



HAL
open science

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

Lore Metz, Terry Guirado, Kristine Beaulieu, Bruno Pereira, Carole Brun, Fabien Coutarel, Martine Duclos, David Thivel

► To cite this version:

Lore Metz, Terry Guirado, Kristine Beaulieu, Bruno Pereira, Carole Brun, et al.. Cognitive work on a walking desk does not lead to compensatory appetitive responses in healthy young adults. *Physiology & behavior*, 2023, 258, pp.114008. 10.1016/j.physbeh.2022.114008 . hal-03855352

HAL Id: hal-03855352

<https://hal.science/hal-03855352>

Submitted on 15 Apr 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives 4.0 International License

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

Lore METZ^{1,2}, Terry GUIRADO^{1,2,3}, Kristine BEAULIEU⁴, Bruno PEREIRA⁵, Carole BRUN^{1,2}, Fabien COUTAREL⁶, Martine DUCLOS^{3,7}, David THIVEL^{1,2}

3 ¹Laboratory of the Metabolic Adaptations to Exercise under Physiological and Pathological
4 Conditions, (AME2P), Clermont Auvergne University, 63170 Aubiere CEDEX, France,

²Auvergne Research Center for Human Nutrition (CRNH), 63000 Clermont-Ferrand, France,
³INRA, UMR 1019, Clermont-Ferrand, France.

⁴School of Psychology, University of Leeds, Leeds LS2 9JT, United Kingdom

5 ⁵Unit of Biostatistics (DRCI), Clermont-Ferrand University Hospital, Clermont-Ferrand,
6 France,

⁶Laboratory ACTé Clermont Auvergne University, 63407 Chamalières Cedex, France

⁷Department 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

7

8

9

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

11 **Highlights**

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

16

17 **Abstract**

18 **Context:** In addition to the low energy expenditure induced by sedentary behaviors such as
19 sitting, it has been shown that intense cognitive work can lead to an increase in food intake.
20 Walking Desk provide the opportunity for office workers to replace prolonged sitting at work
21 with light intensity physical activity. **Objective:** To compare the effects of sitting *vs* standing
22 *vs* walking during a cognitive task on energy intake, appetite sensations, food reward and
23 overall energy balance. **Methods:** Fifteen normal weight (BMI: $24.1 \pm 1.2 \text{ kg.m}^{-2}$) young men
24 (23.4 ± 2.1 years) randomly performed three conditions: sitting desk (SitD), standing desk (StD)
25 and walking desk (WD), while performing a 45-min cognitive task. Energy expenditure was
26 measured by indirect calorimetry, regular appetite sensations were assessed using visual
27 analogue scales, energy intake measured during an *ad libitum* meal and the relative energy
28 intake calculated. Pre and post-test meal food reward was evaluated through the Leeds Food
29 Preference Questionnaire. **Results:** Relative energy intake decreased by 150kcal in WD
30 compared with SitD, however it did not reach statistical significance. There were no differences
31 in appetite sensations nor food reward between the three conditions. Energy expenditure was
32 significantly higher in WD ($141.8 \pm 13 \text{ kcal}$) than in SitD ($78.7 \pm 5 \text{ kcal}$) and StD ($85.9 \pm 8 \text{ kcal}$)
33 ($p \leq 0.05$). **Conclusion:** Walking desk use can decrease sedentary time while working without
34 any appetitive compensation. The small reduction in energy balance with walking while
35 working could induce significant health benefits if repeated over time. Future longer studies
36 need to clarify whether active desks can contribute to the prevention or management of weight
37 gain.

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

39 **1. Introduction**

40 Sedentary behaviors have increased during the last decade and have worsened with the COVID-
41 19 pandemic [1]. The increase in administrative occupational activities has largely contributed
42 to this progression of time spent in a sitting position, which can represent as much as 77% of
43 the whole workday [2]. Sedentary time, especially sitting time, has been recognized as an
44 independent factor for mortality [3-6] and it is clear today that being physically active (i.e.
45 reaching physical activity recommendations) does not protect against the harmful effects of a
46 sedentary lifestyle, unless reaching at least three times the recommended levels of physical
47 activity [3]. In addition to the negative effects of work-related sedentary activities in terms of
48 reduced energy expenditure, performing intense cognitive tasks during sedentary occupational
49 activities can also lead to an increase in energy intake (EI) [7, 8]. Thus, the low energy
50 expenditure associated with sitting and tertiary work, and their relative propensity to increase
51 EI, call for a new consideration of workspaces and workstations, to promote employee health.
52 Interestingly, the implementation of physical exercise before lunchtime has shown to be
53 efficient to decrease EI after a standardized cognitive task [9, 10]. However, the constraints
54 associated with exercising at work (space and equipment available, changing rooms and
55 showers available) may make it difficult to adopt this type of strategy on a daily basis [11].
56 Active workstations such as sit-to-stand and treadmill desks provide the opportunity for office
57 workers to replace prolonged sitting at work with light intensity physical activity [12, 13].
58 Between the three main active desk strategies (standing desk, cycle desk and treadmill desk)
59 that have been investigated over the last decade, treadmill desks are the more energy demanding
60 while standing desks generate an energy load that remains slightly under the sedentary level of
61 1.5 METs [14]. While the energetic impacts of such active desks during working (mental) tasks
62 have been quite largely studied, their potential implications for appetite control remain poorly
63 examined so far. In their work, Josaphat and colleagues [15] have shown that using a standing
64 desk for 75min did not modify subsequent EI compared to the same work task performed in a

