https://doi.org/10.1111/1753-6405.12293

Biddle, S. J. H., O'Connell, S. E., Davies, M. J., Dunstan, D., Edwardson, C. L., Esliger, D. W.,…Munir, F. (2020). Reducing sitting at work: process evaluation of the SMArT Work (Stand More At Work) intervention. *Trials*, *21*(1), 403. https://doi.org/10.1186/s13063-020-04300-7

Biswas, A., Oh, P. I., Faulkner, G. E., Bajaj, R. R., Silver, M. A., Mitchell, M. S., & Alter, D. A. (2015). Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Ann Intern Med*, *162*(2), 123-132. https://doi.org/10.7326/M14-1651

Blackburn, N. E., Wilson, J. J., McMullan, I. I., Caserotti, P., Giné-Garriga, M., Wirth, K.,…Tully, M. A. (2020). The effectiveness and complexity of interventions targeting sedentary behaviour across the lifespan: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*, *17*(1), 53. https://doi.org/10.1186/s12966-020-00957-0

Bláfoss, R., Micheletti, J. K., Sundstrup, E., Jakobsen, M. D., Bay, H., & Andersen, L. L. (2019). Is fatigue after work a barrier for leisure time physical activity? Cross-sectional study among 10,000 adults from the general working population. *Scand J Public Health*, *47*(3), 383-391. https://doi.org/10.1177/1403494818765894

Bláfoss, R., Sundstrup, E., Jakobsen, M. D., Brandt, M., Bay, H., & Andersen, L. L. (2019). Physical workload and bodily fatigue after work: cross-sectional study among 5000 workers. *Eur J Public Health*, *29*(5), 837-842. https://doi.org/10.1093/eurpub/ckz055

Bora, N., K, V., Verma, A., Bharti, A. K., & Sinha, M. K. (2024). Physical activity and sedentary behavior perceptions in overweight and obese adults: A systematic review of qualitative study. *F1000Res*, *13*, 787. https://doi.org/10.12688/f1000research.152905.1

Brierley, M. L., Smith, L. R., Bailey, D. P., Ojo, S. O., Hewson, D. J., Every, S. A.,…Chater, A. M. (2022). Evaluating a multi-component intervention to reduce and break up office workers' sitting with sit-stand desks using the APEASE criteria. *BMC Public Health*, *22*(1), 458.

Buckley, J. P., Hedge, A., Yates, T., Copeland, R. J., Loosemore, M., Hamer, M.,…Dunstan, D. W. (2015). The sedentary office: an expert statement on the growing case for change towards better health and productivity. *Br J Sports Med*, *49*(21), 1357-1362. https://doi.org/10.1136/bjsports-2015-094618

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G.,…Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. https://doi.org/10.1136/bjsports-2020-102955

Cao, C., Friedenreich, C. M., & Yang, L. (2022). Association of Daily Sitting Time and Leisure Time Physical Activity With Survival Among US Cancer Survivors. *JAMA Oncol*, *8*(3), 395-403. https://doi.org/10.1001/jamaoncol.2021.6590

Chan, C. B., & Ryan, D. A. (2009). Assessing the effects of weather conditions on physical activity participation using objective measures. *Int J Environ Res Public Health*, *6*(10), 2639-2654. https://doi.org/10.3390/ijerph6102639

Chau, J. Y., Daley, M., Dunn, S., Srinivasan, A., Do, A., Bauman, A. E., & van der Ploeg, H. P. (2014). The effectiveness of sit-stand workstations for changing office workers' sitting time: results from the Stand@Work randomized controlled trial pilot. *Int J Behav Nutr Phys Act*, *11*, 127. https://doi.org/10.1186/s12966-014-0127-7

Chau, J. Y., Grunseit, A. C., Chey, T., Stamatakis, E., Brown, W. J., Matthews, C. E.,…van der Ploeg, H. P. (2013). Daily sitting time and all-cause mortality: a meta-analysis. *PLoS One*, *8*(11), e80000. https://doi.org/10.1371/journal.pone.0080000

Chau, J. Y., van der Ploeg, H. P., Merom, D., Chey, T., & Bauman, A. E. (2012). Cross-sectional associations between occupational and leisure time sitting, physical

activity and obesity in working adults. *Prev Med*, *54*(3-4), 195-200. https://doi.org/10.1016/j.ypmed.2011.12.020

Chu, A. H., Ng, S. H., Tan, C. S., Win, A. M., Koh, D., & Müller-Riemenschneider, F. (2016). A systematic review and meta-analysis of workplace intervention strategies to reduce sedentary time in white-collar workers. *Obes Rev*, *17*(5), 467-481. https://doi.org/10.1111/obr.12388

Clemes, S. A., O'Connell, S. E., & Edwardson, C. L. (2014). Office workers' objectively measured sedentary behavior and physical activity during and outside working hours. *J Occup Environ Med*, *56*(3), 298-303. https://doi.org/10.1097/JOM.0000000000000101

Coenen, P., Parry, S., Willenberg, L., Shi, J. W., Romero, L., Blackwood, D. M.,…Straker, L. M. (2017). Associations of prolonged standing with musculoskeletal symptoms-A systematic review of laboratory studies. *Gait Posture*, *58*, 310-318. https://doi.org/10.1016/j.gaitpost.2017.08.024

Coenen, P., van der Molen, H. F., Burdorf, A., Huysmans, M. A., Straker, L., Frings-Dresen, M. H., & van der Beek, A. J. (2019). Associations of screen work with neck and upper extremity symptoms: a systematic review with meta-analysis. *Occup Environ Med*, *76*(7), 502-509. https://doi.org/10.1136/oemed-2018-105553

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep*, *22*(1), 7-14.

Commissaris, D. A. C. M., Huysmans, M. A., Mathiassen, S. E., Srinivasan, D., Koppes, L. L. J., & Hendriksen, I. J. M. (2016). Interventions to reduce sedentary behavior and increase physical activity during productive work: a systematic review. *Scand J Work Environ Health*, *42*(3), 181-191. https://doi.org/10.5271/sjweh.3544

Compernolle, S., DeSmet, A., Poppe, L., Crombez, G., De Bourdeaudhuij, I., Cardon, G.,…Van Dyck, D. (2019). Effectiveness of interventions using self-monitoring to reduce sedentary behavior in adults: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*, *16*(1), 63. https://doi.org/10.1186/s12966-019-0824-3

Danquah, I. H., Kloster, S., Holtermann, A., Aadahl, M., Bauman, A., Ersbøll, A. K., & Tolstrup, J. S. (2017). Take a Stand!-a multi-component intervention aimed at

reducing sitting time among office workers-a cluster randomized trial. *Int J Epidemiol*, *46*(1), 128-140. https://doi.org/10.1093/ije/dyw009

de Cássia Pereira Fernandes, R., Pataro, S. M. S., de Carvalho, R. B., & Burdorf, A. (2016). The concurrence of musculoskeletal pain and associated work-related factors: a cross sectional study. *BMC Public Health*, *16*, 628. https://doi.org/10.1186/s12889-016-3306-4

de Vries, J. D., Claessens, B. J., van Hooff, M. L., Geurts, S. A., van den Bossche, S. N., & Kompier, M. A. (2016). Disentangling longitudinal relations between physical activity, work-related fatigue, and task demands. *Int Arch Occup Environ Health*, *89*(1), 89-101. https://doi.org/10.1007/s00420-015-1054-x

de Vries, J. D., van Hooff, M. L. M., Geurts, S. A. E., & Kompier, M. A. J. (2017). Exercise to reduce work-related fatigue among employees: a randomized controlled trial. *Scand J Work Environ Health*, *43*(4), 337-349. https://doi.org/10.5271/sjweh.3634

Deci, E. L., & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. In (Vol. *49 (3)*, pp. 182–185). *Canadian Psychology*: *Psychologie canadienne*.

