Article:
Metz, L, Guirado, T, Beaulieu, K et al. (2023) Cognitive work on a walking desk does not lead to compensatory appetitive responses in healthy young adults. Physiology and Behavior, 258. 114008. ISSN: 0031-9384

https://doi.org/10.1016/j.physbeh.2022.114008

Cognitive work on a walking desk does not lead to compensatory appetitive responses in healthy young adults

Lore METZ[1,2], Terry GUIRADO[1,2,3], Kristine BEAULIEU[4], Bruno PEREIRA[5], Carole BRUN[1,2], Fabien COUTAREL[6], Martine DUCLOS[3,7], David THIVEL[1,2]

[1]Laboratory of the Metabolic Adaptations to Exercise under Physiological and Pathological Conditions, (AME2P), Clermont Auvergne University, 63170 Aubiere CEDEX, France,
[2]Auvergne Research Center for Human Nutrition (CRNH), 63000 Clermont-Ferrand, France,
[3]INRA, UMR 1019, Clermont-Ferrand, France.
[4] School of Psychology, University of Leeds, Leeds LS2 9JT, United Kingdom
[5]Unit of Biostatistics (DRCI), Clermont-Ferrand University Hospital, Clermont-Ferrand, France,
[6] Laboratory ACTé Clermont Auvergne University, 63407 Chamalières Cedex, France
[7]Department of Sport Medicine and Functional Explorations, Clermont-Ferrand University Hospital, G. Montpied Hospital, Clermont-Ferrand, France;

Running Title: Energy balance during cognitive task on active desk

Address for correspondence:
METZ Lore (PhD)
Clermont Auvergne University, EA 3533, Laboratory of the Metabolic Adaptations to Exercise under Physiological and Pathological Conditions (AME2P), BP 80026, F-63171 Aubière cedex, France
Lore.metz@uca.fr
Phone and fax/ 0033 4 73 54 85

Abbreviations

BMI	Body mass index
EB	Energy balance
EE	Energy expenditure
EI	Energy intake
FFM	Fat-free mass
FM	Fat mass
HR	Heart rate
RER	Respiratory exchange ratio
REI	Relative energy intake
SD	Standard deviation
VO_2	Oxygen consumption
VCO_2	Carbon dioxide production
VE	Ventilation

10

Highlights

- Walking while working does not increase food intake at the subsequent meal
- Repetitive use of a walking desk could provide chronic health benefits
- A walking desk increases energy expenditure above sedentary levels contrary to a standing desk

Abstract

Context: In addition to the low energy expenditure induced by sedentary behaviors such as sitting, it has been shown that intense cognitive work can lead to an increase in food intake. Walking Desk provide the opportunity for office workers to replace prolonged sitting at work with light intensity physical activity. **Objective:** To compare the effects of sitting *vs* standing *vs* walking during a cognitive task on energy intake, appetite sensations, food reward and overall energy balance. **Methods:** Fifteen normal weight (BMI: 24.1±1.2 kg.m^{-2}) young men (23.4±2.1years) randomly performed three conditions: sitting desk (SitD), standing desk (StD) and walking desk (WD), while performing a 45-min cognitive task. Energy expenditure was measured by indirect calorimetry, regular appetite sensations were assessed using visual analogue scales, energy intake measured during an *ad libitum* meal and the relative energy intake calculated. Pre and post-test meal food reward was evaluated through the Leeds Food Preference Questionnaire. **Results:** Relative energy intake decreased by 150kcal in WD compared with SitD, however it did not reach statistical significance. There were no differences in appetite sensations nor food reward between the three conditions. Energy expenditure was significantly higher in WD (141.8±13 kcal) than in SitD (78.7±5 8kcal) and StD (85.9±8 kcal) ($p \leq 0.05$). **Conclusion:** Walking desk use can decrease sedentary time while working without any appetitive compensation. The small reduction in energy balance with walking while working could induce significant health benefits if repeated over time. Future longer studies need to clarify whether active desks can contribute to the prevention or management of weight gain.

Keywords: appetite, sedentary behavior, walking desk, energy balance

1. Introduction

Sedentary behaviors have increased during the last decade and have worsened with the COVID-19 pandemic [1]. The increase in administrative occupational activities has largely contributed to this progression of time spent in a sitting position, which can represent as much as 77% of the whole workday [2]. Sedentary time, especially sitting time, has been recognized as an independent factor for mortality [3-6] and it is clear today that being physically active (i.e. reaching physical activity recommendations) does not protect against the harmful effects of a sedentary lifestyle, unless reaching at least three times the recommended levels of physical activity [3]. In addition to the negative effects of work-related sedentary activities in terms of reduced energy expenditure, performing intense cognitive tasks during sedentary occupational activities can also lead to an increase in energy intake (EI) [7, 8]. Thus, the low energy expenditure associated with sitting and tertiary work, and their relative propensity to increase EI, call for a new consideration of workspaces and workstations, to promote employee health. Interestingly, the implementation of physical exercise before lunchtime has shown to be efficient to decrease EI after a standardized cognitive task [9, 10]. However, the constraints associated with exercising at work (space and equipment available, changing rooms and showers available) may make it difficult to adopt this type of strategy on a daily basis [11]. Active workstations such as sit-to-stand and treadmill desks provide the opportunity for office workers to replace prolonged sitting at work with light intensity physical activity [12, 13]. Between the three main active desk strategies (standing desk, cycle desk and treadmill desk) that have been investigated over the last decade, treadmill desks are the more energy demanding while standing desks generate an energy load that remains slightly under the sedentary level of 1.5 METs [14]. While the energetic impacts of such active desks during working (mental) tasks have been quite largely studied, their potential implications for appetite control remain poorly examined so far. In their work, Josaphat and colleagues [15] have shown that using a standing desk for 75min did not modify subsequent EI compared to the same work task performed in a sitting position. Our group recently showed that the use of a cycle desk during a 30-min cognitive task increased absolute EI at the following meal without altering total energy balance (EB) compared to the same mental work performed in a sitting position [9]. In light of these two recent studies, while using active desks is recommended to break sedentary time, it remains unclear whether the induced increase in energy expenditure can significantly help reduce people's short term relative EI after mental work. Although walking desks are the more energy demanding strategy, no study has so far investigated their effects on subsequent appetite and EI.