65 sitting position. Our group recently showed that the use of a cycle desk during a 30-min
66 cognitive task increased absolute EI at the following meal without altering total energy balance
67 (EB) compared to the same mental work performed in a sitting position [9]. In light of these
68 two recent studies, while using active desks is recommended to break sedentary time, it remains
69 unclear whether the induced increase in energy expenditure can significantly help reduce
70 people's short term relative EI after mental work. Although walking desks are the more energy
71 demanding strategy, no study has so far investigated their effects on subsequent appetite and
72 EI.

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

78 **2. Methods**

79 **2.1 Population**

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

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

89 **2.2 Experimental design**

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

104 **2.3 Experimental conditions**

105 **2.3.1 Sessions**

106 Subjects were submitted to three experimental sessions in a randomized order. Participants
107 arrived at the laboratory at 7:30 am, and were submitted to a standardized breakfast which
108 represented 9.5 to 10 kcal per kg of body mass (55% CHO, 30% lipids and 15% protein) [17].

109 The participants were instructed to abstain from stimulants (coffee, tea) and from moderate-to-
110 vigorous physical activity for 24 h prior to each session.

111 A standard seated workstation was used in the control condition. In the standing and walking
112 (1.6 km.h) condition, the Desk (Activ'UP, Collonges sous Salève, France) was systematically
113 adjusted before the task to the participant's height so that their arms were bent at a 90° angle.

114 During the three experimental sessions, subjects were in a stable environmental temperature

115 (22 ± 0.5°C). The cognitive task was a transcription of a text for 45 minutes. The participants
116 were asked to transcribe as much of the text as possible, while making as few mistakes as
117 possible. Participants could not rely on spellcheck. Energy expenditure and heart rate were
118 monitored continuously during every cognitive task.

119 **2.3.2 Measurements**

120 *2.3.2.1 Anthropometric and body composition*

121 Height and body mass were determined using a standard wall-mounted stadiometer and a digital
122 scale (SECA, Les Mureaux, France), respectively. Body mass index (BMI) was calculated as
123 body mass (kg) divided by height squared (m²). Body composition was assessed on the same
124 occasion using impedance analysis (Tanita MC 780). This model has been validated in young
125 adults of various physical activity levels [18].

126 *2.3.2.2 Metabolic and cardiorespiratory parameters*

127 After calibration, oxygen consumption (VO₂), carbon dioxide production (VCO₂), ventilation
128 (VE) and heart rate (HR) were continuously recorded throughout each of the 45-min sessions
129 using indirect calorimetry (MetaMax 3b, Cortex Biophysik, Leipzig, Germany) and HR
130 monitor (Polar, V800, Kempele, Finland). Respiratory exchange ratio (RER; VCO₂/VO₂) and
131 total energy expenditure (EE in kcal) over the 45 min and, of each session, was calculated as
132 follows: VO₂ (L.min⁻¹) x energy equivalent of oxygen x duration (min)[19].

133 *Ad libitum meals and energy intake*

134 Participants were provided with an *ad libitum* buffet meal for lunch (12:00pm). Food items
135 were provided in excess of expected consumption and participants were instructed to eat until
136 “comfortably satiated”. The food selection was covertly weighed by the investigators before
137 and after the meal and participants were unaware of the quantity of calories served. Energy and
138 macronutrient intakes were calculated using a dietary analysis software (Nutrilog software,

139 France). Relative energy intake (REI) for the *ad libitum* lunch meal was calculated as the EI
140 minus the EE of each session.

141 2.3.2.3 *Subjective appetite sensations*

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

146 2.3.2.4 *Food preference and reward*

147 The Leeds Food Preference Questionnaire (LFPQ; described in detail by Dalton and Finlayson)
148 [21] was administered before and after lunch to determine scores of implicit wanting and
149 explicit liking for high-fat (>50% energy) or low-fat (<20% energy) foods matched for
150 familiarity, sweetness, protein and acceptability [22]. Low-fat scores were subtracted from
151 high-fat scores to obtain the fat appeal bias score and savoury scores were subtracted from sweet
152 scores to obtain the taste appeal bias score; thus positive scores indicate greater liking or
153 wanting towards high-fat compared to low-fat foods and towards sweet compared to savoury
154 foods, respectively..