Deery, E., Buckley, J., Morris, M. *et al.* (2024). *Some People Sit, Some People Stand, That's Just What We Do* ": a Qualitative Exploration of Sit-Stand Desk Use in Naturalistic Settings. In. *Occup Health Sci*.

Del Pozo-Cruz, J., García-Hermoso, A., Alfonso-Rosa, R. M., Alvarez-Barbosa, F., Owen, N., Chastin, S., & Del Pozo-Cruz, B. (2018). Replacing Sedentary Time: Meta-analysis of Objective-Assessment Studies. *Am J Prev Med*, *55*(3), 395-402. https://doi.org/10.1016/j.amepre.2018.04.042

Dogra, S., & Stathokostas, L. (2012). Sedentary behavior and physical activity are independent predictors of successful aging in middle-aged and older adults. *J Aging Res*, *2012*, 190654. https://doi.org/10.1155/2012/190654

Dunstan, D. W., Barr, E. L., Healy, G. N., Salmon, J., Shaw, J. E., Balkau, B.,…Owen, N. (2010). Television viewing time and mortality: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Circulation*, *121*(3), 384-391. https://doi.org/10.1161/CIRCULATIONAHA.109.894824

Dupont, F., Léger, P. M., Begon, M., Lecot, F., Sénécal, S., Labonté-Lemoyne, E., & Mathieu, M. E. (2019). Health and productivity at work: which active

workstation for which benefits: a systematic review. *Occup Environ Med*, *76*(5), 281-294. https://doi.org/10.1136/oemed-2018-105397

Dutta, N., Koepp, G. A., Stovitz, S. D., Levine, J. A., & Pereira, M. A. (2014). Using sit-stand workstations to decrease sedentary time in office workers: a randomized crossover trial. *Int J Environ Res Public Health*, *11*(7), 6653-6665. https://doi.org/10.3390/ijerph110706653

Dutta, N., Walton, T., & Pereira, M. A. (2019). One-year follow-up of a sit-stand workstation intervention to decrease sedentary time in office workers. *Prev Med Rep*, *13*, 277-280. https://doi.org/10.1016/j.pmedr.2019.01.008

E F Graves, L., C Murphy, R., Shepherd, S. O., Cabot, J., & Hopkins, N. D. (2015). Evaluation of sit-stand workstations in an office setting: a randomised controlled trial. *BMC Public Health*, *15*, 1145. https://doi.org/10.1186/s12889-015-2469-8

Edwardson, C. L., Biddle, S. J. H., Clemes, S. A., Davies, M. J., Dunstan, D. W., Eborall, H.,…Clarke-Cornwell, A. M. (2022). Effectiveness of an intervention for reducing sitting time and improving health in office workers: three arm cluster randomised controlled trial. *Bmj*, *378*, e069288. https://doi.org/10.1136/bmj-2021-069288

Edwardson, C. L., Maylor, B. D., Biddle, S. J., Clemes, S. A., Cox, E., Davies, M. J.,…Clarke-Cornwell, A. M. (2023). A multicomponent intervention to reduce daily sitting time in office workers: the SMART Work & Life three-arm cluster RCT. *Public Health Res (Southampt)*, *11*(6), 1-229. https://doi.org/10.3310/DNYC2141

Edwardson, C. L., Yates, T., Biddle, S. J. H., Davies, M. J., Dunstan, D. W., Esliger, D. W.,…Munir, F. (2018). Effectiveness of the Stand More AT (SMArT) Work intervention: cluster randomised controlled trial. *Bmj*, *363*, k3870. https://doi.org/10.1136/bmj.k3870

Ekelund, U., Brown, W. J., Steene-Johannessen, J., Fagerland, M. W., Owen, N., Powell, K. E.,…Lee, I. M. (2019). Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants. *Br J Sports Med*, *53*(14), 886-894. https://doi.org/10.1136/bjsports-2017-098963

Ekelund, U., Tarp, J., Steene-Johannessen, J., Hansen, B. H., Jefferis, B., Fagerland, M. W.,…Lee, I. M. (2019). Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis. *BMJ*, *366*, l4570. https://doi.org/10.1136/bmj.l4570

Felez-Nobrega, M., Bort-Roig, J., Briones, L., Sanchez-Niubo, A., Koyanagi, A., Puigoriol, E., & Puig-Ribera, A. (2020). Self-reported and activPAL. *J Sports Sci*, *38*(13), 1566-1574. https://doi.org/10.1080/02640414.2020.1748359

Fishbain, D. A., Cole, B., Cutler, R. B., Lewis, J., Rosomoff, H. L., & Fosomoff, R. S. (2003). Is pain fatiguing? A structured evidence-based review. *Pain Med*, *4*(1), 51-62. https://doi.org/10.1046/j.1526-4637.2003.03008.x

Gao, Z., & Lee, J. E. (2022). Promoting Physical Activity and Reducing Sedentary Behavior to Prevent Chronic Diseases during the COVID Pandemic and Beyond. *J Clin Med*, *11*(16). https://doi.org/10.3390/jcm11164666

Gardner, B., Thuné-Boyle, I., Iliffe, S., Fox, K. R., Jefferis, B. J., Hamer, M.,…Wardle, J. (2014). 'On Your Feet to Earn Your Seat', a habit-based intervention to reduce sedentary behaviour in older adults: study protocol for a randomized controlled trial. *Trials*, *15*, 368. https://doi.org/10.1186/1745-6215-15-368

Gilson, N. D., Burton, N. W., van Uffelen, J. G., & Brown, W. J. (2011). Occupational sitting time: employees' perceptions of health risks and intervention strategies. *Health Promot J Austr*, *22*(1), 38-43. https://doi.org/10.1071/he11038

Grunseit, A. C., Chau, J. Y., van der Ploeg, H. P., & Bauman, A. (2013). "Thinking on your feet": A qualitative evaluation of sit-stand desks in an Australian workplace. *BMC Public Health*, *13*, 365. https://doi.org/10.1186/1471-2458-13-365

Hadgraft, N. T., Healy, G. N., Owen, N., Winkler, E. A., Lynch, B. M., Sethi, P.,…Dunstan, D. W. (2016). Office workers' objectively assessed total and prolonged sitting time: Individual-level correlates and worksite variations. *Prev Med Rep*, *4*, 184-191. https://doi.org/10.1016/j.pmedr.2016.06.011

Hanham, J., Castro-Alonso, J. C., & Chen, O. (2023). Integrating cognitive load theory with other theories, within and beyond educational psychology. *Br J Educ Psychol*, *93 Suppl 2*, 239-250. https://doi.org/10.1111/bjep.12612

Healy, G. N., Eakin, E. G., Owen, N., Lamontagne, A. D., Moodie, M., Winkler, E. A.,…Dunstan, D. W. (2016). A Cluster Randomized Controlled Trial to Reduce Office Workers' Sitting Time: Effect on Activity Outcomes. *Med Sci Sports Exerc*, *48*(9), 1787-1797. https://doi.org/10.1249/MSS.0000000000000972