The aim of this study was to investigate the effects of walking, standing or being in a sitting position during a cognitive task on appetite sensations, EI, energy expenditure and food reward in healthy adult men. We hypothesized that walking while performing a mental task would not affect absolute EI or appetite sensations while decreasing overall energy balance compared to standing or sitting positions.

2. Methods

2.1 Population

Fifteen healthy normal-weight young men were recruited to participate in this randomized crossover study. To be included in the study they had to be free of any illnesses or medications that could interfere with the study outcomes. The participants also had to be habitual breakfast consumers. To better describe the participants' eating behaviour traits, a French version of the TFEQ was administered to our subjects. This questionnaire assesses dietary restraint, disinhibition and susceptibility to hunger [16].

This study was conducted according to the guidelines laid down in the Declaration of Helsinki. Written informed consent was obtained from all participants as requested by the local Research Ethics Committee (CPP Su Est VI).

2.2 Experimental design

After a full medical examination to assess eligibility, the included participants were asked to complete a food preference questionnaire (which was used to compose the buffet meals presented during the experimental sessions). Each participant came to the laboratory on three separate occasions. During the first visit, anthropometry and body composition parameters were assessed. Then, participants completed three experimental visits, in a standardized postprandial state, in a randomized order separated by at least 7 days to perform a cognitive task (text transcription) during 45 min under three different conditions. The first was a sitting condition where subjects were seated on a desk chair while working (SitD); the second corresponded to a standing condition on a standing desk (StD); and the third was a walking condition on a walking desk (WD). Cardiorespiratory parameters were assessed during each condition. Thirty minutes after each session, an *ad libitum* lunch meal was provided and EI measured. Before and after each condition, appetite sensations, food preference and reward were assessed at different times, as well as anxiety and mental workload. Physical activity level was assessed after the last condition during 7 consecutive days using accelerometers.

2.3 Experimental conditions

2.3.1 Sessions

Subjects were submitted to three experimental sessions in a randomized order. Participants arrived at the laboratory at 7:30 am, and were submitted to a standardized breakfast which represented 9.5 to 10 kcal per kg of body mass (55% CHO, 30% lipids and 15% protein) [17]. The participants were instructed to abstain from stimulants (coffee, tea) and from moderate-to-vigorous physical activity for 24 h prior to each session.

A standard seated workstation was used in the control condition. In the standing and walking (1.6 km.h) condition, the Desk (Activ'UP, Collonges sous Salève, France) was systematically adjusted before the task to the participant's height so that their arms were bent at a 90° angle. During the three experimental sessions, subjects were in a stable environmental temperature

(22 ± 0.5°C). The cognitive task was a transcription of a text for 45 minutes. The participants were asked to transcribe as much of the text as possible, while making as few mistakes as possible. Participants could not rely on spellcheck. Energy expenditure and heart rate were monitored continuously during every cognitive task.

2.3.2 Measurements

2.3.2.1 Anthropometric and body composition

Height and body mass were determined using a standard wall-mounted stadiometer and a digital scale (SECA, Les Mureaux, France), respectively. Body mass index (BMI) was calculated as body mass (kg) divided by height squared (m^2). Body composition was assessed on the same occasion using impedance analysis (Tanita MC 780). This model has been validated in young adults of various physical activity levels [18].

2.3.2.2 Metabolic and cardiorespiratory parameters

After calibration, oxygen consumption (VO_2), carbon dioxide production (VCO_2), ventilation (VE) and heart rate (HR) were continuously recorded throughout each of the 45-min sessions using indirect calorimetry (MetaMax 3b, Cortex Biophysik, Leipzig, Germany) and HR monitor (Polar, V800, Kempele, Finland). Respiratory exchange ratio (RER; VCO_2/VO_2) and total energy expenditure (EE in kcal) over the 45 min and, of each session, was calculated as follows: VO_2 ($L.min^{-1}$) x energy equivalent of oxygen x duration (min)[19].

Ad libitum meals and energy intake

Participants were provided with an *ad libitum* buffet meal for lunch (12:00pm). Food items were provided in excess of expected consumption and participants were instructed to eat until ‘‘comfortably satiated’’. The food selection was covertly weighed by the investigators before and after the meal and participants were unaware of the quantity of calories served. Energy and macronutrient intakes were calculated using a dietary analysis software (Nutrilog software, France). Relative energy intake (REI) for the *ad libitum* lunch meal was calculated as the EI minus the EE of each session.

2.3.2.3 Subjective appetite sensations

Participants were asked to rate their hunger, fullness, desire to eat (DTE) and prospective food consumption (PFC) throughout the sessions (150 millimeter visual analogue scales, VAS) at baseline (fasted), immediately after breakfast, before and after the cognitive task, before and after lunch and 30 and 60 min after lunch [20].

2.3.2.4 Food preference and reward

The Leeds Food Preference Questionnaire (LFPQ; described in detail by Dalton and Finlayson) [21] was administered before and after lunch to determine scores of implicit wanting and explicit liking for high-fat (>50% energy) or low-fat (<20% energy) foods matched for familiarity, sweetness, protein and acceptability [22]. Low-fat scores were subtracted from high-fat scores to obtain the fat appeal bias score and savoury scores were subtracted from sweet scores to obtain the taste appeal bias score; thus positive scores indicate greater liking or wanting towards high-fat compared to low-fat foods and towards sweet compared to savoury foods, respectively..

2.3.2.5 State-Trait Anxiety Inventory (STAI)

The STAI consists of two distinct anxiety scales: trait scale (anxiety-trait) and state scale (anxiety-state) [23]. STAI questionnaire were fulfilled during the first visit for the evaluation of the anxiety-trait score, and before and after each experimental session for the anxiety-state. Both scales are composed of 20 questions and require that the subjects describe how they feel generally, on the anxiety-trait scale and how they feel at a specific moment, on the anxiety-state scale.