155 2.3.2.5 *State-Trait Anxiety Inventory (STAI)*

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

162 2.3.2.6 *NASA Task Load Index (NASA-TLX)*

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

173 *2.3.2.7 Daily time spent physically active and sedentary*

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

186 **2.4 Statistics**

187 The sample size estimation was calculated according to (i) differences reported in the
188 literature [7] and (ii) effect-size bounds recommended by Cohen (Cohen, 1988) : small (ES:
189 0.2), medium (ES: 0.5) and large (ES: 0.8, “grossly perceptible and therefore large”). Power
190 calculation based on previous work [7] suggested that a sample size of 15 participants would
191 allow detection of at least 40% difference in EI between cognitive task conditions, a probability
192 of 0.05, and a beta level of 0.80. Statistical analyses were performed using Stata software,
193 Version 15 (StataCorp, College Station, TX, US). Continuous data were expressed as mean and
194 standard-deviation and the assumption of normality was assessed using the Shapiro-Wilk test.
195 The comparisons between sessions (SitD, SD, WD) were performed using random-effects
196 models for crossover designs, taking account of the following effects: session, sequence,
197 *session x sequence* interaction and subject as random effect. The normality of residuals from
198 these models was studied as aforementioned. In case of non-normal distribution, a logarithmic
199 transformation was implemented. A Sidak’s type I error correction was applied to perform
200 multiple comparisons. Random-effects models were also used to measure time effect during
201 each exercise session, (1) time, session and *time x session* interaction as fixed effects, and (2)
202 subject as random-effect in order to model between and within participant variability.
203 Analogous statistical analysis plan was performed to study assumptions of random-effects
204 models and multiple comparisons. Appetite sensations were also compared with area under the
205 curve (AUC) values using the trapezoid method.

206 **3 Results**

207 *3.1 Study population*

208 Table 1 displays the descriptive characteristics of subjects enrolled in the present study.
209 Subjects were young normal-weight men with no cognitive dietary restriction and low levels of
210 disinhibition and susceptibility to hunger. Results for the STAI questionnaire showed low
211 global anxiety-trait scores, underlying the absence of anxiety in their everyday life.
212 Accelerometry data showed that our subjects were active, meaning that they reached the

213 recommendation for daily physical activity [30]. However, they still spent more than half of
214 their waking hours engaged in sedentary behaviors.

215 *3.2 Metabolic and cardiorespiratory parameters*

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

219 Energy expenditure during the whole session was significantly higher for WD compared to SitD
220 and StD (141.8 ± 13.8 kcal vs 78.7 ± 9.8 kcal vs 85.9 ± 8.2 kcal; $p=0.01$) with no difference between
221 those last two (Fig1B). Similarly, the Metabolic Equivalents (METs) was higher for WD
222 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
223 difference in substrate oxidation between the three sessions as reflected by the respiratory
224 exchange ratio (SitD 0.85 ± 0.02 vs StD 0.83 ± 0.02 vs WD 0.83 ± 0.05 ; $p>0.05$) (Fig.1D).

225 *3.3 Energy Intake*

226 As illustrated in figure 2A, there was no significant difference between the three conditions for
227 absolute EI (SitD 1031 ± 287 , StD 939 ± 257 , WD 939 ± 267 kcal; $p>0.05$) nor for relative energy
228 intake (SitD 952 ± 284 , StD 877 ± 246 , WD 798 ± 263 kcal; $p>0.05$). There was no significant
229 difference in the absolute (kcal) or relative contribution (%) to total EI for carbohydrates (SitD
230 48 ± 7 vs StD 47 ± 8 vs WD $49\pm 8\%$; $p>0.05$), lipids (SitD 33 ± 7 vs StD 34 ± 7 vs WD $32\pm 7\%$;
231 $p>0.05$) and proteins (Sit D 18.1 ± 3 vs StD 18.3 ± 3.4 vs WD $18.6\pm 3.7\%$; $p>0.05$) between the
232 three conditions (figure 2B).

233 *3.4 Appetite sensations and food reward*

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

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

239 *3.5 Anxiety and workload parameters*

240 Total score for the NASA Task Load Questionnaire was moderate to high (50 to 60) with no
241 difference between the three conditions (Table 3). The physical demand dimension was the only
242 sub-category showing significant differences with a higher score during StD compared to SitD
243 ($p=0.001$). EI during the three conditions were negatively associated with Physical ($r=-0.318$,
244 $p=0.03$) and Temporal ($r=-0.371$, $p=0.01$) demand dimension assessed after each session. There
245 was a tendency for a positive association between EI and Frustration ($r=0.29$, $p=0.08$).

