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**Metabolic profile in women differs between high versus low energy spenders during a low intensity exercise on a cycle-desk Running Title: Energy profile during cycle-desk use**

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1 Title

2 Metabolic profile in women differs between high versus low energy spenders during a low  
3 intensity exercise on a cycle-desk

4

5 Running Title: Energy profile during cycle-desk use

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32 ***Abstract***

33 Active-desks are emerging strategies aiming at reducing sedentary time while working. A  
34 large inter-individual variability in energy expenditure (EE) profile has been identified and  
35 has to be explored to better optimize and individualize those strategies. Thus the present study  
36 aimed at comparing the metabolic and physical profile of individuals characterized as high  
37 spenders (H-Spenders) *versus* low spenders (L-Spenders) based on EE during a cycle-desk  
38 low intensity exercise. 28 healthy women working in administrative positions were enrolled.  
39 Anthropometric, body composition and fasting metabolic profile parameters were assessed.  
40 EE was determined by indirect calorimetry, at rest and during a 30-min cycle-desk use.  
41 Participants were categorized as H-Spenders and L-Spenders using the median of the  
42 difference between EE at rest and during the 30-min exercise. H-Spenders had higher mean  
43 EE ( $p<0.001$ ) and carbohydrate oxidation ( $p=0.009$ ) during exercise. H-Spenders displayed  
44 higher values for fasting plasma insulin ( $p=0.002$ ) and HOMA-IR ( $p=0.002$ ) and lower values  
45 for HDL-cholesterol ( $p=0.014$ ) than L-Spenders. The percentage of body fat mass was  
46 significantly higher in H-Spenders ( $p=0.034$ ). Individuals expending more energy during a  
47 low intensity cycling exercise presented a less healthy metabolic profile compared with L-  
48 Spenders. Future studies will have to explore whether the chronic use of cycle-desks during  
49 work time can improve energy profile regarding metabolic parameters.

## 50 **Introduction**

51 Over the last century, the technological revolution (i.e. work automation, increase in  
52 transports use) led to tremendous changes in human behaviors favoring a global reduction in  
53 physical activities (PA) and an increase in sedentary behaviors (SB) <sup>1</sup>, particularly in high-  
54 income countries <sup>2,3</sup>. The independent and joint effects of those more recently adopted  
55 behaviors raise the risks of cardio-metabolic morbidity and all-cause mortality <sup>2,4</sup>. With the  
56 growth of desk-bound activities in the work environment, SB have taken an important part in  
57 individuals' daily time <sup>5</sup> resulting in a reduction in PA and total energy expenditure (EE) <sup>6</sup>.  
58 Active workstations (sit to stand, treadmill or cycle-desks) have been suggested as potential  
59 solutions to counterbalance the excessive amount of time spent seated at work <sup>7,8</sup>. Standing  
60 desks have been suggested to increase slightly but significantly EE at work ( $\approx 1.2 \text{ kcal}\cdot\text{min}^{-1}$ ) <sup>9</sup>  
61 compared with sitting position. However, this strategy may not benefit everyone to the same  
62 extent; inter-individual variability has been previously reported in energy during a sit-to-stand  
63 protocol <sup>10,11</sup>. Some individuals displayed a significant increase in EE during a steady-state  
64 standing position compared to a sitting position, while only a small increase in EE was  
65 detected in others in response to this postural change. These previous results from Miles-Chan  
66 and al. <sup>10,11</sup> raised questions regarding standing as an effective strategy to increase EE in the  
67 overall population. The variability in EE adaptation has been associated with some health  
68 parameters such as body fat mass that is positively correlated with the energy cost of standing  
69 posture in healthy inactive individuals <sup>12</sup>. Several studies have questioned the energetic cost of  
70 other different dynamic workstations such as walking on a treadmill or cycling desk <sup>9,13</sup>.  
71 While these studies obviously reported a substantial increase in EE ( $\approx 2\text{-}4 \text{ kcal}\cdot\text{min}^{-1}$ )  
72 compared to seating position <sup>9,14,15</sup>, cycling desks have been suggested to be the best active  
73 workstation in terms of work and psychobiological performances <sup>13</sup>. Nevertheless, none of the  
74 studies investigating EE during cycle-desk utilization have identified the parameters that

75 could explain these different energy profiles. Several authors have noticed that training status  
76 can influence cycling gross efficiency <sup>16,17</sup>, with higher trained subjects being more efficient  
77 (i.e. more thrifty). However, the exercise intensities used in these studies are moderate to high  
78 and might not be representative of EE adaptations during low intensity exercise on a cycle-  
79 desk. Hence, it remains unknown whether the energetic profile of individuals during low  
80 intensity activities such as cycle-desk can be explained by specific anthropometric, body  
81 composition, cardiometabolic parameters or physical fitness. Indeed, understanding the  
82 characteristics of individuals' energetic profiles will enable a better optimization and  
83 individualization of active-desks strategies. In this context, the present study is the first to aim  
84 at comparing body composition, the cardiometabolic and physical fitness profile of  
85 individuals characterized as spenders *versus* non-spenders during a low intensity cycle-desk  
86 exercise, based on EE measurement. We hypothesized that participants with a more efficient  
87 energy profile will present healthier body composition, metabolic health and physical fitness.