2.3.2.6 NASA Task Load Index (NASA-TLX)

The NASA TXL questionnaire was fulfilled by the subjects immediately after the end of each experimental session. The NASA-TLX provides a subjective mental workload score based on the weighted average of six dimensions: mental demand, which signifies the amount of mental and/or perceptual activity required, such as thinking, calculating and deciding; physical demand, which indicates the amount of physical activity required, such as pushing, pulling, turning and controlling; temporal demand, defined as the amount of pressure felt due to the rate at which tasks or task elements occur; overall performance, which is how successful and satisfied one has been in performing a given task; effort, taken to indicate how hard one has had to work to accomplish a certain level of performance; and frustration, which denotes how discouraged versus content one has felt while completing the task [24].

2.3.2.7 Daily time spent physically active and sedentary

Briefly, participants continuously wore for 7 days with at least one weekend day an ActiGraph wGT3X-BT accelerometer ActiGraph, Inc., Pensacola, FL) to determine their PA, and an activPAL3 inclinometer (PAL Technologies Limited, Glasgow, UK) to characterise sedentary time. In order for data to be considered valid, every monitor's data needed to report at least 4 days (including 1 weekend day) of wear with a monitor wear time of ≥ 10 hours/day (600 min/day) [25, 26]. While the accelerometer was removed at night and the inclinometer was worn all day, only the time where every participant wore both the inclinometer and accelerometer were analysed. Subjects were asked to wear AG on the right hip on an elastic belt during waking hours. The AP device was positioned in a nitrile sleeve and attached to the anterior midline of the participant's right thigh using an adhesive patch. The monitor was worn continuously for 24 hours during the 7 days. Analytical approaches of ActiGraph [27, 28] and activPal [29] data have been detailed previously.

2.4 Statistics

The sample size estimation was calculated according to (i) differences reported in the literature [7] and (ii) effect-size bounds recommended by Cohen (Cohen, 1988) : small (ES: 0.2), medium (ES: 0.5) and large (ES: 0.8, "grossly perceptible and therefore large"). Power calculation based on previous work [7] suggested that a sample size of 15 participants would allow detection of at least 40% difference in EI between cognitive task conditions, a probability of 0.05, and a beta level of 0.80. Statistical analyses were performed using Stata software, Version 15 (StataCorp, College Station, TX, US). Continuous data were expressed as mean and standard-deviation and the assumption of normality was assessed using the Shapiro-Wilk test. The comparisons between sessions (SitD, SD, WD) were performed using random-effects models for crossover designs, taking account of the following effects: session, sequence, *session x sequence* interaction and subject as random effect. The normality of residuals from these models was studied as aforementioned. In case of non-normal distribution, a logarithmic transformation was implemented. A Sidak's type I error correction was applied to perform multiple comparisons. Random-effects models were also used to measure time effect during each exercise session, (1) time, session and *time x session* interaction as fixed effects, and (2) subject as random-effect in order to model between and within participant variability. Analogous statistical analysis plan was performed to study assumptions of random-effects models and multiple comparisons. Appetite sensations were also compared with area under the curve (AUC) values using the trapezoid method.

3 Results

3.1 Study population

Table 1 displays the descriptive characteristics of subjects enrolled in the present study. Subjects were young normal-weight men with no cognitive dietary restriction and low levels of disinhibition and susceptibility to hunger. Results for the STAI questionnaire showed low global anxiety-trait scores, underlying the absence of anxiety in their everyday life. Accelerometry data showed that our subjects were active, meaning that they reached the recommendation for daily physical activity [30]. However, they still spent more than half of their waking hours engaged in sedentary behaviors.

3.2 Metabolic and cardiorespiratory parameters

As shown in Fig1A, heart rate was significantly higher in standing and walking sessions compared to sitting (SitD 74±9 *vs* StD 88.3±10.2 *vs* WD 85.3±10.9 bpm; p=0.01), without any difference between the StD and WD sessions (p>0.05).

Energy expenditure during the whole session was significantly higher for WD compared to SitD and StD (141.8±13.8 kcal *vs* 78.7±9.8kcal *vs* 85.9±8.2 kcal; p=0.01) with no difference between those last two (Fig1B). Similarly, the Metabolic Equivalents (METs) was higher for WD compared to SitD and StD (2.4±0.19 *vs* 1.3±0.16 *vs* 1.4±0.12; p=0.01) (Fig1C). There was no difference in substrate oxidation between the three sessions as reflected by the respiratory exchange ratio (SitD 0.85±0.02 *vs* StD 0.83±0.02 *vs* WD 0.83±0.05; p>0.05) (Fig.1D).

3.3 Energy Intake

As illustrated in figure 2A, there was no significant difference between the three conditions for absolute EI (SitD 1031±287, StD 939±257, WD 939±267 kcal; p>0.05) nor for relative energy intake (SitD 952±284, StD 877±246, WD 798±263 kcal; p>0.05). There was no significant difference in the absolute (kcal) or relative contribution (%) to total EI for carbohydrates (SitD 48±7 *vs* StD 47±8 *vs* WD 49±8%; p>0.05), lipids (SitD 33±7 *vs* StD 34±7 *vs* WD 32±7%; p>0.05) and proteins (Sit D18.1±3 *vs* StD 18.3±3.4 *vs* WD 18.6±3.7%; p>0.05) between the three conditions (figure 2B).

3.4 Appetite sensations and food reward

As showed in figure 3, no significant differences were observed between the three conditions for appetite sensations.

Regarding food reward, neither implicit wanting nor explicit liking was found significantly different between conditions as displayed in Table 2. There was a time effect with an increase in taste bias after the lunch for implicit wanting and explicit liking (p=0.001) (Table 2).

3.5 Anxiety and workload parameters

Total score for the NASA Task Load Questionnaire was moderate to high (50 to 60) with no difference between the three conditions (Table 3). The physical demand dimension was the only sub-category showing significant differences with a higher score during StD compared to SitD (p=0.001). EI during the three conditions were negatively associated with Physical (r=-0.318, p=0.03) and Temporal (r=-0.371, p=0.01) demand dimension assessed after each session. There was a tendency for a positive association between EI and Frustration (r=0.29, p=0.08).