246 There was no time effect ($p\geq 0.05$) and no difference in anxiety-state before (SitD: 23.5 ± 4.6 vs
247 StD: 23 ± 3.1 vs WD: 24.3 ± 4.1 ; $p\geq 0.05$) and after (SitD: 23.4 ± 4.5 vs StD: 23.6 ± 3.7 vs WD:
248 22.6 ± 3.1 ; $p\geq 0.05$) the task between the three conditions. A significant negative correlation was
249 found between pre-task anxiety-state and EI ($r=-0.374$, $p=0.01$).

250

251 **4 Discussion**

252 The deleterious impact of tertiary work-related sedentary time requires the development of
253 strategies to reduce the time spent seated. On top of the low energy expenditure associated with
254 this sitting time, the stress caused by intensive mental work can induce fatigue and encourage
255 excessive energy intake at the next meal. Several strategies to limit this energy compensation
256 have been evaluated, such as the implementation of a short period of exercise before the meal
257 [9, 10, 31], active breaks [32] or the use of active workstations during cognitive tasks [9, 15].
258 In the present study we show for the first time that walking at 1.6km/h while performing mental
259 work for 45 min did not affect subsequent absolute EI compared to the same cognitive task
260 performed in a standing or a sitting position. When energy intake is adjusted to the energy

261 expenditure generated in the three conditions, the use of the treadmill favors the lowest energy
262 balance (-150kcal) however this result remains non-significant. Nevertheless, including 45
263 minutes of work on the treadmill daily could contribute to a significant deficit over a week or
264 several months of work and promote weight management. This projection is consistent with the
265 chronic effects demonstrated through the use of treadmill desks on body weight regulation in
266 people with overweight or obesity [33]. Very few studies have investigated the acute effects of
267 active desk use on energy intake. Recently, Josaphat et al [15] showed no difference in energy
268 intake after a 75-min cognitive task performed in a sitting or standing position. Although the
269 cognitive task used was longer in this previous study, our results are in line with it, as we did
270 not find any effect of standing while working compared to sitting on energy intake.
271 Furthermore, our research group has recently shown that the use of a cycle desk during a
272 cognitive task did not reduce subsequent energy intake [9]. Indeed, we have shown that when
273 compared to a seated position, the absolute energy intake was higher but when taking into
274 account the energy expenditure generated from the cycling, the relative energy intake was not
275 different. Thus, altogether, these results suggest that the acute use of active desks does not
276 generate an anorectic effect; however, they do not induce a positive energy balance. In view of
277 the low intensity induced by standing or walking on an active workstation, the absence of
278 anorectic effect may seem to be in agreement with previous studies [9, 10, 34]. Indeed, as
279 mentioned previously, it is now well accepted that intensive exercise (i.e. above 70%VO₂max)
280 is more likely to create an anorectic effect than low-to-moderate intensity exercise [34-36].
281 Contrary to the results from Josaphat et al. [15], we did not find any difference in hunger or
282 prospective food consumption between the different experimental conditions. Nevertheless,
283 although not significant, the standing condition showed the lowest values. This is in line with
284 the significant decrease found for these two appetite sensations in the standing condition in the
285 work from Josaphat et al [15].

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

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

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

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

323

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

332

333 **Author contributions**

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

337

338 **Conflict of interest**

339 We have no conflict of interest disclose.

340 **Funding sources**

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

343

344 **References**

345

- 346 1. Flanagan, E.W., et al., *The Impact of COVID-19 Stay-At-Home Orders on Health Behaviors in*
347 *Adults*. Obesity (Silver Spring), 2021. **29**(2): p. 438-445.
- 348 2. Wick, K., et al., *Deviation between self-reported and measured occupational physical activity*
349 *levels in office employees: effects of age and body composition*. Int Arch Occup Environ
350 Health, 2016. **89**(4): p. 575-82.
- 351 3. Ekelund, U., et al., *Does physical activity attenuate, or even eliminate, the detrimental*
352 *association of sitting time with mortality? A harmonised meta-analysis of data from more*
353 *than 1 million men and women*. Lancet, 2016. **388**(10051): p. 1302-10.
- 354 4. Patterson, R., et al., *Sedentary behaviour and risk of all-cause, cardiovascular and cancer*
355 *mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis*.
356 Eur J Epidemiol, 2018. **33**(9): p. 811-829.
- 357 5. Biswas, A., et al., *Sedentary time and its association with risk for disease incidence, mortality,*
358 *and hospitalization in adults: a systematic review and meta-analysis*. Ann Intern Med, 2015.
359 **162**(2): p. 123-32.
- 360 6. Bellettiere, J., et al., *Associations of sitting accumulation patterns with cardio-metabolic risk*
361 *biomarkers in Australian adults*. PLoS One, 2017. **12**(6): p. e0180119.
- 362 7. Chaput, J.P. and A. Tremblay, *Acute effects of knowledge-based work on feeding behavior*
363 *and energy intake*. Physiol Behav, 2007. **90**(1): p. 66-72.
- 364 8. Chaput, J.P., et al., *Glycemic instability and spontaneous energy intake: association with*
365 *knowledge-based work*. Psychosom Med, 2008. **70**(7): p. 797-804.
- 366 9. Thivel, D., et al., *Effect of Acute Exercise and Cycling Desk on Energy Intake and Appetite*
367 *Response to Mental Work: The CORTEX Study*. J Phys Act Health, 2021. **18**(4): p. 433-439.
- 368 10. Neumeier, W.H., et al., *Exercise following Mental Work Prevented Overeating*. Med Sci Sports
369 Exerc, 2016. **48**(9): p. 1803-9.
- 370 11. Genin, P.M., et al., *Health and Fitness Benefits But Low Adherence Rate: Effect of a 10-Month*
371 *Onsite Physical Activity Program Among Tertiary Employees*. J Occup Environ Med, 2018.
372 **60**(9): p. e455-e462.