## 88 **Methods**

### 89 *Participants*

90 Twenty-eight healthy women, administrative employees, with a body mass index  
91 (BMI) ranging from 18.5 to 29.9 kg/m<sup>2</sup> and aged between 18 to 60 years, participated in the  
92 present study. To be included in the study participants had to: i) be engaged in less than 150  
93 minutes of moderate-to-vigorous physical activity per week based on self-reported data; ii)  
94 declare having regular menstrual cycles; iii) not be pregnant or lactating; iv) be free of any  
95 cardiovascular or metabolic disorders; v) not be dieting; vi) be free of any medication  
96 (excepted oral contraceptive); and vii) have a stable body weight (<3 kg change during the 6  
97 months prior to screening). This study was approved by the French ethical committee (Comité  
98 de Protection Personne Ile De France VIII 19 09 66) and all methods were performed in

99 accordance with the relevant guidelines and regulations. Written informed consent was  
100 obtained for all participants in the present study.

### 101 *Experimental design*

102 After a full medical examination to assess eligibility, all subjects were asked to join the  
103 laboratory (laboratory AME2P, Aubière, France) for an experimental visit between January  
104 6<sup>th</sup> and January 24<sup>th</sup>, 2020. Subjects were asked to keep their habitual daily activities, avoid  
105 any stressful situations and not consume caffeine for the 24h prior to the test day. All  
106 participants completed this experimental session (Figure 1) during the follicular phase of their  
107 menstrual cycle. Subjects reported to the laboratory at ~08.00 am, after a 12-hour overnight  
108 fast. Evaluation started with body composition assessment and EE at rest was then  
109 investigated. Blood sample was obtained before a light intensity cycling exercise during  
110 which EE was measured. Participants' physical fitness was evaluated on the same day after a  
111 standardized breakfast meal. Finally, before leaving the laboratory, participants received an  
112 accelerometer to be worn for the following 7 days in order to assess their daily physically  
113 active and sedentary time.

### 114 *Anthropometric measurement and body composition*

115 Height was measured with a stadiometer at the nearest 0.1 cm, waist circumference (WC)  
116 was measured with a tape measure at the nearest 0.5 cm and WC to height ratio (WHtR) was  
117 calculated. Body weight was assessed using a calibrated scale (SECA, Les Mureaux, France)  
118 and fat mass percentage (%FM) and fat-free mass (FFM-kg) were evaluated by bioelectrical  
119 impedance (Tanita MC-780, USA, Arlington Heights), following the manufacturer's  
120 instructions.

### 121 *Energy expenditure and substrate oxidation*

122 After calibration of the device, indirect calorimetry with a facemask (MetaMax 3b, Cortex  
123 Biophysik, Leipzig, Germany) was used to measure  $VO_2$  and  $VCO_2$  for EE and substrate  
124 oxidation assessment. A heart rate monitor (Polar A300, Polar, Kempele, Finland) was used  
125 for the length of the experiment. Prior to resting condition subjects were sitting quietly for 15  
126 minutes. For resting condition, subjects were lying comfortably in a deckchair in a  
127 thermoneutral environment for at least 20 minutes. After this period, subjects were asked to  
128 stay calm, not speak and avoid any movement. Gas exchanges were recorded for 15 minutes  
129 minimum and only the last 5 minutes were analyzed as previously suggested <sup>18</sup> and were  
130 defined as “Rest” time measure.

