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1 **Office workers' experiences of attempts to reduce sitting-**  
2 **time: An exploratory, mixed-methods uncontrolled**  
3 **intervention pilot study**

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26 **Office workers' experiences of attempts to reduce sitting-time: An exploratory,**  
27 **mixed-methods uncontrolled intervention pilot study**

28 **Abstract**

29 *Background.* Office workers typically sit for most of the workday, which has been linked to  
30 physical and mental ill-health and premature death. This mixed-methods study sought to  
31 identify barriers and facilitators to reducing sitting and increasing standing among office  
32 workers who received an intervention prototype (the 'ReSiT [Reducing Sitting Time]  
33 Study'). The intervention comprised a sit-stand workstation and tailored advice to enhance  
34 motivation, capability and opportunity to displace sitting with standing.

35 *Methods.* Twenty-nine UK university office workers (aged  $\geq 18$ y, working  $\geq 3$  days per week,  
36 most time spent at a seated desk) participated in a 13-week uncontrolled study. They were  
37 initially monitored for one-week. In a subsequent face-to-face consultation, participants  
38 received sitting time feedback from a prior one-week monitoring period, and selected from a  
39 set of tailored sitting-reduction techniques. Quantitative data comprising sitting, standing and  
40 stepping time, which were objectively monitored for 7 consecutive days across three post-  
41 intervention timepoints, were descriptively analysed. Qualitative data, from semi-structured  
42 interviews conducted at 1, 6 and 12-weeks post-intervention, were thematically analysed.

43 *Results.* Compared to baseline, mean sitting time decreased at weeks 1, 6 and 12 by  
44 49.7mins, 118.2mins, and 109.7mins respectively. Despite prior concerns about colleagues'  
45 reactions to standing, many reported encouragement from others, and standing could be  
46 equally conducive to social interaction or creating private, personal space. Some perceived  
47 less cognitively-demanding tasks to be more conducive to standing, though some found  
48 standing offered a valued break from challenging tasks. Participants prioritised workload  
49 over sitting reduction and were more likely to stand after rather than during work task  
50 completion. Temporary context changes, such as holidays, threatened to derail newfound  
51 routines.

52 *Conclusions.* Our findings emphasise the importance of understanding workers' mental  
53 representations of their work, and the social functions of sitting and standing in the  
54 workplace. Workplace intervention developers should incorporate a pre-intervention sitting  
55 time monitoring period, encourage workers to identify personally meaningful tasks and cues  
56 for standing, and build organisational support for sitting-reduction. We will use these insights  
57 to refine our intervention for self-administered delivery.

58 *Trial registration.* ISRCTN29395780 (registered 21 November 2016)

59 **Keywords:** Sedentary behaviour, workplace, qualitative, occupational health

## 60 **Background**

61 Prolonged sitting is associated with poor mental and physical health and premature  
62 death [1–4]. Office workers typically sit for two-thirds of their waking day, so are at  
63 particular risk [5, 6]. Offsetting this risk requires displacing sitting with standing or light  
64 activity. Expert guidance recommends that workers regularly break up sitting and accumulate  
65 2-4h standing per 8h workday [7]. Sitting-reduction interventions are needed to achieve these  
66 targets.

67 Successful implementation of such interventions depends upon acknowledging the  
68 complex organisational, social and cultural factors that shape the modern workplace [8].  
69 Some workplace sitting-reduction approaches show efficacy yet lack acceptability, because  
70 they fail to address the needs and priorities of organisations or their employees. For example,  
71 automated prompts to stand, delivered at fixed intervals (e.g. hourly), can reduce sitting time  
72 [9], but some workers report dissatisfaction because prompts disrupt their workflow [10].  
73 Similarly, workers who volunteered to stand felt unable to fully engage in otherwise-seated  
74 meetings [11]. Interventions that adversely impact productivity are unlikely to be acceptable  
75 to employees or managers [12].