- 373 12. Duvivier, B.M., et al., *Minimal intensity physical activity (standing and walking) of longer*
374 *duration improves insulin action and plasma lipids more than shorter periods of moderate to*
375 *vigorous exercise (cycling) in sedentary subjects when energy expenditure is comparable.*
376 PLoS One, 2013. **8**(2): p. e55542.
- 377 13. Hervieux, V., A. Tremblay, and C. Biron, *Active meetings on stationary bicycle: An intervention*
378 *to promote health at work without impairing performance.* Appl Ergon, 2021. **90**: p. 103269.
- 379 14. Josaphat, K.J., et al., *Use of Active Workstations in Individuals with Overweight or Obesity: A*
380 *Systematic Review.* Obesity (Silver Spring), 2019. **27**(3): p. 362-379.
- 381 15. Josaphat, K.J., et al., *Acute Impact of the Use of a Standing Desk on Appetite Sensations and*
382 *Energy Intake.* J Phys Act Health, 2020. **17**(12): p. 1240-1246.
- 383 16. Stunkard, A.J. and S. Messick, *The three-factor eating questionnaire to measure dietary*
384 *restraint, disinhibition and hunger.* J Psychosom Res, 1985. **29**(1): p. 71-83.
- 385 17. Isacco, L., P. Duché, and N. Boisseau, *Influence of hormonal status on substrate utilization at*
386 *rest and during exercise in the female population.* Sports Med, 2012. **42**(4): p. 327-42.
- 387 18. Verney, J., et al., *Comparisons of a Multi-Frequency Bioelectrical Impedance Analysis to the*
388 *Dual-Energy X-Ray Absorptiometry Scan in Healthy Young Adults Depending on their Physical*
389 *Activity Level.* J Hum Kinet, 2015. **47**: p. 73-80.
- 390 19. Zuntz N, S.D., *Studien Zu Einer Physiologie Des Marches.* 1901, Berlin: Verlag von August
391 Hirchwald,.
- 392 20. Flint, A., et al., *Reproducibility, power and validity of visual analogue scales in assessment of*
393 *appetite sensations in single test meal studies.* Int J Obes Relat Metab Disord, 2000. **24**(1): p.
394 38-48.
- 395 21. Dalton, M. and G. Finlayson, *Psychobiological examination of liking and wanting for fat and*
396 *sweet taste in trait binge eating females.* Physiol Behav, 2014. **136**: p. 128-34.
- 397 22. Finlayson, G., N. King, and J. Blundell, *The role of implicit wanting in relation to explicit liking*
398 *and wanting for food: implications for appetite control.* Appetite, 2008. **50**(1): p. 120-7.
- 399 23. Spielberger, C., *State-Trait Anxiety Inventory for adults. Sample set, manual, scoring key.*
400 1985, Mind Garder: Redwood City, CA.
- 401 24. Hart, S. and L. Staveland, *Development of NASA-TLX (Task Load Index): Results of emprical*
402 *and theoretical research.* 1988, Elsevier Science Publishers B. V.; North-Holland. p. 139–183.
- 403 25. Aguilar-Farias, N., et al., *How many days are enough for measuring weekly activity behaviours*
404 *with the ActivPAL in adults?* J Sci Med Sport, 2019. **22**(6): p. 684-688.
- 405 26. Tudor-Locke, C., S.M. Camhi, and R.P. Troiano, *A catalog of rules, variables, and definitions*
406 *applied to accelerometer data in the National Health and Nutrition Examination Survey,*
407 *2003-2006.* Prev Chronic Dis, 2012. **9**: p. E113.
- 408 27. Choi, L., et al., *Assessment of wear/nonwear time classification algorithms for triaxial*
409 *accelerometer.* Med Sci Sports Exerc, 2012. **44**(10): p. 2009-16.
- 410 28. Kozey-Keadle, S., et al., *Validation of wearable monitors for assessing sedentary behavior.*
411 Med Sci Sports Exerc, 2011. **43**(8): p. 1561-7.
- 412 29. Lyden, K., et al., *Validity of two wearable monitors to estimate breaks from sedentary time.*
413 Med Sci Sports Exerc, 2012. **44**(11): p. 2243-52.
- 414 30. Bull, F.C., et al., *World Health Organization 2020 guidelines on physical activity and sedentary*
415 *behaviour.* Br J Sports Med, 2020. **54**(24): p. 1451-1462.
- 416 31. Lemay, V., et al., *Exercise and negative energy balance in males who perform mental work.*
417 Pediatr Obes, 2014. **9**(4): p. 300-9.
- 418 32. De Jong, N.P., et al., *Breaking up Sedentary Time in Overweight/Obese Adults on Work Days*
419 *and Non-Work Days: Results from a Feasibility Study.* Int J Environ Res Public Health, 2018.
420 **15**(11).
- 421 33. Koepp, G.A., et al., *Treadmill desks: A 1-year prospective trial.* Obesity (Silver Spring), 2013.
422 **21**(4): p. 705-11.
- 423 34. Imbeault, P., et al., *Acute effects of exercise on energy intake and feeding behaviour.* Br J
424 Nutr, 1997. **77**(4): p. 511-21.