Healy, G. N., Matthews, C. E., Dunstan, D. W., Winkler, E. A., & Owen, N. (2011). Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. *Eur Heart J*, *32*(5), 590-597. https://doi.org/10.1093/eurheartj/ehq451

Henderson, B., Stuckey, R., & Keegel, T. (2018). Current and ceased users of sit stand workstations: a qualitative evaluation of ergonomics, safety and health factors within a workplace setting. *BMC Public Health*, *18*(1), 1374. https://doi.org/10.1186/s12889-018-6296-6

Hergenroeder, A., Quinn, T. D., Perdomo, S. J., Kline, C. E., & Gibbs, B. B. (2022). Effect of a 6-month sedentary behavior reduction intervention on well-being and workplace health in desk workers with low back pain. *Work*, *71*(4), 1145-1155. https://doi.org/10.3233/WOR-205178

Ishii, K., Shibata, A., & Oka, K. (2018). Work Engagement, Productivity, and Self-Reported Work-Related Sedentary Behavior Among Japanese Adults: A Cross-Sectional Study. *J Occup Environ Med*, *60*(4), e173-e177. https://doi.org/10.1097/JOM.0000000000001270

Jochem, C., Wallmann-Sperlich, B., & Leitzmann, M. F. (2019). The Influence of Sedentary Behavior on Cancer Risk: Epidemiologic Evidence and Potential Molecular Mechanisms. *Curr Nutr Rep*, *8*(3), 167-174. https://doi.org/10.1007/s13668-019-0263-4

Judah, G., Gardner, B., Kenward, M. G., DeStavola, B., & Aunger, R. (2018). Exploratory study of the impact of perceived reward on habit formation. *BMC Psychol*, *6*(1), 62. https://doi.org/10.1186/s40359-018-0270-z

Júdice, P. B., Silva, H., Teno, S. C., & Hetherington-Rauth, M. (2024). The effectiveness of a 6-month intervention with sit-stand workstation in office workers: Results from the SUFHA cluster randomized controlled trial. *Work*. https://doi.org/10.3233/WOR-230624

Júdice, P. B., Silva, H., Teno, S. C., Monteiro, P., Silva, M. N., Carraça, E. V.,…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

Júdice, P. B., Sousa-Sá, E., & Palmeira, A. L. (2023). Discrepancies Between Self-reported and Objectively Measured Smartphone Screen Time: Before and During Lockdown. *J Prev (2022)*, *44*(3), 291-307. https://doi.org/10.1007/s10935-023-00724-4

Karakolis, T., Barrett, J., & Callaghan, J. P. (2016). A comparison of trunk biomechanics, musculoskeletal discomfort and productivity during simulated sit-stand office work. *Ergonomics*, *59*(10), 1275-1287. https://doi.org/10.1080/00140139.2016.1146343

Karakolis, T., & Callaghan, J. P. (2014). The impact of sit-stand office workstations on worker discomfort and productivity: a review. *Appl Ergon*, *45*(3), 799-806. https://doi.org/10.1016/j.apergo.2013.10.001

Karihtala, T., Valtonen, A. M., Kautiainen, H., Hopsu, L., Halonen, J., Heinonen, A., & Puttonen, S. (2023). Relationship between occupational and leisure time physical activity and the need for recovery after work. *Arch Public Health*, *81*(1), 17. https://doi.org/10.1186/s13690-022-01017-8

Katzmarzyk, P. T., Powell, K. E., Jakicic, J. M., Troiano, R. P., Piercy, K., Tennant, B., & COMMITTEE*, P. A. G. A. (2019). Sedentary Behavior and Health: Update from the 2018 Physical Activity Guidelines Advisory Committee. *Med Sci Sports Exerc*, *51*(6), 1227-1241. https://doi.org/10.1249/MSS.0000000000001935

Kazi, A., Haslam, C., Duncan, M., Clemes, S., & Twumasi, R. (2019). Sedentary behaviour and health at work: an investigation of industrial sector, job role, gender and geographical differences. *Ergonomics*, *62*(1), 21-30. https://doi.org/10.1080/00140139.2018.1489981

Keown, M. K., Skeaff, C. M., Perry, T. L., Haszard, J. J., & Peddie, M. C. (2018). Device-Measured Sedentary Behavior Patterns in Office-Based University Employees. *J Occup Environ Med*, *60*(12), 1150-1157. https://doi.org/10.1097/JOM.0000000000001467

Kikuchi, H., Inoue, S., Sugiyama, T., Owen, N., Oka, K., Nakaya, T., & Shimomitsu, T. (2014). Distinct associations of different sedentary behaviors with health-related

attributes among older adults. *Prev Med*, *67*, 335-339. https://doi.org/10.1016/j.ypmed.2014.08.011

Kim, E., Park, C. H., Lee, H. S., Lee, M. Y., & Cho, S. J. (2024). Sex Differences in the Association between Prolonged Sitting Time and Anxiety Prevalence among Korean Adults. *Brain Sci*, *14*(7). https://doi.org/10.3390/brainsci14070729

Konradt, U., Nath, A., Krys, S., & Heblich, F. (2022). Longitudinal Effects of a sit-stand desk intervention - persistence, Fade-Out, and psychological momentum: a Randomized Controlled Trial. *BMC Psychol*, *10*(1), 246. https://doi.org/10.1186/s40359-022-00948-9

Lam, K., Baurecht, H., Pahmeier, K., Niemann, A., Romberg, C., Biermann-Stallwitz, J.,…Jochem, C. (2022). How effective and how expensive are interventions to reduce sedentary behavior? An umbrella review and meta-analysis. *Obes Rev*, *23*(5), e13422. https://doi.org/10.1111/obr.13422

Landais, L. L., Jelsma, J. G. M., Dotinga, I. R., Timmermans, D. R. M., Verhagen, E. A. L. M., & Damman, O. C. (2022). Office workers' perspectives on physical activity and sedentary behaviour: a qualitative study. *BMC Public Health*, *22*(1), 621. https://doi.org/10.1186/s12889-022-13024-z

Liu, S. H., Eaton, C. B., Driban, J. B., McAlindon, T. E., & Lapane, K. L. (2016). Comparison of self-report and objective measures of physical activity in US adults with osteoarthritis. In *Rheumatol Int* (Vol. 36, pp. 1355-1364). https://doi.org/10.1007/s00296-016-3537-9

Ma, J., Ma, D., Li, Z., & Kim, H. (2021). Effects of a Workplace Sit-Stand Desk Intervention on Health and Productivity. *Int J Environ Res Public Health*, *18*(21). https://doi.org/10.3390/ijerph182111604

MacEwen, B. T., Saunders, T. J., MacDonald, D. J., & Burr, J. F. (2017). Sit-Stand Desks To Reduce Workplace Sitting Time In Office Workers With Abdominal Obesity: A Randomized Controlled Trial. *J Phys Act Health*, *14*(9), 710-715. https://doi.org/10.1123/jpah.2016-0384

Mansfeldt, J. M., & Magkos, F. (2023). Compensatory Responses to Exercise Training As Barriers to Weight Loss: Changes in Energy Intake and Non-exercise Physical Activity. *Curr Nutr Rep*, *12*(2), 327-337. https://doi.org/10.1007/s13668-023-00467-y

Mansoubi, M., Pearson, N., Biddle, S. J., & Clemes, S. A. (2016). Using Sit-to-Stand Workstations in Offices: Is There a Compensation Effect? *Med Sci Sports Exerc*, *48*(4), 720-725. https://doi.org/10.1249/MSS.0000000000000802