There was no time effect (p≥0.05) and no difference in anxiety-state before (SitD: 23.5±4.6 *vs* StD: 23±3.1 *vs* WD: 24.3±4.1; p≥0.05) and after (SitD: 23.4±4.5 *vs* StD: 23.6±3.7 *vs* WD: 22.6±3.1; p≥0.05) the task between the three conditions. A significant negative correlation was found between pre-task anxiety-state and EI (r=-0.374, p=0.01).

4 Discussion

The deleterious impact of tertiary work-related sedentary time requires the development of strategies to reduce the time spent seated. On top of the low energy expenditure associated with this sitting time, the stress caused by intensive mental work can induce fatigue and encourage excessive energy intake at the next meal. Several strategies to limit this energy compensation have been evaluated, such as the implementation of a short period of exercise before the meal [9, 10, 31], active breaks [32] or the use of active workstations during cognitive tasks [9, 15]. In the present study we show for the first time that walking at 1.6km/h while performing mental work for 45 min did not affect subsequent absolute EI compared to the same cognitive task performed in a standing or a sitting position. When energy intake is adjusted to the energy expenditure generated in the three conditions, the use of the treadmill favors the lowest energy balance (-150kcal) however this result remains non-significant. Nevertheless, including 45 minutes of work on the treadmill daily could contribute to a significant deficit over a week or several months of work and promote weight management. This projection is consistent with the chronic effects demonstrated through the use of treadmill desks on body weight regulation in people with overweight or obesity [33]. Very few studies have investigated the acute effects of active desk use on energy intake. Recently, Josaphat et al [15] showed no difference in energy intake after a 75-min cognitive task performed in a sitting or standing position. Although the cognitive task used was longer in this previous study, our results are in line with it, as we did not find any effect of standing while working compared to sitting on energy intake. Furthermore, our research group has recently shown that the use of a cycle desk during a cognitive task did not reduce subsequent energy intake [9]. Indeed, we have shown that when compared to a seated position, the absolute energy intake was higher but when taking into account the energy expenditure generated from the cycling, the relative energy intake was not different. Thus, altogether, these results suggest that the acute use of active desks does not generate an anorectic effect; however, they do not induce a positive energy balance. In view of the low intensity induced by standing or walking on an active workstation, the absence of anorectic effect may seem to be in agreement with previous studies [9, 10, 34]. Indeed, as mentioned previously, it is now well accepted that intensive exercise (i.e. above 70%VO_2max) is more likely to create an anorectic effect than low-to-moderate intensity exercise [34-36]. Contrary to the results from Josaphat et al. [15], we did not find any difference in hunger or prospective food consumption between the different experimental conditions. Nevertheless, although not significant, the standing condition showed the lowest values. This is in line with the significant decrease found for these two appetite sensations in the standing condition in the work from Josaphat et al [15].

Importantly, our sample was composed of physically active young men who otherwise did not present an altered eating behaviour profile, which might partly explain the lack of difference in energy intake and appetite sensations between conditions. Cognitive or emotional stress has been shown to increase energy intake. However, it seems that this relationship is more prevalent in women than in men [37, 38]. We assessed the mental and physical stress and strain induced by the different conditions using different questionnaires (STAI and NASA TXL). Our results show that performing the same cognitive task while standing or walking does not induce any particular stress compared to sitting. We found that two dimensions of workload (physical demand and temporal demand) and the state-anxiety score before each session were negatively associated with energy intake. This indicates that when a higher workload or anxiety level were anticipated, a lower EI at the meal test was observed. This is in line with the study of Perusse-Lachance et al [39] underscoring sex difference in response to a cognitive stress. More specifically they found that a cognitive task increased EI in normal-weight women whereas it decreased EI in young normal-weight men. In addition to the intersex difference in the relationship between stress and energy intake, subjects with a moderate to high level of physical activity – which is the case in our sample – seem to better adjust their energy balance, which may also contribute to explain the observed lack of difference [40].

The energy expenditure generated by the use of the treadmill was significantly higher than that generated by the sitting and standing postures. Although few studies have compared the energy cost of these three postures/activities, our results confirm those of previous studies showing that only cycling desks or walking desks can increase energy expenditure above the sedentary threshold [41]. Although standing desks are presented as active workstation strategies, and have beneficial effects on certain parameters such as glycemic control, they remain a sedentary activity from an energetic point of view [42].

An interesting result of our study is that despite a lower energy demand than walking, the mental work performed in the standing position is perceived as a more strenuous physical demand when assessed by the NASA TXL questionnaire than walking. This last result underlines the good acceptability of new workspace management strategies such as the daily use of a walking desk.

Although this work provides new insights regarding the control of appetite in response to cognitive tasks performed in sedentary or active situations, some limitations must be mentioned. The relatively modest sample size composes the main limitation, but it remains in the range of previously published studies assessing energy expenditure and intake during posture allocations or low intensity exercises [7]. Moreover, this study only included young, normal-weighted men, which does not allow us to generalize our results to the general population. It will be essential to evaluate in future studies these appetitive and energy balance responses in women as well as in subjects with overweight and obesity.

To conclude, this study suggests the use of active desks such as the walking desk as an interesting strategy to reduce sedentary time without generating greater mental strain than during sitting work. In addition, despite the increase in energy expenditure with walking on a treadmill, subsequent energy intake is not modified compared to a seated condition. Thus, the use of walking desks among tertiary employees seems promising to reduce sedentary behavior and to prevent the associated health risks. However, further studies seem necessary to better identify the potential interactions between the use of such active desks and the nature of the mental tasks imposed to employees.

Author contributions

LM, DT, TG, MD, FC: Conceptualization; LM, TG, MD: Data curation, Investigation; BP, MD, KB, CB LM, DT: Formal analysis; LM, DT, KB,: Methodology, Project administration; LM, DT, KB, MD: Writing; LM, DT, KB : Review, Editing.

Conflict of interest

We have no conflict of interest disclose.