- 425 35. Ueda, S.Y., et al., *Comparable effects of moderate intensity exercise on changes in anorectic*
426 *gut hormone levels and energy intake to high intensity exercise.* J Endocrinol, 2009. **203**(3): p.
427 357-64.
- 428 36. King, N.A., V.J. Burley, and J.E. Blundell, *Exercise-induced suppression of appetite: effects on*
429 *food intake and implications for energy balance.* Eur J Clin Nutr, 1994. **48**(10): p. 715-24.
- 430 37. Weinstein, S.E., D.J. Shide, and B.J. Rolls, *Changes in food intake in response to stress in men*
431 *and women: psychological factors.* Appetite, 1997. **28**(1): p. 7-18.
- 432 38. Wallis, D.J. and M.M. Hetherington, *Stress and eating: the effects of ego-threat and cognitive*
433 *demand on food intake in restrained and emotional eaters.* Appetite, 2004. **43**(1): p. 39-46.
- 434 39. Pérusse-Lachance, E., et al., *Sex differences in the effects of mental work and moderate-*
435 *intensity physical activity on energy intake in young adults.* ISRN Nutr, 2013. **2013**: p. 723250.
- 436 40. Beaulieu, K., et al., *Homeostatic and non-homeostatic appetite control along the spectrum of*
437 *physical activity levels: An updated perspective.* Physiol Behav, 2018. **192**: p. 23-29.
- 438 41. Podrekar, N., Ž. Kozinc, and N. Šarabon, *Effects of cycle and treadmill desks on energy*
439 *expenditure and cardiometabolic parameters in sedentary workers: review and meta-*
440 *analysis.* Int J Occup Saf Ergon, 2021. **27**(3): p. 728-736.
- 441 42. Miles-Chan, J.L. and A.G. Dulloo, *Posture Allocation Revisited: Breaking the Sedentary*
442 *Threshold of Energy Expenditure for Obesity Management.* Front Physiol, 2017. **8**: p. 420.

443

444

445 **Figure legends**

446 Figure 1: Heart Rate (A), Total energy expenditure (B), Metabolic Equivalent Task (METs) (C)
447 and Respiratory Exchange Ratio (D) assessed during 45min of mental work done in a Sitting
448 (SitD), Standing (StD) position or while walking on a walking Desk (WD). * $p \leq 0.05$, **
449 $p \leq 0.001$.