Martinez-Gomez, D., Guallar-Castillon, P., Leon-Munoz, L. M., Lopez-Garcia, E., & Rodriguez-Artalejo, F. (2013). Combined impact of traditional and non-traditional health behaviors on mortality: a national prospective cohort study in Spanish older adults. *BMC Med*, *11*, 47. https://doi.org/10.1186/1741-7015-11-47

Matthews, C. E., Moore, S. C., Sampson, J., Blair, A., Xiao, Q., Keadle, S. K.,…Park, Y. (2015). Mortality Benefits for Replacing Sitting Time with Different Physical Activities. *Med Sci Sports Exerc*, *47*(9), 1833-1840. https://doi.org/10.1249/mss.0000000000000621

Mclean, L., Tingley, M., Scott, R. N., & Rickards, J. (2001). Computer terminal work and the benefit of microbreaks. *Appl Ergon*, *32*(3), 225-237. https://doi.org/10.1016/s0003-6870(00)00071-5

Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement Sci*, *6*, 42. https://doi.org/10.1186/1748-5908-6-42

Mielke, G. I., da Silva, I. C., Owen, N., & Hallal, P. C. (2014). Brazilian adults' sedentary behaviors by life domain: population-based study. *PLoS One*, *9*(3), e91614. https://doi.org/10.1371/journal.pone.0091614

Mitchell, M. S., Goodman, J. M., Alter, D. A., John, L. K., Oh, P. I., Pakosh, M. T., & Faulkner, G. E. (2013). Financial incentives for exercise adherence in adults: systematic review and meta-analysis. *Am J Prev Med*, *45*(5), 658-667. https://doi.org/10.1016/j.amepre.2013.06.017

Nahum-Shani, I., Smith, S. N., Spring, B. J., Collins, L. M., Witkiewitz, K., Tewari, A., & Murphy, S. A. (2018). Just-in-Time Adaptive Interventions (JITAIs) in Mobile Health: Key Components and Design Principles for Ongoing Health Behavior Support. *Ann Behav Med*, *52*(6), 446-462. https://doi.org/10.1007/s12160-016-9830-8

Nelson-Wong, E., Corrigan, J., Mertz, P., Kutcher, S., Carlson, I., DiRocco, T., & Hall-Nelson, B. (2021). Office-workers maintain decreased workplace sitting time

long-term following participation in a sit-stand desk intervention study. *Ergonomics*, 1-9. https://doi.org/10.1080/00140139.2021.1998647

Nelson-Wong, E., Gallagher, K., Johnson, E., Antonioli, C., Ferguson, A., Harris, S.,…Miller, J. B. (2020). Increasing standing tolerance in office workers with standing-induced back pain. *Ergonomics*, *63*(7), 804-817. https://doi.org/10.1080/00140139.2020.1761034

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

Neuhaus, M., Healy, G. N., Dunstan, D. W., Owen, N., & Eakin, E. G. (2014). Workplace sitting and height-adjustable workstations: a randomized controlled trial. *Am J Prev Med*, *46*(1), 30-40. https://doi.org/10.1016/j.amepre.2013.09.009

Neupane, S., Leino-Arjas, P., Nygård, C. H., Oakman, J., & Virtanen, P. (2017). Developmental pathways of multisite musculoskeletal pain: what is the influence of physical and psychosocial working conditions? *Occup Environ Med*, *74*(7), 468-475. https://doi.org/10.1136/oemed-2016-103892

Ng, J. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Duda, J. L., & Williams, G. C. (2012). Self-Determination Theory Applied to Health Contexts: A Meta-Analysis. *Perspect Psychol Sci*, *7*(4), 325-340. https://doi.org/10.1177/1745691612447309

Nguyen, A., Arippa, F., Kiok, M., Pau, M., Harris-Adamson, C. (2021). The Relationship Between Fidgeting, Posture Changes, Physical Activity, and Musculoskeletal Discomfort in Office Workers. In (Vol. 222). Proceedings of the 21st Congress of the International Ergonomics Association (IEA 2021): In: Black, N.L., Neumann, W.P., Noy, I. (eds).

Nguyen, P., Le, L. K., Nguyen, D., Gao, L., Dunstan, D. W., & Moodie, M. (2020). The effectiveness of sedentary behaviour interventions on sitting time and screen time in children and adults: an umbrella review of systematic reviews. *Int J Behav Nutr Phys Act*, *17*(1), 117. https://doi.org/10.1186/s12966-020-01009-3

Ognibene, G. T., Torres, W., von Eyben, R., & Horst, K. C. (2016). Impact of a Sit-Stand Workstation on Chronic Low Back Pain: Results of a Randomized Trial. *J*

Occup Environ Med, *58*(3), 287-293. https://doi.org/10.1097/JOM.0000000000000615

Ojo, S. O., Bailey, D. P., Hewson, D. J., & Chater, A. M. (2019). Perceived Barriers and Facilitators to Breaking Up Sitting Time among Desk-Based Office Workers: A Qualitative Investigation Using the TDF and COM-B. *Int J Environ Res Public Health*, *16*(16). https://doi.org/10.3390/ijerph16162903

Organization, W. H. (2018). G*lobal action plan on physical activity 2018-2030: more active people for a healthier world*. In (World Health Organization ed.).

Owen, N., Healy, G. N., Matthews, C. E., & Dunstan, D. W. (2010). Too much sitting: the population health science of sedentary behavior. *Exerc Sport Sci Rev*, *38*(3), 105-113. https://doi.org/10.1097/JES.0b013e3181e373a2

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D.,…Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. https://doi.org/10.1136/bmj.n71

Panahi, S., & Tremblay, A. (2018). Sedentariness and Health: Is Sedentary Behavior More Than Just Physical Inactivity? *Front Public Health*, *6*, 258. https://doi.org/10.3389/fpubh.2018.00258

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

Parry, S. P., Coenen, P., Shrestha, N., O'Sullivan, P. B., Maher, C. G., & Straker, L. M. (2019). Workplace interventions for increasing standing or walking for decreasing musculoskeletal symptoms in sedentary workers. *Cochrane Database Syst Rev*, *2019*(11). https://doi.org/10.1002/14651858.CD012487.pub2

Patterson, R., McNamara, E., Tainio, M., de Sá, T. H., Smith, A. D., Sharp, S. J.,…Wijndaele, K. (2018). Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *Eur J Epidemiol*, *33*(9), 811-829. https://doi.org/10.1007/s10654-018-0380-1

Pereira, M. A., Mullane, S. L., Toledo, M. J. L., Larouche, M. L., Rydell, S. A., Vuong, B.,…Buman, M. P. (2020). Efficacy of the 'Stand and Move at Work' multicomponent workplace intervention to reduce sedentary time and improve

cardiometabolic risk: a group randomized clinical trial. *Int J Behav Nutr Phys Act*, *17*(1), 133. https://doi.org/10.1186/s12966-020-01033-3

Prince, S. A., Elliott, C. G., Scott, K., Visintini, S., & Reed, J. L. (2019). Device-measured physical activity, sedentary behaviour and cardiometabolic health and fitness across occupational groups: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*, *16*(1), 30. https://doi.org/10.1186/s12966-019-0790-9

Prince, S. A., Reid, R. D., & Reed, J. L. (2019). Comparison of self-reported and objectively measured levels of sitting and physical activity and associations with markers of health in cardiac rehabilitation patients. *Eur J Prev Cardiol*, *26*(6), 653-656. https://doi.org/10.1177/2047487318806357