131 During the exercise condition, subjects were submitted to a 30-min light exercise using a  
132 cycle-desk (DeskCycle, 3D Innovations LLC., Greeley, CO, USA) with a resistance set at 2  
133 out of 8 per design of the ergometer and a revolution per minute (RPM) at 50 during the  
134 whole test, representing a power of ~16 Watts. An investigator supervised that participants  
135 respected the speed during the cycling test and reported at the end of the exercise the distance  
136 covered to ensure the test condition was similar between subjects. After the 30-min exercise  
137 testing, subjects had 1-min of recovery. Gas exchanges were measured during the entire  
138 exercise test and recovery period. EE, using Weir’s equation <sup>19</sup>, respiratory quotient (RQ;  
139  $VCO_2/VO_2$ ) and substrate utilization, using Péronnet & Massicotte equations <sup>20</sup> were  
140 calculated for the whole 30-min exercise session and also at rest, and after 5 (Start), 10, 20, 30  
141 minutes of exercise. Mean values of the last 2 minutes of each period were considered for  
142 analysis as done in previous studies <sup>21</sup>. The first minute of recovery was also considered for  
143 analysis.

#### 144 *Cardiometabolic outcomes*

145 Systolic and diastolic blood pressures were measured in a seated position using an  
146 auditory stethoscope with a blood pressure cuff adapted to the arm circumference. Subjects

147 remained comfortably installed on a deckchair to collect a fasting blood sample. Plasma  
148 glucose, triglycerides, light-density lipoprotein cholesterol (LDL-cholesterol), high-density  
149 lipoprotein cholesterol (HDL-cholesterol) and total cholesterol were measured by enzymatic  
150 commercial assays. Insulin was assessed by chemiluminescent enzyme immunoassays. The  
151 enzymatic kits can be found in Supplemental file 1. All blood samples were centrifuged and  
152 plasma was kept frozen in aliquots at -80°C prior to analyses. The homeostasis model  
153 assessment of insulin resistance (HOMA-IR) was calculated by the following formula: fasting  
154 blood insulin (mU/L) x fasting blood glucose (mmol/L) / 22.5<sup>22</sup>.

### 155 *Physical fitness*

156 *Aerobic fitness:* Participants performed a 6 min step test as described before<sup>23</sup>.  
157 Participants wore a heart rate monitor (Polar A300, Polar, Kempele, Finland) to continuously  
158 record heart rate from the start to the end of the test, 30 seconds and 1 minute in recovery.

159 *Upper and lower limb strength:* Participants performed a handgrip test as described in  
160 previous studies<sup>24</sup>. Then, participants were seated with a hip joint at 105° of flexion and were  
161 attached on the trunk, the hip and the left leg to the dynamometer chair (Biodex System 2,  
162 Biodex, Shirley, USA) with Velcro straps. Torque was measured on isometric 3s-Maximum  
163 Voluntary Contraction (MVC) and on concentric MVC at a velocity of 60°/sec and 120°/sec.

### 164 *Daily physical activity and sedentary time*

165 From the day after the experiment, every subject was asked to wear triaxial  
166 accelerometers (ActiGraph wGT3X-BT, ActiGraph, Inc., Pensacola, FL) during 7 days with  
167 at least one weekend day. Participants wore the device on the right hip<sup>25</sup> on an elastic belt.  
168 Data were collected at a frequency of 60 Hz and converted to counts per 1s epoch using the  
169 manufacturer's software (ActiLife version 6.13.4). Non wear time was defined as 90 minutes  
170 of 0 count per minute (cpm) with an allowance of 2 minutes of activity when it is placed



171 between two 30-min windows of 0 cpm<sup>26</sup>. To be accepted in the analysis, accelerometer data  
172 had to be at least 4 days (including 1 weekend day) of wear with a monitor wear time of  $\geq 10$   
173 hours/day (600 min/day)<sup>27</sup>. SB was calculated with the vertical axis and PA with vector  
174 magnitude. SB was defined as  $<150 \text{ counts min}^{-1}$ <sup>28</sup>, light intensity PA (LIPA) was obtained  
175 by subtracting SB and data below  $2,689 \text{ counts min}^{-1}$ , MVPA was defined as 2,690-6166  
176  $\text{counts min}^{-1}$ , vigorous PA (VPA) was defined as  $<6467 \text{ counts min}^{-1}$ <sup>29</sup>.

### 177 *Statistical analyzes*

178 The sample size was estimated in order to compare the metabolic and physical profile  
179 of individuals characterized as high spenders (H-Spenders) versus low spenders (L-Spenders)  
180 based on EE during a cycle-desk low intensity exercise. To highlight significant differences  
181 greater than 1 point effect-size, 14 participants by group (H-Spenders vs. L-Spenders) were  
182 needed for 80% satisfactory statistical power and a two-sided type I error at 5%.