76 Height-adjustable sit-stand workstations (SSWs) allow alternation between sitting and  
77 standing while working, so are viewed favourably by workers [13, 14]. SSWs take two  
78 forms: sit-stand desks allow adjustment of the entire desk-top surface and are costly, whereas  
79 desk-mounted sit-stand units adjust only monitor and keyboard height and are relatively  
80 inexpensive. Both can reduce sitting time: although trials have typically been of low quality,  
81 SSWs reduce sitting by around 100mins per 8h workday [9], with effects persisting over time  
82 [9, 15–19]. Yet, 100mins reduction in sitting may fall short of achieving 2-4h standing time.  
83 Supplementing SSWs with other techniques may enhance effectiveness [18].

84 Effectiveness and acceptability of sitting-reduction interventions, more broadly, may  
85 also be enhanced by acknowledging how, why, and in what contexts office workers choose –  
86 or choose not – to stand. For example, although generally acceptable, desk-mounted SSWs  
87 limit space and pose practical problems for paper-based work (Chau et al, 2014). Studies  
88 have documented apprehension about colleagues’ potentially discouraging reactions from  
89 colleagues [11–13, 20]. People appear less likely to stand in meetings about sensitive topics,  
90 for example, to avoid detracting from the seriousness of the meeting [11].

91 Office workers’ responses to sitting-reduction strategies can reveal not only  
92 engagement with those strategies, but also broader barriers and facilitators of implementing  
93 sitting-reduction. The present study focuses on office workers’ experiences of attempts to

94 limit sitting in response to an intervention prototype. The intervention aimed to reduce sitting  
95 and increase standing via feedback on sitting time, a range of tailored sitting-reduction  
96 techniques, and a desk-mounted SSW. Although originally designed to assess the  
97 acceptability of intervention components [21], our data transpired to predominantly offer  
98 insight into how office workers seek to reduce sitting and increase standing within the  
99 constraints of their working practices. While we also report intervention engagement, the  
100 main research question that guided the present analysis was: *how did office workers*  
101 *experience their attempts to reduce sitting?* The study was registered (ISRCTN29395780).  
102 Deviations from our published protocol [21] are detailed in Additional File 1.

103

## 104 **Method**

### 105 *Participants, design and procedure*

106 Office workers were recruited from a UK university (n=29), between November 2016  
107 and March 2017, to a 13-week uncontrolled intervention study. Sample size was determined  
108 by a predetermined recruitment window, constrained by funding. The study was advertised  
109 via posters at the host organisation, and fortnightly through all-staff circular emails  
110 throughout the 5-month recruitment period. The study was presented as an opportunity ‘to  
111 improve your workplace health, try out a sit-stand desk, and earn a £100 Amazon voucher’.  
112 Inclusion criteria required participants to: be aged 18 years or over; work at least 3 days per  
113 week; and spend most of their typical working day seated at a workstation, of which they  
114 were the sole user. Workers were not eligible where they: reported a physical condition  
115 prohibiting standing for prolonged periods; had previously participated in workplace standing  
116 research; ever used an SSW for two or more consecutive days; or intended to be absent for 10  
117 consecutive workdays or leave the employ of the host organisation during the study period.

118 All those who expressed interest and were eligible attended the Preliminary Session,  
119 at which they provided consent and self-reported demographic characteristics (Table 1) and  
120 were fitted with an accelerometer-inclinometer device for 7-day continuous wear. Ten days  
121 later, they completed the Intervention Session at which they received accelerometry  
122 feedback, tailored advice, and a height-adjustable SSW. They were fitted with an  
123 accelerometer-inclinometer for further 7-day wear at the close of the Intervention Session,  
124 and 5- and 11-weeks post-intervention. Accelerometer data were collected and a semi-  
125 structured interview was conducted at one, 6 and 12-weeks post-intervention. Participants  
126 received a £100 (\$125) Amazon voucher on study completion.