Puetz, T. W. (2006). Physical activity and feelings of energy and fatigue: epidemiological evidence. *Sports Med*, *36*(9), 767-780. https://doi.org/10.2165/00007256-200636090-00004

Punnett, L., & Wegman, D. H. (2004). Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. *J Electromyogr Kinesiol*, *14*(1), 13-23. https://doi.org/10.1016/j.jelekin.2003.09.015

Renaud, L. R., Jelsma, J. G. M., Huysmans, M. A., van Nassau, F., Lakerveld, J., Speklé, E. M.,…van der Ploeg, H. P. (2020). Effectiveness of the multi-component dynamic work intervention to reduce sitting time in office workers - Results from a pragmatic cluster randomised controlled trial. *Appl Ergon*, *84*, 103027. https://doi.org/10.1016/j.apergo.2019.103027

Rhodes, R. E., Janssen, I., Bredin, S. S. D., Warburton, D. E. R., & Bauman, A. (2017). Physical activity: Health impact, prevalence, correlates and interventions. *Psychol Health*, *32*(8), 942-975. https://doi.org/10.1080/08870446.2017.1325486

Rosenkranz, S. K., Mailey, E. L., Umansky, E., Rosenkranz, R. R., & Ablah, E. (2020). Workplace Sedentary Behavior and Productivity: A Cross-Sectional Study. *Int J Environ Res Public Health*, *17*(18). https://doi.org/10.3390/ijerph17186535

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol*, *55*(1), 68-78. https://doi.org/10.1037//0003-066x.55.1.68

Sadarangani, K. P., Schuch, F. B., De Roia, G., Martínez-Gomez, D., Chávez, R., Lobo, P.,…Meyer, J. (2023). Exchanging screen for non-screen sitting time or physical

activity might attenuate depression and anxiety: A cross-sectional isotemporal analysis during early pandemics in South America. *J Sci Med Sport*, *26*(6), 309-315. https://doi.org/10.1016/j.jsams.2023.04.007

Santos, A. C., Willumsen, J., Meheus, F., Ilbawi, A., & Bull, F. C. (2023). The cost of inaction on physical inactivity to public health-care systems: a population-attributable fraction analysis. *Lancet Glob Health*, *11*(1), e32-e39. https://doi.org/10.1016/S2214-109X(22)00464-8

Saunders, T. J., McIsaac, T., Douillette, K., Gaulton, N., Hunter, S., Rhodes, R. E.,…Healy, G. N. (2020). Sedentary behaviour and health in adults: an overview of systematic reviews. *Appl Physiol Nutr Metab*, *45*(10 (Suppl. 2)), S197-S217. https://doi.org/10.1139/apnm-2020-0272

Schwartz, B., Kapellusch, J. M., Baca, A., & Wessner, B. (2019). Medium-term effects of a two-desk sit/stand workstation on cognitive performance and workload for healthy people performing sedentary work: a secondary analysis of a randomised controlled trial. *Ergonomics*, *62*(6), 794-810. https://doi.org/10.1080/00140139.2019.1577497

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. *Hum Factors*, *61*(5), 816-824. https://doi.org/10.1177/0018720818807043

Shen, J., Barbera, J., & Shapiro, C. M. (2006). Distinguishing sleepiness and fatigue: focus on definition and measurement. *Sleep Med Rev*, *10*(1), 63-76. https://doi.org/10.1016/j.smrv.2005.05.004

Shrestha, B., & Dunn, L. (2020). The Declaration of Helsinki on Medical Research involving Human Subjects: A Review of Seventh Revision. *J Nepal Health Res Counc*, *17*(4), 548-552. https://doi.org/10.33314/jnhrc.v17i4.1042

Shrestha, N., Grgic, J., Wiesner, G., Parker, A., Podnar, H., Bennie, J. A.,…Pedisic, Z. (2019). Effectiveness of interventions for reducing non-occupational sedentary behaviour in adults and older adults: a systematic review and meta-analysis. *Br J Sports Med*, *53*(19), 1206-1213. https://doi.org/10.1136/bjsports-2017-098270

Shrestha, N., Ijaz, S., Kukkonen-Harjula, K. T., Kumar, S., & Nwankwo, C. P. (2015). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *1*, Cd010912. https://doi.org/10.1002/14651858.CD010912.pub2

Silva, H., G F Ramos, P., Teno, S. C., & Júdice, P. B. (2024). Impact of a 6-month sit-stand desk-based intervention on regional musculoskeletal discomfort and overall post-work fatigue in office workers: a cluster randomised controlled trial. *Ergonomics*, 1–14. https://doi.org/10.1080/00140139.2024.2414197

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 Syst Rev*, *3*(3), Cd010912. https://doi.org/10.1002/14651858.CD010912.pub3

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Pedisic, Z. (2018a). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *12*(12), Cd010912. https://doi.org/10.1002/14651858.CD010912.pub5

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Pedisic, Z. (2018b). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *6*(6), Cd010912. https://doi.org/10.1002/14651858.CD010912.pub4

Silva, H., G F Ramos, P., Teno, S. C., & Júdice, P. B. (2024). Impact of a 6-month sit-stand desk-based intervention on regional musculoskeletal discomfort and overall post-work fatigue in office workers: a cluster randomised controlled trial. *Ergonomics*, 1-14. https://doi.org/10.1080/00140139.2024.2414197

Silva, H., Ramos, P. G. F., Teno, S. C., & Júdice, P. B. (2024). The Impact of Sit-Stand Desks on Full-Day and Work-Based Sedentary Behavior of Office Workers: A Systematic Review. *Hum Factors*, 187208241305591. https://doi.org/10.1177/00187208241305591

Silva, H., Teno, S. C., & Júdice, P. B. (2024). Are there compensatory behaviors in response to a sit-stand desk intervention? *J Occup Health*. https://doi.org/10.1093/joccuh/uiae067

Stamatakis, E., Gale, J., Bauman, A., Ekelund, U., Hamer, M., & Ding, D. (2019). Sitting Time, Physical Activity, and Risk of Mortality in Adults. *J Am Coll Cardiol*, *73*(16), 2062-2072. https://doi.org/10.1016/j.jacc.2019.02.031

Stephens, S. K., Eakin, E. G., Clark, B. K., Winkler, E. A. H., Owen, N., LaMontagne, A. D.,…Healy, G. N. (2018). What strategies do desk-based workers choose to reduce sitting time and how well do they work? Findings from a cluster randomised controlled trial. *Int J Behav Nutr Phys Act*, *15*(1), 98. https://doi.org/10.1186/s12966-018-0731-z

Stephens, S. K., Winkler, E. A. H., Eakin, E. G., Clark, B. K., Owen, N., Moodie, M.,…Healy, G. N. (2019). Temporal features of sitting, standing and stepping

changes in a cluster-randomised controlled trial of a workplace sitting-reduction intervention. *Int J Behav Nutr Phys Act*, *16*(1), 111. https://doi.org/10.1186/s12966-019-0879-1

Sterud, T. (2014). Work-related mechanical risk factors for long-term sick leave: a prospective study of the general working population in Norway. *Eur J Public Health*, *24*(1), 111-116. https://doi.org/10.1093/eurpub/ckt072

Sugiyama, T., Hadgraft, N., Clark, B. K., Dunstan, D. W., & Owen, N. (2020). Sitting at work & waist circumference-A cross-sectional study of Australian workers. *Prev Med*, *141*, 106243. https://doi.org/10.1016/j.ypmed.2020.106243

Teno, S. C., Silva, M. N., & Júdice, P. B. (2024). Physical activity and sedentary behaviour-specific domains and their associations with mental health in adults: a systematic review. . In (pp. 1–28): A*dvances in Mental Health*.