183 Statistical analysis was performed using Stata software (version 15, StataCorp,  
184 College Station, Texas, USA). Data were presented as mean and standard deviation. The  
185 Shapiro-Wilk test was used to test the assumption of distribution normality for quantitative  
186 parameters. Energy profile was determined by categorizing difference between EE at rest and  
187 27 minutes of exercise (3-27min) (Delta Exo-Rest) according to statistical distribution, i.e. to  
188 median of the sample<sup>30,31</sup>. This categorization enabled to have two different groups: High  
189 Spenders (H-Spenders) and Low Spenders (L-Spenders). The comparisons between groups  
190 (above versus below the median value), were performed by repeated-measures ANOVA and  
191 post-hoc Bonferroni test was used for multiple comparisons with significance levels set at  
192  $p < 0.05$ . The statistical tests were two-sided, with type I error at 0.05. Then, a sensitivity  
193 analysis was conducted to guaranty that these analyzes realized according to median value  
194 were robust and that conclusions can be supported by the results. Delta Exo-Rest was  
195 categorized according to values ranged between interquartile ranges. The comparisons were

196 performed as aforementioned. More precisely, for each value of Delta Exo-Rest between first  
197 and third quartile, continuous variables were compared among  $<$  or  $\geq$  of each value of Delta  
198 Exo-Rest. The results were expressed as Hedges' effect size (ES) and 95% confidence  
199 intervals, and were interpreted according to Cohen's rules of thumb, which defines effect-size  
200 bounds as: small (ES: 0.2), medium (ES: 0.5) and large (ES: 0.8: grossly perceptible and  
201 therefore large). Multivariate analysis was conducted using multiple linear regression to  
202 adjust results on weight of participants. The assumption of residuals normality was analyzed  
203 as aforementioned. When appropriate, a logarithmic transformation was applied. As these  
204 analyzes could be considered as exploratory, individual p-values have been reported without  
205 applying any mathematical correction but with specific attention to the magnitude of  
206 differences (i.e. ES), according to several works reported in the literature like those discussed  
207 by Bender and Lange<sup>32</sup>. Furthermore, principal component analysis was also performed to  
208 investigate relationships between quantitative variables using R software (R Foundation for  
209 Statistical Computing, Vienna, Austria). This statistical method was useful for analyzing  
210 assets as elements of quantitative variables in order to i) uncover the underlying relationships  
211 and structures of the measured variables (latent constructs) and ii) to aggregate subjects into  
212 clusters such that each cluster represents a topic.

## 213 **Results**

### 214 *Anthropometric, body composition and cardiometabolic outcomes*

215 H-Spenders and L-Spenders were aged  $37.7 \pm 7.6$  and  $41.9 \pm 10.9$  y.o., respectively,  
216 with a mean BMI of  $23.9 \pm 3.8$  and  $21.6 \pm 1.7$  kg/m<sup>2</sup>. H-Spenders had a higher percentage of  
217 body fat mass (p=0.034) and WHtR (p=0.025) and lower fasting plasma concentration of  
218 HDL-C (p=0.014) compared to L-Spenders (Table 1). A lower insulin sensitivity was  
219 observed for H-Spenders compared to L-Spenders, as indicated by greater plasma insulin  
220 concentrations (p=0.002) and HOMA-IR (p=0.002) values (Table 1). No other between-group

221 significant difference was reported in body composition and cardiometabolic outcomes (Table  
222 1).

### 223 *Daily physical activity, sedentary time and physical fitness*

224 As displayed in Table 2, no significant difference was observed between the two groups for  
225 aerobic fitness, upper and lower limb strength, total and segmented (by intensities) physical  
226 activity levels and sedentary time (Table 2). Based on the recorded physically active and  
227 sedentary time, our population can be considered sedentary and physically inactive <sup>1</sup>.

### 228 *Energy expenditure, heart rate and substrate oxidation*

229 Overall, Delta Exo-Rest for EE showed large variability (0.5 to 1.8 kcal.min) (Figure  
230 2). Mean EE during the 30-min exercise increased significantly compared to mean resting EE  
231 in both H-Spenders ( $2.26 \pm 0.2$  vs  $0.98 \pm 0.12$  kcal/min,  $p < 0.001$ ) and L-Spenders ( $1.91 \pm 0.15$  vs  
232  $0.93 \pm 0.11$  kcal/min,  $p < 0.001$ ). There was no between-group difference in EE at rest  
233 ( $0.98 \pm 0.12$  vs  $0.93 \pm 0.12$  kcal/min, respectively). However, H-Spenders had higher EE than L-  
234 Spenders at every time point of the exercise test: start ( $2.38 \pm 0.19$  vs  $1.93 \pm 0.16$  kcal/min,  
235  $p < 0.001$ , respectively), 10min ( $2.26 \pm 0.18$  vs  $1.92 \pm 0.13$  kcal/min,  $p < 0.001$ , respectively),  
236 20min ( $2.21 \pm 0.22$  vs  $1.88 \pm 0.15$  kcal/min,  $p < 0.001$ , respectively), and 30min ( $2.18 \pm 0.17$  vs  
237  $1.92 \pm 0.15$  kcal/min,  $p < 0.001$ , respectively) (Figure 3A). At 1min-recovery, EE was not  
238 significantly different between the groups ( $1.56 \pm 0.30$  vs  $1.39 \pm 0.20$  kcal/min, H-Spenders vs  
239 L-Spenders, respectively).