127 All procedures, which were approved by the King’s College London Psychiatry,  
128 Nursing and Midwifery Ethics Panel (LRS-16/17-3718), were administered to each  
129 participant individually in a private room at their workplace by SD. SD is a male post-  
130 doctoral researcher with an experimental psychology background, and quantitative and  
131 qualitative data collection and analysis experience.

132 TABLE 1 HERE

133 *Intervention*

134 *Preliminary Session.* Participants were fitted with an activPAL accelerometer-  
135 inclinometer (PAL Technologies, Glasgow, UK) using standard protocol [6]. activPALs are  
136 posture-sensitive, and reliably distinguish sitting, standing, and stepping [22]. Participants  
137 were asked to monitor their work tasks over the following 7 days, using self-generated task  
138 categories (e.g. ‘phone calls’, ‘word processing’). Tasks were recorded via replies to twice-  
139 daily emails from the researcher. On the final monitoring day, participants were also asked to  
140 estimate their total sitting time for each workday (9am-5pm) over the 7-day period.

141 *Intervention session.* Ten days after the Preliminary Session, the researcher met each  
142 participant in a private room at their workplace, to administer the intervention.

143 *Sitting time feedback:* Visual and verbal personalised feedback on sitting patterns  
144 during the monitoring period (i.e., ‘-1–0 weeks’ [baseline]) was provided and discussed in  
145 comparison to self-estimated sitting time.

146 *Tailored behaviour change guidance:* Next, participants were asked which one of  
147 three statements, representing the fundamental determinants of behaviour [23], was most  
148 diagnostic of them: “I do not feel capable of reducing my sitting at work” (capability); “I do  
149 not feel I have the opportunity to reduce my sitting at work” (opportunity); “I do not feel  
150 motivated to reduce my sitting at work” (motivation; all response options were ‘yes’ [most  
151 applicable] or ‘no’). Next, they chose from a menu of behaviour change strategies linked to  
152 their diagnostic statement. Five strategies (of which two were each offered only to those  
153 selecting one other strategy) targeted capability; three motivation; and one opportunity (Table  
154 2). Following spoken delivery of chosen strategies, participants could choose advice relating  
155 to any other strategy, regardless of their diagnostic statement. Participants could choose as  
156 many strategies as desired.

157 *Sit-stand workstation:* Lastly, a height-adjustable VariDesk Pro Plus 30 desk-mounted  
158 unit (Varidesk, TX, USA; £325 [US\$405])) was fitted to the participant’s desk for the 12-  
159 week period. Participants were given ergonomic instructions and accompanying tips to  
160 promote frequent, ergonomically-sound SSW use (Table 1). Participants were permitted to

161 retain the SSW indefinitely after participation, but this was only revealed to them upon study  
162 completion, so did not represent an active intervention component.

163 *Reminders of intervention content:* Participants were given the option of receiving  
164 email reminders over the 12-week intervention period of the key points from the Intervention  
165 Session. Participants specified the desired content and receipt frequency of these emails. All  
166 participants were emailed a summary of key points from the Intervention Session one day  
167 after that session.

## 168 TABLE 2 HERE

### 169 *Data collection and analysis*

170 *Quantitative data: intervention engagement.* Engagement was explored by describing  
171 the frequency with which each of the behaviour change strategies was selected, and  
172 inspecting sitting and activity levels over time. Accelerometry data on sitting, standing, and  
173 stepping time from the 5 workdays within the 7-day wear period, as measured between the  
174 Preliminary and Intervention Sessions (-1–0 weeks [baseline]), and at 0–1, 5–6, and 11–12-  
175 week post-intervention, were extracted using specialist software (activPAL™ Professional  
176 v7.2.32; PAL Technologies Ltd, Glasgow, UK). A considerable amount of data at each  
177 timepoint were missing due to malfunctioning devices. A repeated-measures mixed-effects  
178 model assessed sitting, standing and stepping time changes, using study period (i.e. -1–0, 0–  
179 1, 5–6, 11–12-weeks) as predictor, and data for each of the 5 workdays in each period as  
180 covariates. Effect sizes for mean differences from baseline (Cohen’s d) were calculated for  
181 descriptive purposes.