Thomas, B. H., Ciliska, D., Dobbins, M., & Micucci, S. (2004). A process for systematically reviewing the literature: providing the research evidence for public health nursing interventions. *Worldviews Evid Based Nurs*, *1*(3), 176-184. https://doi.org/10.1111/j.1524-475X.2004.04006.x

Thorp, A. A., Healy, G. N., Winkler, E., Clark, B. K., Gardiner, P. A., Owen, N., & Dunstan, D. W. (2012). Prolonged sedentary time and physical activity in workplace and non-work contexts: a cross-sectional study of office, customer service and call centre employees. *Int J Behav Nutr Phys Act*, *9*, 128. https://doi.org/10.1186/1479-5868-9-128

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E.,…Participants, S. T. C. P. (2017). Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. *Int J Behav Nutr Phys Act*, *14*(1), 75. https://doi.org/10.1186/s12966-017-0525-8

Tremblay, M. S., Colley, R. C., Saunders, T. J., Healy, G. N., & Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Appl Physiol Nutr Metab*, *35*(6), 725-740. https://doi.org/10.1139/H10-079

Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: a systematic review. *Public Health*, *121*(12), 909-922. https://doi.org/10.1016/j.puhe.2007.04.009

Turrisi, T. B., Bittel, K. M., West, A. B., Hojjatinia, S., Mama, S. K., Lagoa, C. M., & Conroy, D. E. (2021). Seasons, weather, and device-measured movement

behaviors: a scoping review from 2006 to 2020. *Int J Behav Nutr Phys Act*, *18*(1), 24. https://doi.org/10.1186/s12966-021-01091-1

van Dommelen, P., Coffeng, J. K., van der Ploeg, H. P., van der Beek, A. J., Boot, C. R., & Hendriksen, I. J. (2016). Objectively Measured Total and Occupational Sedentary Time in Three Work Settings. *PLoS One*, *11*(3), e0149951. https://doi.org/10.1371/journal.pone.0149951

van Veldhoven, M., & Broersen, S. (2003). Measurement quality and validity of the "need for recovery scale". *Occup Environ Med*, *60 Suppl 1*(Suppl 1), i3-9. https://doi.org/10.1136/oem.60.suppl_1.i3

Walsh, M. M., Krusmark, M. A., Jastrembski, T., Hansen, D. A., Honn, K. A., & Gunzelmann, G. (2023). Enhancing learning and retention through the distribution of practice repetitions across multiple sessions. *Mem Cognit*, *51*(2), 455-472. https://doi.org/10.3758/s13421-022-01361-8

Wang, C., Lu, E. Y., Sun, W., Chang, J. R., & Tsang, H. W. H. (2024). Effectiveness of interventions on sedentary behaviors in office workers: a systematic review and meta-analysis. *Public Health*, *230*, 45-51. https://doi.org/10.1016/j.puhe.2024.02.013

Wang, X., Li, Y., & Fan, H. (2019). The associations between screen time-based sedentary behavior and depression: a systematic review and meta-analysis. *BMC Public Health*, *19*(1), 1524. https://doi.org/10.1186/s12889-019-7904-9

Waters, C. N., Ling, E. P., Chu, A. H., Ng, S. H., Chia, A., Lim, Y. W., & Müller-Riemenschneider, F. (2016). Assessing and understanding sedentary behaviour in office-based working adults: a mixed-method approach. *BMC Public Health*, *16*, 360. https://doi.org/10.1186/s12889-016-3023-z

Watson, A. K., Hernandez, B. F., Kolodny-Goetz, J., Walker, T. J., Lamont, A., Imm, P.,…Fernandez, M. E. (2022). Using Implementation Mapping to Build Organizational Readiness. *Front Public Health*, *10*, 904652. https://doi.org/10.3389/fpubh.2022.904652

Werneck, A. O., Stubbs, B., Fernandes, R. A., Szwarcwald, C. L., & Silva, D. R. (2019). Leisure time physical activity reduces the association between TV-viewing and depressive symptoms: A large study among 59,401 Brazilian adults. *J Affect Disord*, *252*, 310-314. https://doi.org/10.1016/j.jad.2019.03.066

West, J. T., Miller, W. M., Jeon, S., & Ye, X. (2020). The Effects of a Preconditioning Rolling Session on Subsequent Eccentric Exercise-Induced Muscle Damage. *J Strength Cond Res*, *34*(8), 2112-2119. https://doi.org/10.1519/jsc.0000000000003678

Wilkerson, A. H., Bhochhibhoya, S., & Dragicevic, A. (2021). "It Feels Unhealthy to be Sitting for 40 hours a Week": A Qualitative Analysis of Employee Perceptions of Standing Desk Use in the Workplace. *J Occup Environ Med*, *63*(4), 322-328. https://doi.org/10.1097/JOM.0000000000002128

Zaidel, C., Musich, S., Karl, J., Kraemer, S., & Yeh, C. S. (2021). Psychosocial Factors Associated with Sleep Quality and Duration Among Older Adults with Chronic Pain. *Popul Health Manag*, *24*(1), 101-109. https://doi.org/10.1089/pop.2019.0165

Zhou, L., Deng, X., Xu, M., Wu, Y., Shang, X., E, F.,…Li, X. (2023). The effects of active workstations on reducing work-specific sedentary time in office workers: a network meta-analysis of 23 randomized controlled trials. *Int J Behav Nutr Phys Act*, *20*(1), 92. https://doi.org/10.1186/s12966-023-01467-5

Zhou, Y., Huang, Z., Liu, Y., & Liu, D. (2024). The effect of replacing sedentary behavior with different intensities of physical activity on depression and anxiety in Chinese university students: an isotemporal substitution model. *BMC Public Health*, *24*(1), 1388. https://doi.org/10.1186/s12889-024-18914-y