240 The light cycling exercise significantly increased heart rate compared to resting  
241 position in both H-Spenders ( $86 \pm 11$  vs  $70 \pm 12$  beats/min,  $p < 0.001$ ) and L-Spenders ( $81 \pm 10$  vs  
242  $68 \pm 9$  beats/min,  $p < 0.001$ ) with no differences between the two groups. This increase was  
243 consistent across the entire duration of cycling for both groups (Figure 3B).

244 RQ was similar between H-Spenders and L-Spenders at rest ( $0.84\pm 0.05$  vs  $0.83\pm 0.04$ ,  
245 respectively) but was significantly higher in H-Spenders during the whole duration of exercise  
246 compared to L-Spenders ( $p=0.021$ ) (Figure 4A). Taking all data together, there was a time  
247 effect ( $p=0.009$ ) for carbohydrates (CHO) oxidation, which was significantly higher during  
248 exercise compared to rest ( $p=0.008$ ) and recovery ( $p=0.006$ ). Resting CHO oxidation was  
249 significantly higher in H-Spenders compared to L-Spenders ( $3.33\pm 1.2$  vs  $2.82\pm 0.94$   
250 mg/min/kgFFM,  $p=0.017$ , respectively). No significant difference was observed between  
251 groups at start, while H-Spenders oxidized significantly more CHO than L-Spenders during  
252 cycling at 10min ( $6.52\pm 2.28$  vs  $4.53\pm 1.48$  mg/min/FFM,  $p=0.009$ , respectively), 20min  
253 ( $6.52\pm 2.34$  vs  $4.79\pm 1.47$  mg/min/kgFFM,  $p=0.049$ , respectively) and 30min ( $6.47\pm 2.15$  vs  
254  $4.14\pm 1.38$  mg/min/kgFFM,  $p=0.008$ , respectively). No significant difference was reported at  
255 recovery between groups and compared to rest.

256 There was also a time effect for lipid oxidation, which was higher during exercise  
257 compared to rest for both H-Spenders ( $3.88\pm 1.55$  vs  $1.28\pm 0.33$  mg/min/kgFFM,  $p<0.001$ ) and  
258 L-Spenders ( $3.85\pm 1.48$  vs  $1.27\pm 0.34$  mg/min/kgFFM,  $p<0.001$ ). A group effect was noticed at  
259 the start of exercise and during recovery, with H-Spenders oxidizing more lipid than L-  
260 Spenders at start ( $5.94\pm 1.69$  vs  $4.76\pm 1.03$  mg/min/kgFFM,  $p=0.030$ , respectively) and  
261 oxidizing less lipid than L-Spenders during recovery ( $2.1\pm 0.44$  vs  $4.84\pm 2.34$  mg/min/kgFFM,  
262  $p=0.002$ , respectively). No significant difference was reported for any other time of the  
263 exercise test.

264 Relative to total EE at rest, there was no significant difference in CHO oxidation in  
265 percentage between H-Spenders and L-Spenders ( $53.5\pm 17.8\%$  vs  $49.5\pm 14.9\%$ ,  $p=0.26$ ) or for  
266 lipid oxidation ( $46.5\pm 15.5\%$  vs  $50.4\pm 12.4\%$ ,  $p=0.46$ ) (Figure 4B). During exercise, CHO  
267 oxidation was representing a greater percentage of total EE ( $44\pm 10.9\%$  vs  $35.7\pm 8.6\%$ ,  
268  $p=0.050$ ) and lipid oxidation a lower percentage ( $56\pm 8.9\%$  vs  $64.3\pm 7.2\%$ ,  $p=0.045$ ) in H-

269 Spenders compared to L-Spenders (Figure 4C). No specific correlation were found between  
270 EE or substrate oxidation parameters and body composition, anthropometric data or blood  
271 parameters.