Funding sources

This work has been supported by the Challenge 3 Mobility of the CAP2025 I-Site project of UCA as well as by the Health in Motion International Research Chaire of the UCA foundation.

References

1. Flanagan, E.W., et al., *The Impact of COVID-19 Stay-At-Home Orders on Health Behaviors in Adults.* Obesity (Silver Spring), 2021. **29**(2): p. 438-445.
2. Wick, K., et al., *Deviation between self-reported and measured occupational physical activity levels in office employees: effects of age and body composition.* Int Arch Occup Environ Health, 2016. **89**(4): p. 575-82.
3. Ekelund, U., et al., *Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women.* Lancet, 2016. **388**(10051): p. 1302-10.
4. Patterson, R., et al., *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, 2018. **33**(9): p. 811-829.
5. Biswas, A., et al., *Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis.* Ann Intern Med, 2015. **162**(2): p. 123-32.
6. Bellettiere, J., et al., *Associations of sitting accumulation patterns with cardio-metabolic risk biomarkers in Australian adults.* PLoS One, 2017. **12**(6): p. e0180119.
7. Chaput, J.P. and A. Tremblay, *Acute effects of knowledge-based work on feeding behavior and energy intake.* Physiol Behav, 2007. **90**(1): p. 66-72.
8. Chaput, J.P., et al., *Glycemic instability and spontaneous energy intake: association with knowledge-based work.* Psychosom Med, 2008. **70**(7): p. 797-804.
9. Thivel, D., et al., *Effect of Acute Exercise and Cycling Desk on Energy Intake and Appetite Response to Mental Work: The CORTEX Study.* J Phys Act Health, 2021. **18**(4): p. 433-439.
10. Neumeier, W.H., et al., *Exercise following Mental Work Prevented Overeating.* Med Sci Sports Exerc, 2016. **48**(9): p. 1803-9.
11. Genin, P.M., et al., *Health and Fitness Benefits But Low Adherence Rate: Effect of a 10-Month Onsite Physical Activity Program Among Tertiary Employees.* J Occup Environ Med, 2018. **60**(9): p. e455-e462.

12. Duvivier, B.M., et al., *Minimal intensity physical activity (standing and walking) of longer duration improves insulin action and plasma lipids more than shorter periods of moderate to vigorous exercise (cycling) in sedentary subjects when energy expenditure is comparable.* PLoS One, 2013. **8**(2): p. e55542.
13. Hervieux, V., A. Tremblay, and C. Biron, *Active meetings on stationary bicycle: An intervention to promote health at work without impairing performance.* Appl Ergon, 2021. **90**: p. 103269.
14. Josaphat, K.J., et al., *Use of Active Workstations in Individuals with Overweight or Obesity: A Systematic Review.* Obesity (Silver Spring), 2019. **27**(3): p. 362-379.
15. Josaphat, K.J., et al., *Acute Impact of the Use of a Standing Desk on Appetite Sensations and Energy Intake.* J Phys Act Health, 2020. **17**(12): p. 1240-1246.
16. Stunkard, A.J. and S. Messick, *The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger.* J Psychosom Res, 1985. **29**(1): p. 71-83.
17. Isacco, L., P. Duché, and N. Boisseau, *Influence of hormonal status on substrate utilization at rest and during exercise in the female population.* Sports Med, 2012. **42**(4): p. 327-42.
18. Verney, J., et al., *Comparisons of a Multi-Frequency Bioelectrical Impedance Analysis to the Dual-Energy X-Ray Absorptiometry Scan in Healthy Young Adults Depending on their Physical Activity Level.* J Hum Kinet, 2015. **47**: p. 73-80.
19. Zuntz N, S.D., *Studien Zu Einer Physiologie Des Marches*. 1901, Berlin: Verlag von August Hirchwald,.
20. Flint, A., et al., *Reproducibility, power and validity of visual analogue scales in assessment of appetite sensations in single test meal studies.* Int J Obes Relat Metab Disord, 2000. **24**(1): p. 38-48.
21. Dalton, M. and G. Finlayson, *Psychobiological examination of liking and wanting for fat and sweet taste in trait binge eating females.* Physiol Behav, 2014. **136**: p. 128-34.
22. Finlayson, G., N. King, and J. Blundell, *The role of implicit wanting in relation to explicit liking and wanting for food: implications for appetite control.* Appetite, 2008. **50**(1): p. 120-7.
23. Spielberger, C., *State-Trait Anxiety Inventory for adults. Sample set, manual, scoring key.* 1985, Mind Garder: Redwood City, CA.
24. Hart, S. and L. Staveland, *Development of NASA-TLX (Task Load Index): Results of emprical and theoretical research.* 1988, Elsevier Science Publishers B. V;: North-Holland. p. 139–183.
25. Aguilar-Farias, N., et al., *How many days are enough for measuring weekly activity behaviours with the ActivPAL in adults?* J Sci Med Sport, 2019. **22**(6): p. 684-688.
26. Tudor-Locke, C., S.M. Camhi, and R.P. Troiano, *A catalog of rules, variables, and definitions applied to accelerometer data in the National Health and Nutrition Examination Survey, 2003-2006.* Prev Chronic Dis, 2012. **9**: p. E113.
27. Choi, L., et al., *Assessment of wear/nonwear time classification algorithms for triaxial accelerometer.* Med Sci Sports Exerc, 2012. **44**(10): p. 2009-16.
28. Kozey-Keadle, S., et al., *Validation of wearable monitors for assessing sedentary behavior.* Med Sci Sports Exerc, 2011. **43**(8): p. 1561-7.
29. Lyden, K., et al., *Validity of two wearable monitors to estimate breaks from sedentary time.* Med Sci Sports Exerc, 2012. **44**(11): p. 2243-52.
30. Bull, F.C., et al., *World Health Organization 2020 guidelines on physical activity and sedentary behaviour.* Br J Sports Med, 2020. **54**(24): p. 1451-1462.
31. Lemay, V., et al., *Exercise and negative energy balance in males who perform mental work.* Pediatr Obes, 2014. **9**(4): p. 300-9.
32. De Jong, N.P., et al., *Breaking up Sedentary Time in Overweight/Obese Adults on Work Days and Non-Work Days: Results from a Feasibility Study.* Int J Environ Res Public Health, 2018. **15**(11).
33. Koepp, G.A., et al., *Treadmill desks: A 1-year prospective trial.* Obesity (Silver Spring), 2013. **21**(4): p. 705-11.
34. Imbeault, P., et al., *Acute effects of exercise on energy intake and feeding behaviour.* Br J Nutr, 1997. **77**(4): p. 511-21.