Annex IV: Poster presentation acceptance letter

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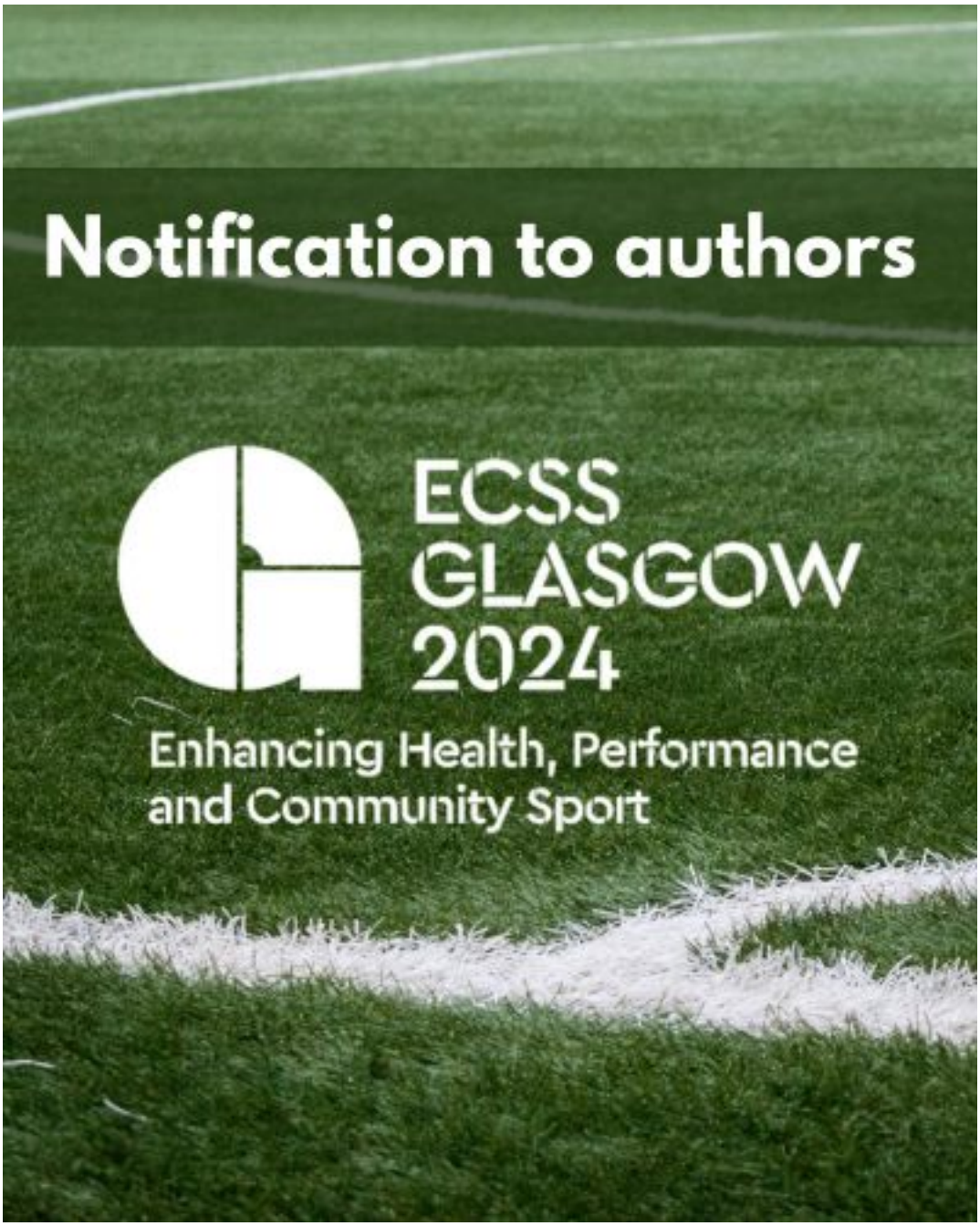

Dear Hélio,

We're pleased to inform you that your abstract has been accepted for the 29th Annual Congress of the European College of Sport Science, 2-5 July 2024 in Glasgow.

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Yours sincerely,

Maria Francesca Piacentini

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Impact of a 6-month sit-stand desk-based intervention on musculoskeletal discomfort and post-work fatigue in office workers: a cluster randomized controlled trial

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Introduction

- Sedentary behavior (SB) is particularly concerning since adults in developed countries spend more than 60% of their waking time sitting, mostly at their workplace [1, 2].
- Office workers spend long periods with static neck postures and in repetitive hand/wrist movements, often with awkward back posture [3].
- The prevalence of musculoskeletal symptoms is high among sedentary workers [4], and these symptoms are reported by more than 90% of office workers [5].
- In addition to musculoskeletal discomfort, SB and increased occupational physical activity are associated with the need for recovery after work (NFR) [6].
- These effects can manifest throughout the workday and intensify after the completion of work activities.

Purpose

- This study aims to evaluate the impact of a 6-month intervention with a sit-stand desk on office workers' musculoskeletal discomfort and NFR in comparison to a control group.

Methods

- **Participants**: We included 38 full-time office workers, ranging from 20 to 60 years old.
- **Study design:** This study used a two-arm (1:1) clustered randomized controlled trial design, where participants were randomly assigned to either the intervention or control group.
- **Intervention groups:** The intervention group attended the psychoeducational session and was provided with the opportunity to have a sit-stand desk in their workplace, allowing them to work seated or standing and change between these postures as many times they desired for 6 months. The control group only attended a psychoeducational session regarding the independent benefits of reducing and interrupting sitting time with standing, with no contextual change during the 6-month intervention (i.e., no access to the sit/stand desk).
- **Study assessments:** The evaluations took place at two different times, as shown in **Figure 1**.
- A modified version of the Nordic Musculoskeletal Questionnaire was used to assess musculoskeletal complaints and other health symptoms experienced during the previous week. This questionnaire covers nine regions of the body, including the neck, shoulders, elbows, hands/wrists, thorax, lumbar region, hips/thighs, knees and ankles/feet. Participants rated the pain in each region on a scale from zero (no pain) to nine (as much pain as possible) [7].
- NFR Scale [8] was used to assess the need to recuperate from work induced efforts. The questionnaire presents 11 items with dichotomic answers 0 ("no") and 1 ("yes"). A higher total NFR score indicated that the worker was needing greater recovery time from their work tasks.
- **Statistical Analysis:** Data were analyzed with SPSS Statistics for Windows version 28.0, 2024 (SPSS Inc., an IBM Company, Chicago). A repeated measure analysis of variance (ANCOVA) was used to examine differences between groups from baseline to 6 months to compare the effect of intervention on the dependent variables. Paired-sample T-tests were performed to examine time effect within groups. Statistical significance was set at 5%.

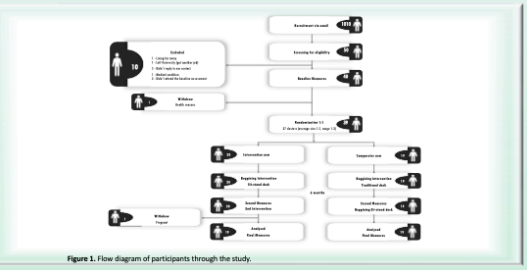

Figure 1. Flow diagram of participants through the study.

Results

Table 1. Changes in Nordic Musculoskeletal Questionnaire and NFR scores at 6-month follow-up between participants randomised to usual care (control) or the SUFHA intervention.

Region	Mean (SD) at Baseline		Mean (SD) at 6 months		p	Mean Difference from Baseline to 6 Months (95% CI)			
	CG[a] (n=19)	IG[b] (n=19)	CG[a] (n=19)	IG[b] (n=19)	Time*group	CG[a] (n=19)	Time	IG[b] (n=19)	Time
Neck	2.58 (3.47)	2.47 (3.37)	1.95 (3.24)	1.74 (2.85)	0.937	-0.63 (-2.74 to 1.48)	0.537	-0.74 (-2.52 to 1.04)	0.396
Shoulder	1.37 (2.73)	2.21 (3.15)	0.79 (2.51)	1.05 (2.27)	0.441	-0.58 (-1.52 to 0.36)	0.213	-1.16 (-2.41 to 0.90)	0.067
Upper back	0.63 (2.31)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.242	-0.63 (-1.75 to 0.48)	0.250	0.00 (0.00 to 0.00)	1.000
Elbow	0.00 (0.00)	0.90 (2.69)	0.00 (0.00)	0.90 (2.42)	1.00	0.00 (0.00 to 0.00)	1.000	0.00 (-0.32 to 0.32)	1.000
Hand/wrist	0.63 (2.01)	2.00 (3.43)	0.42 (1.84)	1.00 (2.00)	0.403	-0.21 (-1.57 to 1.15)	0.749	-1.00 (-2.52 to 0.52)	0.185
Low back	3.26 (3.26)	3.68 (3.16)	2.00 (2.69)	2.63 (3.25)	0.807	-1.26 (-2.70 to 0.17)	0.081	-1.05 (-2.14 to 0.31)	0.056
Hip/thigh	0.84 (2.12)	2.53 (3.61)	0.16 (0.69)	1.63 (3.08)	0.806	-0.68 (-1.79 to 0.42)	0.209	-0.90 (-2.3 to 0.51)	0.199
Pain score	9.32 (10.31)	13.79 (13.95)	5.32 (6.46)	8.90 (10.70)	0.752	-4.00 (-8.36 to 0.36)	0.070	-4.89 (-8.86 to -0.93)	0.018*
NFR score	6.11 (2.96)	4.74 (3.12)	5.05 (3.49)	3.05 (2.84)	0.486	-1.05 (-2.44 to 0.33)	0.128	-1.68 (-2.96 to -0.41)	0.013*