### 272 *Principal component analysis*

273 Lastly, the associations between the different parameters studied were illustrated by a  
274 principal component analysis (Figure 5). Our data has shown a strong correlation between  
275 Delta Exo-Rest and some cardiometabolic parameters, such as inulin, HOMA-IR, LDL-  
276 cholesterol, glucose and triglycerides (Figure 5). Also, the variability of energy expenditure  
277 between rest and low intensity cycling was strongly associated with higher values of body  
278 composition and anthropometric parameters (fat mass, fat-free mass, BMI, WC and  
279 WC/height) (Figure 5).

## 280 **Discussion**

281 Active workstations are currently promoted to decrease office-related sedentary time  
282 and increase PA in a public health perspective. The aim of the present study was to examine  
283 associations between energy expenditure during a low intensity exercise on a cycle-desk  
284 device and body composition, cardiometabolic parameters and physical fitness of tertiary  
285 employees. Our data shows that two energetic profiles (H-Spenders or L-Spenders) can be  
286 identified in premenopausal women. More importantly, those two profiles show significant  
287 differences in anthropometric data, body composition (fat mass and WHtR) and metabolic  
288 outcomes (insulin, HOMA-IR, and HDL-Cholesterol), with H-Spenders presenting a less  
289 healthy metabolic profile.

290 Our results show that a light intensity cycle-desk exercise can significantly increase EE  
291 between 1.9 and 2.4 METs compared to resting. This result is in line with previous studies  
292 <sup>14,33</sup> and demonstrates that light intensity cycling allows to increase EE above EE associated

293 with sedentary activities (i.e. 1.5 METs). A number of studies have questioned the effect of  
294 cycle-desk use on EE <sup>14,21,34</sup> but, none of them has looked for the potential factors that could  
295 explain this EE variability. Heterogeneity in energy responses has been reported in other  
296 studies from a sitting position to a steady-state standing position <sup>10,11</sup> with individuals  
297 characterized as “energy-savers” or “energy-spenders”. While studies of Miles-Chan et al. <sup>10</sup>  
298 reported only 18% of their subject having a significant increase in EE compared to sitting  
299 (increase >5% resting EE), all subjects of our study significantly increased their EE during the  
300 low-intensity cycling session. Differences in the magnitude of responses between the two  
301 studies are likely explained by the higher energetic demand induced by cycle-desk used in the  
302 present study compared to the standing position alone (1.9 to 2.3 METs vs ~1.2 METs) <sup>9</sup>.

303 Light-intensity cycling was more demanding for H-Spenders who were eliciting higher EE at  
304 each period of exercise than L-Spenders. During exercise, H-Spenders oxidized more CHO,  
305 both in total amounts and relatively to EE, but a lower percentage of lipids compared to the L-  
306 Spenders, while H-Spenders had significantly more fat mass than L-Spenders. Relationships  
307 between fat mass percentage, body weight and substrate oxidation during exercise have been  
308 investigated in several studies with no clear association between these parameters <sup>35,36</sup>.

309 Studies comparing substrate oxidation during exercise in women with normal weight and  
310 overweight did not show clear differences <sup>35,36</sup>. It suggests that excess of fat mass does not  
311 necessarily result in a decrease in the ability to oxidize lipids. However, fat mass localization  
312 in normal or overweighed subjects seems to be more associated with substrate oxidation  
313 during exercise <sup>37,38</sup> than percentage of fat mass *per se*, with lower body fat mass profile being  
314 associated with better ability to oxidize lipids. In this line, we found that H-Spenders  
315 displayed higher %FM and WHtR, suggesting higher abdominal repartition of fat mass in  
316 individuals with this energy profile. The ability to rely predominantly on lipids or  
317 carbohydrates during submaximal exercise has been associated with the concept of metabolic

318 flexibility, which is defined as the capacity to adjust fuel utilization to changes in fuel  
319 availability<sup>39</sup>. Metabolic state associated with glucose intolerance or insulin resistance has  
320 been shown to favor CHO oxidation during low intensity exercise compared to control  
321 subjects<sup>40</sup> and has been associated with metabolic inflexibility<sup>41</sup>. The metabolic challenge  
322 induced in our study by a 30-min low intensity cycling exercise suggests that H-Spenders are  
323 less metabolically flexible than L-Spenders as they are less able to rely on lipids during a low  
324 intensity exercise<sup>42</sup>. Physical fitness and training status are also known to influence the ability  
325 to preferentially rely on lipids during low and moderate intensity exercise<sup>43</sup>. Thus, the H-  
326 Spenders and L-Spenders profiles could have been explained by differences in physical  
327 capacities of the subjects. This appears however unlikely here since heart rate during step test  
328 and higher and lower limb strength did not differ significantly between the two groups.