35. Ueda, S.Y., et al., *Comparable effects of moderate intensity exercise on changes in anorectic gut hormone levels and energy intake to high intensity exercise.* J Endocrinol, 2009. **203**(3): p. 357-64.
36. King, N.A., V.J. Burley, and J.E. Blundell, *Exercise-induced suppression of appetite: effects on food intake and implications for energy balance.* Eur J Clin Nutr, 1994. **48**(10): p. 715-24.
37. Weinstein, S.E., D.J. Shide, and B.J. Rolls, *Changes in food intake in response to stress in men and women: psychological factors.* Appetite, 1997. **28**(1): p. 7-18.
38. Wallis, D.J. and M.M. Hetherington, *Stress and eating: the effects of ego-threat and cognitive demand on food intake in restrained and emotional eaters.* Appetite, 2004. **43**(1): p. 39-46.
39. Pérusse-Lachance, E., et al., *Sex differences in the effects of mental work and moderate-intensity physical activity on energy intake in young adults.* ISRN Nutr, 2013. **2013**: p. 723250.
40. Beaulieu, K., et al., *Homeostatic and non-homeostatic appetite control along the spectrum of physical activity levels: An updated perspective.* Physiol Behav, 2018. **192**: p. 23-29.
41. Podrekar, N., Ž. Kozinc, and N. Šarabon, *Effects of cycle and treadmill desks on energy expenditure and cardiometabolic parameters in sedentary workers: review and meta-analysis.* Int J Occup Saf Ergon, 2021. **27**(3): p. 728-736.
42. Miles-Chan, J.L. and A.G. Dulloo, *Posture Allocation Revisited: Breaking the Sedentary Threshold of Energy Expenditure for Obesity Management.* Front Physiol, 2017. **8**: p. 420.

Figure legends

Figure 1: Heart Rate (A), Total energy expenditure (B), Metabolic Equivalent Task (METs) (C) and Respiratory Exchange Ratio (D) assessed during 45min of mental work done in a Sitting (SitD), Standing (StD) position or while walking on a walking Desk (WD). *p≤0.05, ** p≤0.001.

Figure 2: Absolute and Relative energy intake (A) and relative contribution of macronutrients (B) assessed after an *ad libitum* buffet meal proposed after 45min of mental work done in a Sitting (SitD), Standing (StD) position or while walking on a walking Desk (WD). CHO: carbohydrates; EI: energy intake*p≤0.05, ** p≤0.001.

Figure 3: Appetite feelings during each experimental condition (panels A, C, E and G) and Area Under the Curve (AUC) (Panels B,D,F and H): 45min of mental work done in a Sitting (SitD), Standing (StD) position or while walking on a walking Desk (WD). PFC: prospective food consumption; DTE: desire to eat.

Fig.1

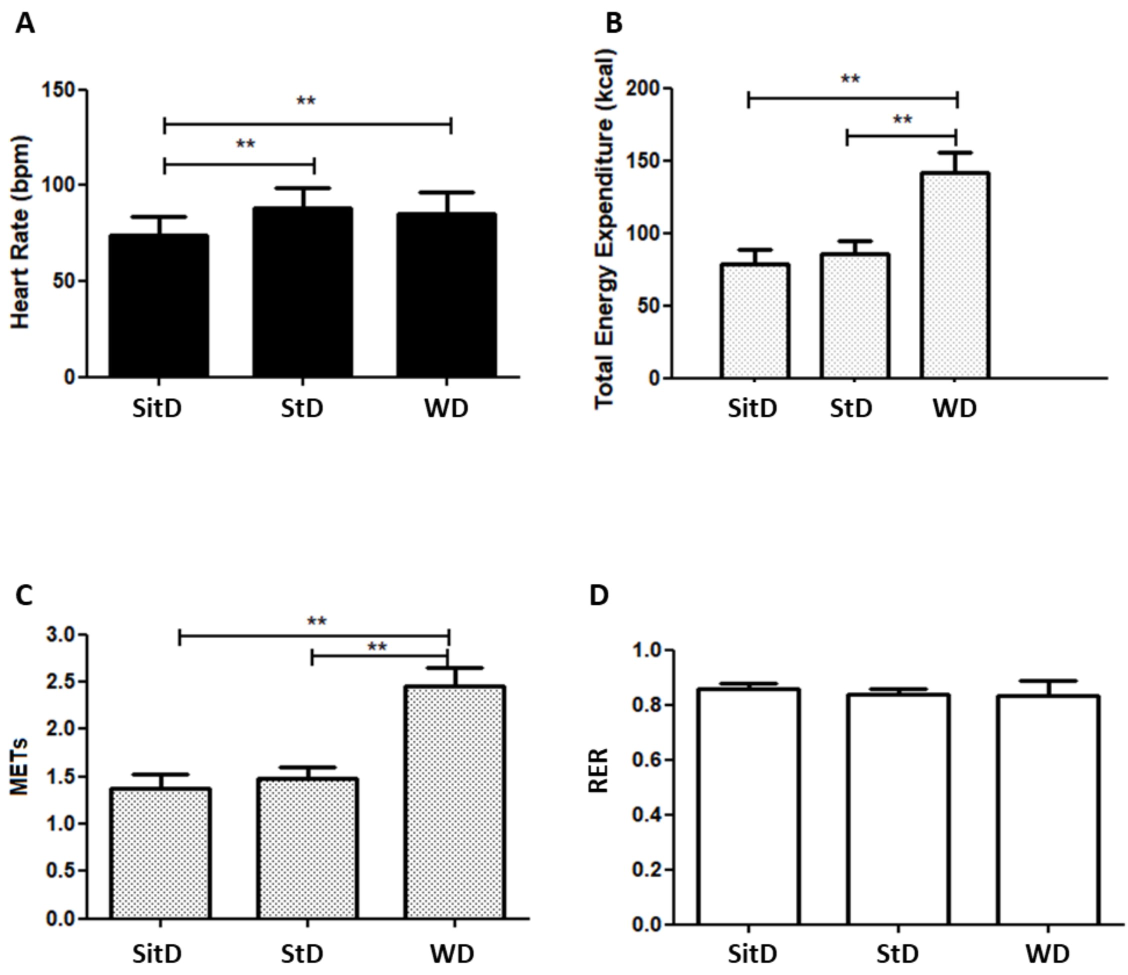
A
Heart Rate (bpm)
150
100
50
0
**
**
SitD
StD
WD
B
Total Energy Expenditure (kcal)
200
150
100
50
0
**
**
SitD
StD
WD
C
METs
3.0
2.5
2.0
1.5
1.0
0.5
0.0
**
**
SitD
StD
WD
D
RER
1.0
0.8
0.6
0.4
0.2
0.0
SitD
StD
WD