182 *Qualitative data: experiences of attempts to reduce sitting.* Each participant was  
183 invited to take part in three one-to-one, face-to-face semi-structured interviews (at 1, 6, 12  
184 weeks post-intervention), which explored: expectations and experiences of implementing the  
185 chosen strategies and of sitting and standing more broadly; SSW use; and the conduciveness  
186 of social and physical environments. Later interviews focused more on maintenance.  
187 Interview schedules are presented in Additional File 2. Interviews were audio-recorded and  
188 transcribed verbatim. Across the three timepoints, interview duration ranged from 9 to  
189 43mins (mean 18mins). Twenty-one (72%) participants completed all three interviews, and  
190 eight (28%) completed only the 1- and 6-week post-intervention interviews, citing lack of  
191 availability for the third interview. Pertinent utterances within the Intervention Session,  
192 recorded in note form by the researcher, were also used as data.

193 All available qualitative data were analysed using realist inductive Thematic Analysis  
194 procedures [24]. Two coders (SD, BG) independently preliminarily analysed all data,



195 involving data familiarisation and assigning labels to pertinent events. Comparison of notes  
196 between coders informed development of a thematic framework, which guided more in-depth  
197 coding conducted by BG. Themes were labelled using ‘in vivo’ codes to ensure they were  
198 grounded in real-world participant experiences. A third researcher (JH) inspected the  
199 framework and data excerpts and agreed that the analysis was supported by the data.

200

## 201 **Results**

### 202 *Sample description*

203 Of 29 participants, 21 (72%) were female. Age ranged from 18-24y to 55-59y, and monthly  
204 income ranged from £1.5-2.4k to ≥£3.9k. Most were White (21; 72%), and 22 (76%) had a  
205 university degree or higher. Seventeen people (59%) were in administrative roles. At baseline  
206 (-1-0 weeks), mean sitting time was 355mins/workday (5h 55m; 74% of 8h workday),  
207 standing time 82mins (17%), and stepping time 43mins (9%).

### 208 *Quantitative analyses: Intervention engagement*

209 *Selection of techniques.* Most participants (23/29; 80%) stated that none of the  
210 capability, motivation or opportunity statements applied to them, as they were sufficiently  
211 able and motivated, with enough opportunity to reduce sitting. Of the remainder, two stated  
212 that they most lacked capability (one lacked physical and social capability, the other  
213 psychological capacity), two most lacked motivation, and two most lacked perceived  
214 opportunity due to busy working schedules. Nonetheless, when invited to select from all  
215 strategies, 26 participants (90%) chose to receive advice on at least one strategy. Twenty  
216 participants (69% of sample) chose Goal Setting or Action Planning; six chose both, eight  
217 chose Goal Setting only, and six Action Planning only (Table 2). All who chose Action  
218 Planning also opted for Habit Formation advice.

219 *Behavioural responses.* Study period predicted sitting time ( $F[3, 122.5] = 28.9$ ,  
220  $p < .001$ ): relative to baseline (-1-0 weeks), sitting time reduced by 50min at 0-1 week,  
221 118min at 5-6 weeks, and 110mins at 11-12 weeks, by which point mean sitting time (245m;  
222 4h 5min) represented 51% of the 8h workday (Table 3). An equivalent increase was  
223 observed in standing time (+49m at 0-1 week; +116m, 5-6 weeks; +113m, 11-12 weeks;  $F[3,$   
224  $120.7] = 31.1$ ,  $p < .001$ ), but there was no change in stepping time ( $F[3, 138.1] = 2.1$ ,  $p = .10$ ).

225

TABLE 3 HERE

### 226 *Qualitative analyses: Experiences of attempts to reduce sitting*

227 Five themes related to: motives, expectations and outcomes; physical and practical  
228 challenges; social dynamics; counter-motives and use of cues; and routinisation.