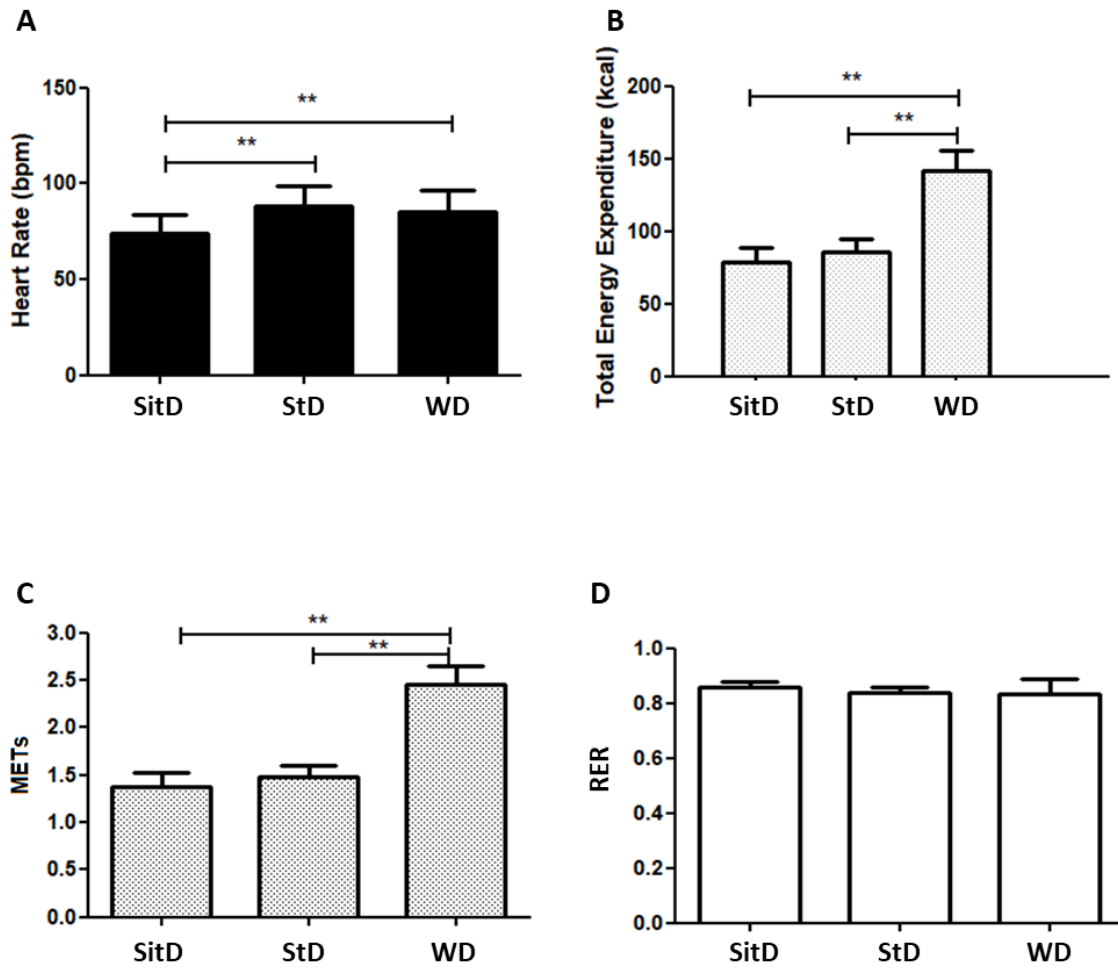
450 Figure 2: Absolute and Relative energy intake (A) and relative contribution of macronutrients
451 (B) assessed after an *ad libitum* buffet meal proposed after 45min of mental work done in a
452 Sitting (SitD), Standing (StD) position or while walking on a walking Desk (WD). CHO:
453 carbohydrates;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

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

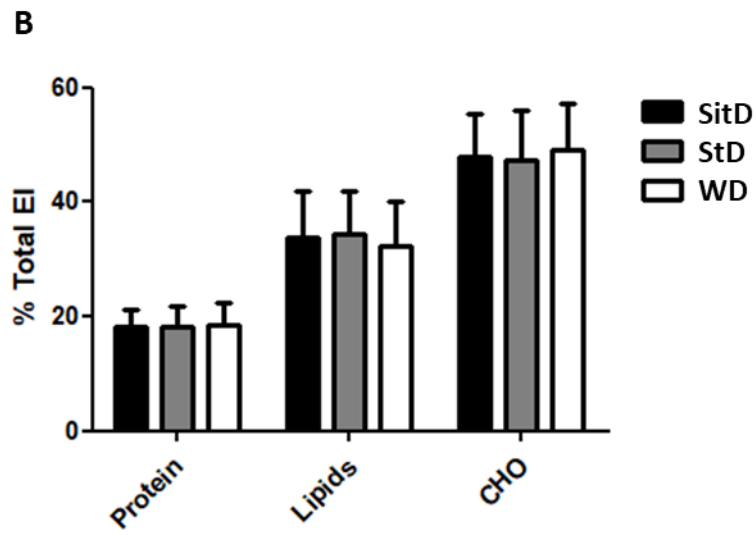
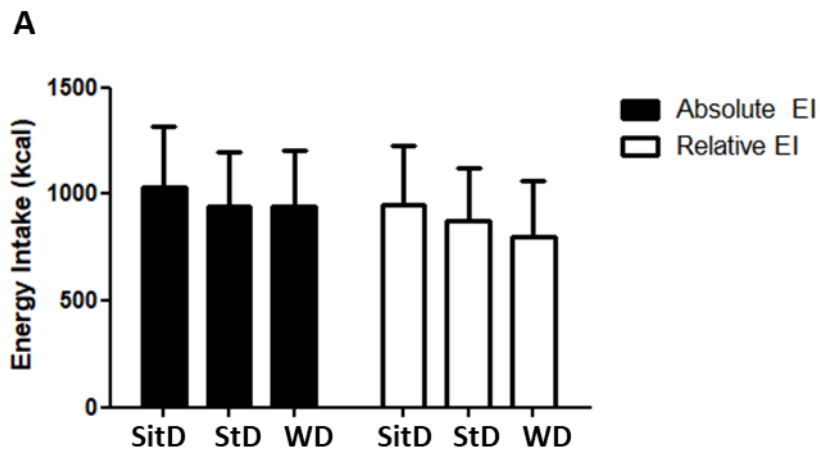
458