Fig.2

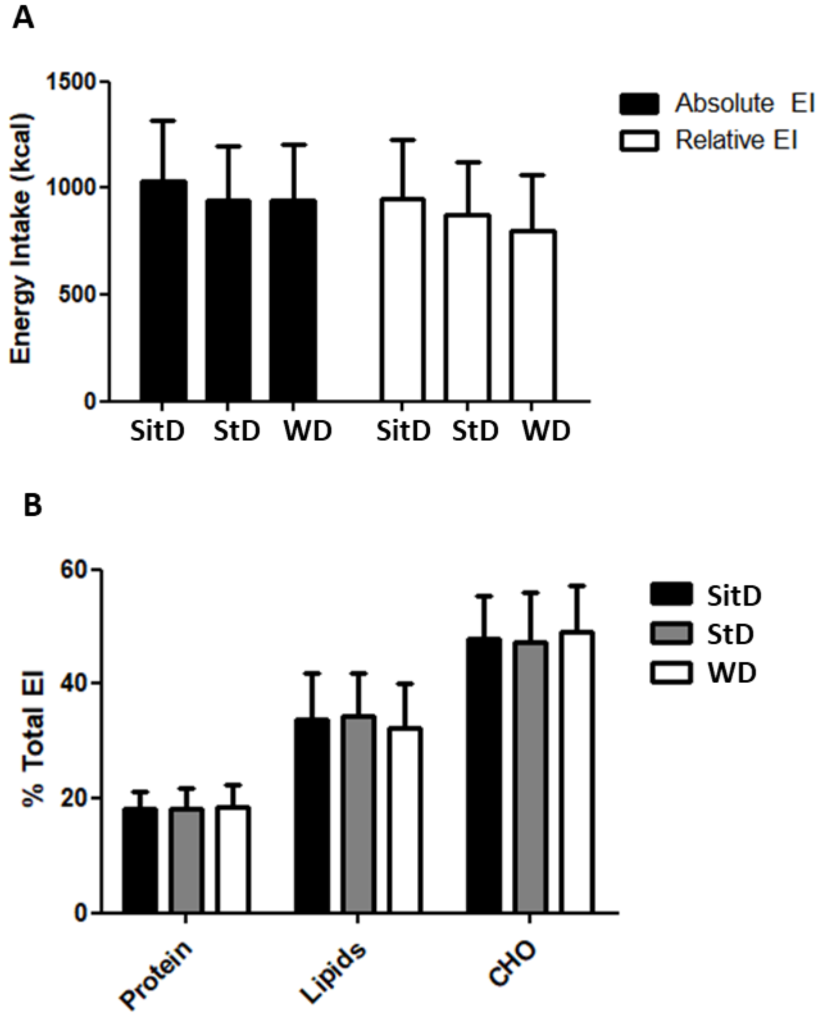
A
1500
1000
500
0
Energy Intake (kcal)
SitD
StD
WD
SitD
StD
WD
Absolute EI
Relative EI
B
60
40
20
0
% Total EI
Protein
Lipids
CHO
SitD
StD
WD