329 The potential mechanisms explaining heterogeneity in energy profile have been poorly  
330 investigated in previous studies questioning strategies to decrease SB during work time.  
331 Miles-Chan et al.<sup>10</sup> did not find any association between body weight or height and EE when  
332 comparing energy cost in sitting *vs* standing positions. In a second study of the same research  
333 group, the energy cost of standing posture maintenance was positively correlated with body  
334 weight and WC<sup>12</sup>. Recently, Amaro-Gahete et al.<sup>44</sup> showed that FFM could partly explain  
335 differences in EE profiles in sitting *vs.* standing position. Although H-Spenders had a higher  
336 percentage of fat mass, no difference in FFM was observed. These results are also concordant  
337 with the study of Chen et al.<sup>45</sup>, in which were reported relationships between energy  
338 efficiency and fat mass during walking, with subjects with obesity having decreased work  
339 efficiency compared to individuals with normal-weight during normal-speed walking. We  
340 further examined the cardiometabolic parameters of the two energy profiles. Our results  
341 suggest that H-Spenders showed a less healthy cardiometabolic profile as indicated by higher  
342 levels of fasting insulin, HOMA-IR and lower level of HDL-Cholesterol than L-Spenders.

343 Metabolic profile and substrate oxidation during exercise of H-Spenders further feature  
344 similarities with those of subjects with obesity and/or type 2 diabetes <sup>40</sup>.

345 Individualization of exercise programs is a cornerstone of health management. Our results  
346 suggest that physical activity level and fitness capacities are not sufficient to discriminate  
347 people and that an energy evaluation at rest and during exercise should be assessed to  
348 personalize prescription. In light of our results, we can assume the H-Spenders benefit more  
349 from the same cycle-desk program than L-Spenders. Depending on the energy profile, it could  
350 be expected that cycle-desk use recommendations may need to differ in terms of time and/or  
351 intensity of pedaling. Given the increased demand and/or necessity in the utilization of active  
352 desks, this could have important implications for metabolic health management.

353 One potential limitation needs to be considered. We only studied women, thus those results  
354 are only applicable to the female population. However, Miles-Chan et al. <sup>10</sup> reported different  
355 energetic profiles among male individuals during an activity at a lower intensity suggesting  
356 that the existence of different energy profiles might not be sex dependent. Nevertheless, the  
357 relation with body composition or metabolic profile could depend on this factor as shown by  
358 Chen et al. <sup>45</sup>. It is well known that hormonal status affects EE and two of our participants  
359 were taking oral contraceptives. Currently, there is no clear scientific evidence that oral  
360 contraceptives could induce modification of EE at rest or during exercise.

## 361 **Conclusion**

362 This study confirms that light cycling exercise enables to increase EE compared to  
363 resting but, inter-individual heterogeneity exists in the magnitude of energetic response.  
364 Differences in physical fitness, habitual time spent active or sedentary are not explaining this  
365 inter-individual variability. However, female individuals who spend less energy during a low  
366 intensity cycling activity present a healthier metabolic profile than those who displayed higher



367 EE. Identification of energy profile could represent a strategy to better individualize the use of  
368 dynamic workstations to optimize EE during workdays. Future studies will need to investigate  
369 whether long-term utilization of light-intensity cycling desk at work can improve metabolic  
370 health outcomes of sedentary office workers, especially those with less healthy metabolic  
371 profiles.

372

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376

### 377 **Author contributions**

378 TG, LM, MD and DT designed the study; TG, PB, ELR and AB performed the experiments;  
379 TG, LM, DT, LI, BP, AB and MD contributed significantly to the writing and revision of the  
380 manuscript. All the authors read and approved the final manuscript.

381

### 382 **Competing interests**

383 None of the authors had any conflict of interest associated with the study. The results of the  
384 study are presented clearly, honestly, and without fabrication, falsification, or inappropriate  
385 data manipulation.

386

387       **References**

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- 494

Table 1. Characteristics of the study population

Variables	Low spenders	High spenders
N	14	14
Age (years)	41.9 (10.9)	37.7 (7.6)
Height (cm)	164.4 (4.7)	163.8 (7.3)
Body weight (kg)	58.4 (4.6)	64.5 (11.8)
BMI (kg/m <sup>2</sup> )	21.6 (1.7)	23.9 (3.8)
Body fat mass (%)	25.9 (5.9)	31.5 (6.6)*
Body fat-free mass (kg)	40.9 (2.4)	41.4 (4.8)
Waist circumference (cm)	73.2 (6.0)	82.0 (11.3)
Waist circumference/height	0.44 (0.04)	0.50 (0.07)*
Systolic blood pressure (mmHg)	112.1 (5.8)	121.1 (14.9)
Diastolic blood pressure (mmHg)	70.0 (6.0)	76.1 (8.4)
Glucose (mmol/L)	4.79 (0.32)	5.12 (0.90)
Insulin (mIU/L)	4.04 (1.72)	9.25 (6.46)**
HOMA-IR	0.86 (0.36)	2.30 (2.35)**
Total cholesterol (g/L)	1.73 (0.45)	1.68 (0.25)
HDL-Cholesterol (g/L)	0.66 (0.09)	0.54 (0.13)*
LDL-Cholesterol (g/L)	0.99 (0.24)	1.00 (0.27)
Triglycerides (g/L)	0.83 (0.38)	0.72 (0.28)