459 **Fig.1**

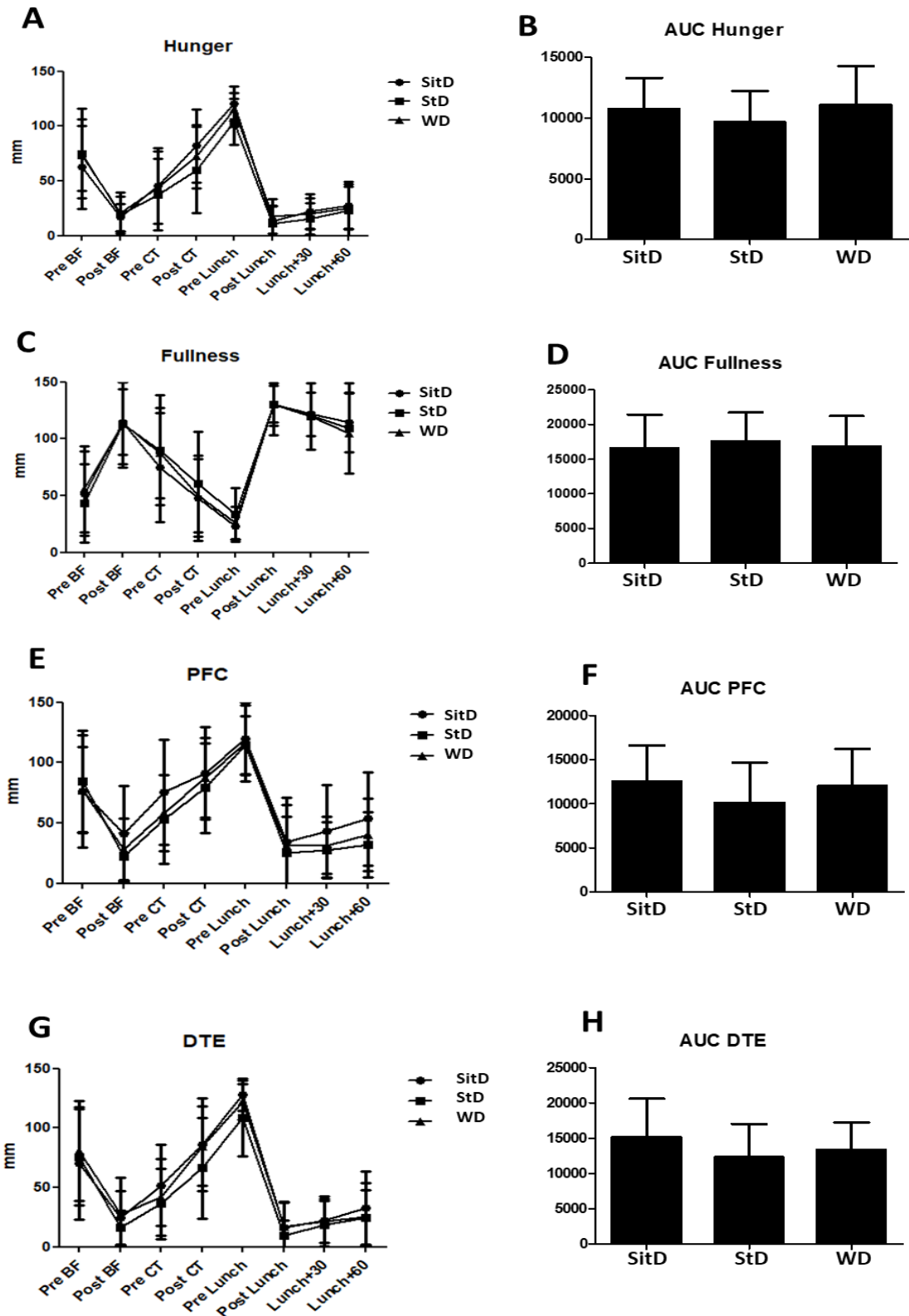
460



461



465 Fig.3



466

467

468 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/m ²)	24.2 ± 1.5
Fat mass (%)	17.3 ± 3.6
Fat-free mass (kg)	60.3 ± 4.2
Eating Behaviour Profile	
<i>Three factor eating questionnaire (TFEQ)</i>	
Cognitive dietary restraint	1.62 ± 0.5
Disinhibition	2.27 ± 0.6
Susceptibility to hunger	1.64 ± 0.5
Anxiety Profile	
<i>State Trait Anxiety Inventory (STAI)</i>	
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

469

470

471

472

473 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
 474 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			

475

476 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
 477 (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

478

479

*Significantly different from SitD condition

480