229 “I sit at my desk an awful lot”: Motives, expectations and outcomes

230 Most people entered the study to trial the sit-stand workstation (SSW). Many  
231 appeared aware of possible health benefits of displacing sitting with standing, such as  
232 alleviation of existing health problems, or avoiding deterioration of health. Some saw the  
233 intervention as a cue to acting on prior motivation:

234 Participant 11, Interview 1 (P11, I1): *I do sit at my desk an awful lot and I ... know*  
235 *that that's not good for my health, so anything that ... gives me a nudge to actually do*  
236 *something about it is bound to be good.*

237 Most were strongly motivated to stand, and felt physically capable of standing,  
238 though some felt trepidation about responses from co-workers for contravening workplace  
239 norms (“*it's that sense [of] is that acceptable, for this person [to be] doing it differently?*”;  
240 P5, I1).

241 Others worried that working at a different height to other colleagues “*might be quite*  
242 *irritating*” (P6, I1) or intrusive (“*do they think you're looking over their shoulder or*  
243 *something?*”; P1, I1), or suggestive of an undesired social identity (“*there's the perception*  
244 *that standing desk people are ... trendy, health-conscious people*”; P5, I1).

245 The intervention was perceived as beneficial in multiple ways. Accelerometry  
246 feedback raised awareness of true sitting patterns (“*it was quite shocking ... when I realised*  
247 *how much time [I had sat]*”; P14, I1). Many participants reported increased standing time,  
248 mostly due to the SSW. Some reported that standing spurred further movement (“*[I'm] more*  
249 *likely to move to another bit of the office ... because I'm already standing*”; P27, I1). For  
250 some, the intervention instilled a ‘sit less, move more’ mindset, characterised by greater  
251 awareness and use of opportunities for reducing sitting at work and elsewhere:

252 P5, I3: *[On the train] even if there's a seat available, I think, 'Oh, I'll just stand', not*  
253 *only because the journey is not going to be that long, but also I should just stand, it'll*  
254 *be healthier, I don't need to sit down. [...] That thought has occurred to me more*  
255 *since starting [the intervention].*

256 Participants attributed improvements in posture, strength and balance (“*since I've*  
257 *started with the desk I can stand with minimal or no wobble*”; P16, I2), and reductions in pain  
258 (“*I'm not getting as much backache as I used to*”; P3, I2), to increased standing.

259 Some felt that standing boosted alertness, in turn increasing productivity (“*I feel a lot*  
260 *better and I do feel energised*”; P4, I1), though some felt it had no impact (“*I'm not fussed*  
261 *whether I stand up or sit down [...] but I like to have the option*”; P22, I3).

262 “It's been a lot more tiring than I thought”: Physical and practical challenges

263 While some reported less fatigue than expected (*“I thought my back would be sore ...*  
264 *but actually it’s been absolutely fine”*; P22, I3), several participants experienced  
265 unanticipated physical fatigue from standing (*“[it’s] been a lot more tiring than I thought”*;  
266 P28, I1). While discomfort often prompted participants to sit, most reported fatigue  
267 diminishing as they gained experience (*“I grew accustomed to how it would feel”*; P8, I3).

268 Participants reported various practical barriers to SSW use, which many felt could not  
269 easily be used with equipment essential for work tasks, or for paper-based tasks. Some were  
270 able to adapt to the constraints imposed by the workstation:

271 P17, I2: *I might put paperwork on the bottom bit of the desk and my keyboard on the*  
272 *higher bit if I’m not using it as much, [or] sometimes I ... put paperwork on my chair.*  
273 *[...] I haven’t found that there’s anything where I can’t stand.*

#### 274 “Everybody’s been really interested”: Social dynamics

275 Despite prior concerns, most experienced encouragement from colleagues. Some felt  
276 minimally self-conscious because their workstation lacked visibility (*“I’m out of the way ... if*  
277 *I were standing up in the middle [of the open-plan office], I’d feel an idiot”*; P6, I2), or  
278 because they had explicitly gained approval to stand (*“I said ‘I’m not going to sit with you if*  
279 *that’s alright, I’m going to carry on standing’ [and] they went, ‘that’s fine’”*; P4, I1). Several  
280 people reported that standing, and particularly the SSW, facilitated interaction:

281 P15, I1: *Everybody’s been really interested ... they’re saying ‘oh, that’s cool’. The*  
282 *novelty helps in terms of the motivation.*

283 Some felt more psychologically comfortable being approached by others when  
284 standing, which created more equitable power relationships (*“I enjoyed the aspect of being on*  
285 *the same equivalent level and eye level”*; P19, I3). Some found standing ‘empowering’ (P13,  
286 I1) when making phone calls:

287 P11, I1: *There’s this tiny little bit more confidence [when] standing up with [voice]*  
288 *calls ... I feel as though I’m towering over them.*

289 Several people found standing conducive to collaboration when colleagues gathered  
290 around the SSW, due to greater monitor accessibility (*“it’s really good if you are both*  
291 *standing instead of huddled over at a computer”*; P14, I3). Enhanced visibility when standing  
292 could however compromise privacy. Several participants reported that colleagues were more  
293 likely to interrupt them (*“you’re more approachable [when standing]”*; P19, I3), and some  
294 were more distracted by others’ activities, when standing:

295 P14, I2: *When I'm standing up ... if there's something going on ... I hear a bit better,*  
296 *and hear something else going on, whereas when I'm sitting I'm more likely just to*  
297 *hear it but then carry on with my work.*

298 “Now is a good time”: Counter-motives and cues to standing

299 Participants cited multiple factors that could derail standing. Many found it  
300 psychologically effortful to raise the SSW, which precluded short standing bouts (P7, I3: *“If*  
301 *I've only got a brief period of time [...] it seems an awful lot of effort to stand up”*).  
302 Tiredness also limited motivation (*“I wasn't sleeping properly [...] [it felt like] an effort to be*  
303 *at work, let alone also stand up”*; P16, I3), though some stood to offset postprandial tiredness  
304 (*“I'll hoik [the workstation] up and it'll give me a bit more energy”*; P9, I2).

305 Participants' primary motivation was to complete work tasks, so they did not stand  
306 where it was seen to conflict with working (P7, I3: *“I need to do what I need to do, work has*  
307 *to come first”*). Being engrossed in work led to forgetting to stand. For one person, sitting  
308 was comforting during stressful periods:

309 P21, I3: *[My job] is high pressure the whole time, and so ... I feel a bit sorry for*  
310 *myself and sitting down is like a treat.*

311 Time cues were effective for some (P1, I1: *“I just put a timer on my phone and I reset*  
312 *it every half-hour and I go up and down”*), but many people ignored them because they  
313 suggested action at moments when standing was not prioritised:

314 P23, I2: *I had my reminders on my watch which continually told me to stand, but I*  
315 *found myself turning that off ... because I got caught up with other things.*

316 For most, completion of a work task acted as a convenient and salient cue to stand (a  
317 *“natural break point”*; P5, I1). Many described a *“sorting out”* period (P26, I2) upon arriving  
318 at work, characterised by answering emails and mentally preparing for the day ahead,  
319 completion of which commonly cued standing:

320 P25, I3: *I've checked my emails, done all that sort of thing. ... Once I have got my*  
321 *brain into the tasks for today then I'll do the standing [and] get down to the nitty-*  
322 *gritty of the work.*

323 Some chose to stand after lunch to aid digestion:

324 P19, I1: *You have your lunch, feel a bit lethargic, and then it's nice to stand. It's*  
325 *almost working that lunch off. I enjoy that.*

326 Participants were also cued to stand when expecting to perform certain tasks. Most  
327 felt standing was ill-suited to cognitively-intensive tasks (*“if I need to really concentrate on*  
328 *something then sitting is better”*; P9, I1), so chose to stand for routine tasks (*“this morning I*

329 *was just sending emails and looking at stuff, it was easy to stand*"; P6, I1). Some deemed  
330 standing helpful for maintaining focus when performing less cognitively engaging tasks.