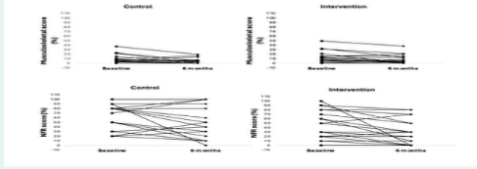

Figure 1 - Inter-individual Change in score musculoskeletal discomfort and NFR score.

Conclusions

- Our 6-month intervention using sit-stand desks effectively reduced musculoskeletal discomfort and NFR in the intervention group. However, despite these improvements, no significant differences were observed between the intervention and control groups.
- These results suggest that reducing SB in the workplace can benefit workers' musculoskeletal discomfort and NFR, among other proven health benefits.
- Further investment in sit-stand desk interventions is needed to continue to identify the most effective strategies for reducing SB and, consequently, reducing musculoskeletal discomfort and NFR.

References

1 – Colley, R.C., et al., *Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey.* Health Rep, 2011. **22**(1): p. 7-14.
2 – Bennie, J.A., et al., *Total and domain-specific sitting time among employees in desk-based work settings in Australia.* Aust N Z J Public Health, 2015. **39**(3): p. 237-42.
3 – Neupane, S., et al., *Developmental pathways of multisite musculoskeletal pain: what is the influence of physical and psychosocial working conditions?* Occup Environ Med, 2017. **74**(7): p. 468-475.
4 – Cho, C.Y., Y.S. Hwang, and R.J. Cherng, *Musculoskeletal symptoms and associated risk factors among office workers with high workload computer use.* J Manipulative Physiol Ther, 2012. **35**(7): p. 534-40.
5 – Parry, S.P., et al., *Workplace interventions for increasing standing or walking for decreasing musculoskeletal symptoms in sedentary workers.* Cochrane Database Syst Rev, 2019. **2019**(11).
6 – Karihtala, T., et al., *Relationship between occupational and leisure-time physical activity and the need for recovery after work.* Arch Public Health, 2023. **81**(1): p. 17.
7 – Andersen, K., et al., *Comparative efficacy and safety of aliskiren, an oral direct renin inhibitor, and ramipril in hypertension: a 6-month, randomized, double-blind trial.* J Hypertens, 2008. **26**(3): p. 589-99.
8 – van Veldhoven, M. and S. Broersen, *Measurement quality and validity of the "need for recovery scale".* Occup Environ Med, 2003. **60 Suppl 1**(Suppl 1): p. i3-9.

Acknowledgments
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European College of Sport Science – Glasgow 2024:
Scottish Event campus, Glasgow - July 2nd-5th, 2024 – Scotland

Annex V - Oral presentation at a national scientific conference

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Presentation title: *Is it the same? An analysis into the 75 min/week of vigorous physical activity or 150 min/week of moderate physical activity*

Event: Congresso de Exercício e Saúde CIDEFES/MANZ – Portugal Fit 2022

Location and date: Santarém, Portugal – November 2022

Authors: Silva, H., Teno, S. C., Júdice, P. B.

Abstract

Background: Physical inactivity is the fourth leading cause of death. The benefits of physical activity (PA) are well-known and accumulating 150min/week of moderate PA or 75min/week of vigorous PA are recommended to acquire these benefits. The evidence regarding the independency between PA and sedentary behavior (SB) is controverting. No investigation explored how attaining each of these recommendations may differently impact SB of adults.

Purpose: To compare the SB levels and other health-related variables between inactive and active adults based on the two main proposed PA recommendations.

Study design: This was a cross-sectional study with data from an observational study performed in outdoor infrastructures for the practice of PA such as green parks, outdoor fitness equipment, and walking/running paths with distinct context from the municipality of Oeiras/Portugal. This study was approved by the Ethics Committee of Lusófona University, and all participants gave their consent prior to participation.

Methods: The data collection took place between March and April of 2022 by face to face interviews. Data analyses were performed using the IBM SPSS software (version 25.0), including descriptive statistics and a one-way ANOVA. Body mass index (BMI) was calculated as weight(kg)/height(m)^2. Sleep duration was calculated based on the self-reported moment of falling asleep and waking up. SB and PA variables were assessed with the short version of the IPAQ.

Results: The sample consisted of 403 participants (57.3% women), with an average age of 48.5 years (±17.1 years). No differences were found for SB and sleep duration between the inactive and active participants, based on the 75min/week of vigorous PA guideline, with only significant differences for BMI, favoring the active ones (p=0.036). Contrarily, individuals who met the recommendation of 150min/week of moderate PA

presented significantly lower SB (Δ=-75min/day; p<0.001), and no differences in sleep duration or BMI (p>0.05).

Conclusion: Our findings suggest that only the 150min/week moderate PA guideline can significantly lower SB, with no impact on SB from the 75min/week of vigorous PA guideline. Even though both guidelines represent health benefits, they may not imply the same reduction in SB, which is also aimed in the latest public recommendations.

Annex VI - Oral presentation at a national scientific conference

****

Presentation title: The impact of sit-stand desks on sedentary behavior of office workers: Systematic review**.**

Event: Congresso de Exercício e Saúde CIDEFES/MANZ – Portugal Fit 2023

Location and date: Santarém, Portugal – November 2023

Authors: Silva, H., Ramos, P. G. F., Teno, S. C., Júdice, P. B.

Abstract

Introduction: Sedentary behavior (SB) is particularly worrying since, in developed countries, adults spend more than 60% of their potential waking time in this behavior, mostly due to their work setting. Workers represent approximately half of the global population, and sitting jobs are the perfect target for reducing SB. Sit-stand desks seem a valuable strategy to reduce sitting time without interfering with workplace productivity.

Objective: Gather the existing evidence about using sit-stand desks to reduce SB in the workplace from randomized and nonrandomized controlled trials (RCTs).

Method: A search of studies published between January 2008 and June 2023 was performed through electronic databases. The search included a combination of key terms based on PICO, and the review was developed according to the PRISMA guidelines.

Results: Twenty-four studies were included in this review, 9 with a moderate quality rate, 2 rated as weak and 1 strong. In the RCTs in which SB was objectively measured, mean reductions were found favoring the intervention group at 3 months (-73.8 min/day), 6 months (-59.3 min/day), 8 months (-117 min/day), and 12 months (-55.8 min/day), compared to the control group.

Conclusion: The evidence suggests that interventions using sit-stand desks can effectively assist office workers in reducing SB. However, most interventions took place in English-speaking countries, with a lack of information on their effectiveness in Europe, especially in southern countries, justifying further investigation on this subject to develop effective strategies translatable to the real world with confidence.