Fig.3

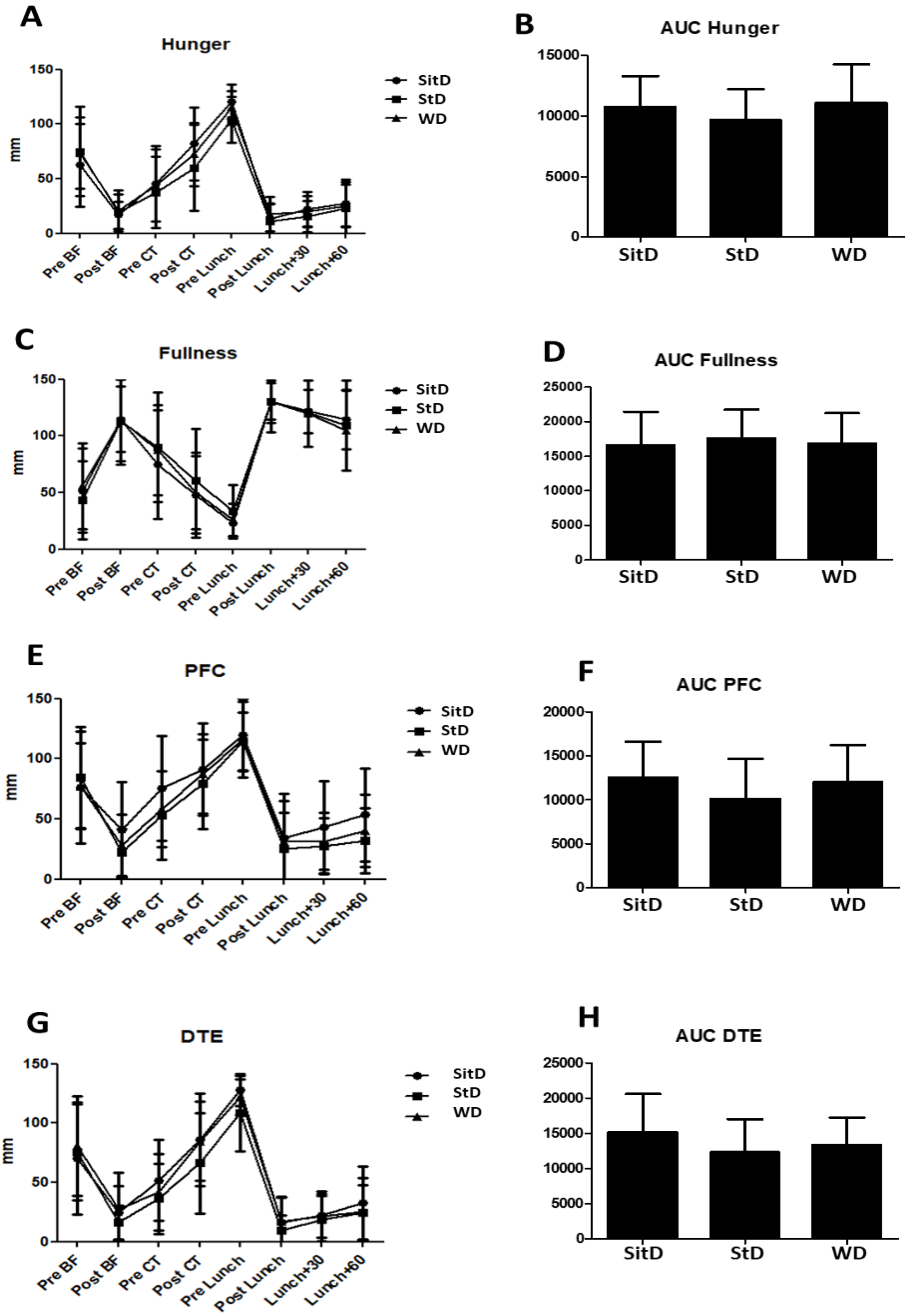
A
Hunger
150
100
50
0
mm
Pre BF
Post BF
Pre CT
Post CT
Pre Lunch
Post Lunch
Lunch+30
Lunch+60
SitD
StD
WD
B
AUC Hunger
15000
10000
5000
0
SitD
StD
WD
C
Fullness
D
AUC Fullness
25000
20000
15000
10000
5000
0
E
PFC
F
AUC PFC
20000
15000
10000
5000
0
G
DTE
H
AUC DTE
25000
20000
15000
10000
5000
0

Table 1: Descriptive characteristics of research participants

	N=15
Anthropometrics and body composition	
Age (years)	23.4 ± 2.9
Body weight (kg)	76.8 ± 5.2
Height (cm)	178.4± 5.4
BMI (kg/m2)	24.2 ± 1.5
Fat mass (%)	17.3 ± 3.6
Fat-free mass (kg)	60.3 ± 4.2
Eating Beahviour Profile	
Three factor eating questionnaire (TFEQ)	
Cognitive dietary restraint	1.62 ± 0.5
Disinhibition	2.27 ± 0.6
Susceptibility to hunger	1.64 ± 0.5
Anxiety Profile	
State Trait Anxiety Inventory (STAI)	
Anxiety – Trait	33.3 ± 5.9
Physical Activity Level	
Sedentary behavior (min/day)	567.3 ± 75.3
Sedentary behavior (% of day)	68 ± 10.2
Light PA (min/day)	210.5 ± 75.1
Light PA (% of day)	24.8 ± 7.7
Moderate to Vigorous PA (min/day)	52.6 ± 24.1
Moderate to Vigorous PA (% of day)	6.4 ± 2.6
Vigorous PA (min/day)	8.2 ± 10.4
Vigorous PA (% of day)	0.9 ± 1.1

Table 2: Implicit wanting and explicit liking for high vs low fat foods and sweet vs savory foods before and after lunch after 45min of mental work done in a Sitting (SitD), Standing (StD) position or while walking on a walking Desk (WD).

			SitD	**StD**	**WD**	**Time**	**Condition**	**Interaction time*condition**
Implicit Wanting	Fat Bias	Before	15.07 ± 25.6	13 ± 34.1	11.4 ± 31.5	0.25	0.67	0.78
		After	9.2 ± 20.7	8.7 ± 15.2	6.1 ± 18.1			
	Taste Bias	Before	-32.5 ± 34.3	-20.6 ± 42	-24 ± 31.2	**0.001**	0.56	0.65
		After	55.4 ± 29.9	54.1 ± 27.2	45.9 ± 35.4			
Explicit Liking	Fat Bias	Before	3.3 ± 14.4	5 ± 18.2	5.2 ± 16	0.29	0.54	0.63
		After	5 ± 6.9	4.6 ± 8.9	3.2 ± 10.1			
	Taste Bias	Before	-8.8 ± 15.9	-7.5 ± 23.5	-5 ± 17.2	**0.001**	0.47	0.43
		After	22 ± 20.8	21.7 ± 15.2	25 ± 19.2			

Table 3: Score at the NASA Task-Load during 45min of mental work done in a Sitting (SitD), Standing (StD) position or while walking on a walking desk (WD)

		SitD	StD	WD	Condition
NASA Task- Load index	Total score	58 ± 11.5	60.4 ± 8.2	55.1 ± 10.9	0.37
	Mental demand	64.6 ± 18.5	64.3 ± 15.2	59.3 ± 20.7	0.67
	Physical demand	17.3 ± 12.4	44.6 ± 14.5*	34.3 ± 12.5	**0.001**
	Temporal demand	58 ± 16.34	50 ± 24.3	47.3 ± 12.8	0.40
	Overall performance	50.6 ± 20.4	49.6 ± 15.5	52 ± 17.8	0.93
	Effort	47.3 ± 21	59.6± 13.2	52.6 ± 17.8	0.19
	Frustration	48.3 ± 21.2	49 ±17.2	44.6 ±16.8	0.79

*Significantly different from SitD condition