BMI, body mass index; HOMA-IR, homeostatic model assessment of insulin resistance; HDL, high-density lipoprotein cholesterol; LDL, light-density lipoprotein cholesterol.

Values are presented as mean score (standard deviation) or percentage.

Boldface indicates statistical significance (\* $p < 0.05$ , \*\* $p < 0.01$ ), respectively with Mann-Whitney test.

Table 2. Physical activity level, sedentary time and physical fitness of the study population

Variables	Low spenders	High spenders
N	14	14
Valid days of accelerometer wear	5.7 (0.4)	6.0 (0)
Weekdays	3.9 (0.3)	4.0 (0)
Weekend days	1.8 (0.4)	2.0 (0)
Number of minutes of accelerometer data (min/day)	352.9 (64.3)	368.9 (55.4)
Sedentary time (%/daily waking hours)	87.8 (2.9)	87.9 (3.1)
Total physical activity (%/daily waking hours)	12.2 (2.9)	12.0 (3.1)
LPA (%)	3.1 (1.1)	3.4 (1.1)
MVPA (%)	7.9 (1.9)	7.7 (2.7)
VPA (%)	1.2 (0.5)	0.9 (0.4)
Handgrip dominant hand (kg)	29.1 (4.7)	29.3 (4.7)
Handgrip non-dominant hand (kg)	28.0 (4.8)	26.5 (5.0)
Rest heart rate step test (bpm)	65.8 (6.8)	74.8 (12.7)
Heart rate step test (bpm)	147.9 (18.0)	160.3 (16.7)
Heart rate step test +30 (bpm)	124.5 (19.9)	136.0 (19.3)
Heart rate step test +60 (bpm)	106.2 (20.1)	118.1 (17.6)
Isometric strength (nm)	136.1 (31.7)	131.1 (36.6)
Isokinetic power 60°/sec (w)	142.7 (33.2)	140.1 (34.0)
Isokinetic power 120°/sec (w)	236.5 (55.7)	215.1 (60.5)

LPA, light intensity physical activity; MVPA, moderate-to-vigorous physical activity; VPA, vigorous physical activity.

Values are presented as mean score (standard deviation) or percentage.



498 Figures legends

499 Figure 1. Schematic representation of the experimental design. EE, energy expenditure; Lw.,  
500 lower.

501

502 Figure 2. Characterization of Delta Exo-Rest between H-Spenders and L-Spenders. Data are  
503 presented as mean  $\pm$  SEM.

504

505 Figure 3. Comparison of EE (A), heart rate (B), from resting condition to light cycling  
506 exercise and recovery in each EE response group: H-Spenders and L-Spenders.

507 Data are presented as mean  $\pm$  SEM. §§§, time effect at  $p < 0.001$ ; \*\*\*, significantly different  
508 between low spenders and high spenders at  $p < 0.001$ .

509

510 Figure 4. Respiratory quotient (A) during light cycling exercise. Substrate oxidation during  
511 Rest (B) and light cycling exercise (C).

512 A, data are presented as mean  $\pm$  SEM. B and C, data are expressed as mean percentage of  
513 CHO and lipids consumption relating to total energy expenditure. NS, not statistically  
514 significant; \*, significantly different between low spenders and high spenders at  $p < 0.05$ .

515 Figure 5. Principal component analysis of the study parameters.

516 BMI, body mass index; DH, dominant hand; FFM, fat-free mass; FM, fat mass; HG,  
517 handgrip; HOMA-IR, homeostatic model assessment of insulin resistance; HDL, high-density  
518 lipoprotein cholesterol; HRST, heart rate step test; Isok, isokinetic; Isom, isometric; LDL,  
519 light-density lipoprotein cholesterol; LPA, light intensity physical activity; MVPA, moderate-to-  
520 vigorous physical activity; NDH, non-dominant hand; VPA, vigorous physical activity; WC, waist  
521 circumference

522