331 Others reported that switching from sitting to standing provided valuable 'thinking space':

332 P14, I3: *I was having some issues so then I stood up and it just woke me up a bit I*  
333 *suppose. So instead of the monotony of just sitting there trying to work a problem out,*  
334 *it was quite good to stand up and almost look at it differently from [a] standing*  
335 *[perspective].*

336 Where participants could not rely on external cues due to variable work patterns,  
337 standing was inconsistent and sporadic.

### 338 "Getting into a rhythm": Routinisation of standing

339 Most participants incorporated some standing into their working routine. Routinised  
340 standing was characterised by lesser mental effort ("*it's part of my routine now ... it's not a*  
341 *chore for me*"; P24, I1), and reduced reliance on external cues ("*I just know that when I'm*  
342 *coming in [to the office, the SSW] is going up*"; P9, I1). Several people adapted to the  
343 workstation over time, becoming able to complete most tasks standing ("*I have started to do*  
344 *more tasks standing up, whereas before it was [only] repetitive things*"; P14, I2), and could  
345 become "*completely absorbed [in work] and forget that I'm standing*" (P25, I2). Routinised  
346 standers used physical discomfort as a cue to stand.

347 Newfound standing routines were liable to disruption, due to absences from work, or  
348 changes in workload. Some struggled to re-establish standing after such disruption and found  
349 that standing became physically arduous again. While some participants effortfully but  
350 successfully recovered standing after such disruption, others lapsed into old sitting habits:

351 P23, I2: *A week's holiday and then a period of just meetings after meetings pretty*  
352 *much every day, and at that point [my standing] kind of declined. I got to a stage ...*  
353 *where I thought oh God, I actually haven't stood ... properly for a week. It felt like I*  
354 *had gone right back to the beginning again.*

## 355 **Discussion**

357 This study of 29 office workers explored experiences of a workplace intervention  
358 comprising a sit-stand workstation (SSW) and tailored advice. Sitting time reduced from  
359 baseline by 50mins at 1-week, 118mins at 6-weeks, and 110mins at 12-weeks post-  
360 intervention. This corresponded with increases in standing and at 12-weeks mean standing  
361 time was 3h 14min, firmly achieving the 2-4h recommendation [7]. Interviews provided  
362 important insight into contextual factors that shaped participants' experiences. Findings

363 support further development of our intervention and generate broader design and  
364 implementation recommendations for workplace sitting-reduction interventions.

365 Although only a small uncontrolled study, observed reductions in sitting time justify  
366 further development and testing of our intervention. Qualitative data pointed to potential  
367 reasons for declines in sitting. Device-based feedback raised awareness of sitting, in turn  
368 leading people to adopt a ‘sit less, move more’ mindset both in the workplace and elsewhere  
369 (e.g., when commuting; [25]). This testifies to the lack of attention people pay to sitting and  
370 suggests an ‘audit and feedback’ approach may motivate sitting reduction.

371 Few participants reported deficiencies in motivation, capability, or opportunity at the  
372 study outset. Nonetheless, most opted to receive advice on goals and planning, implying that  
373 they expected to reduce their sitting most if they were more psychologically capable, or better  
374 able to capitalise on opportunities. Qualitative data highlighted the potential for unforeseen  
375 barriers to impact on attempts to sit less, apparently by diminishing capability or perceived  
376 opportunities. One such barrier was physical effort; several participants found standing more  
377 taxing than anticipated [11], though physical fatigue diminished over time for some. Sitting-  
378 reduction interventions might manage expectations by highlighting the possibility of mild  
379 discomfort and offering mitigating strategies. Participants could use discomfort as a cue to  
380 transitioning not only from sitting to standing, but also from standing to sitting.

381 Our data support previous studies in suggesting that people find some tasks less suited  
382 to standing [13, 25, 26]. While there were predictable practical barriers to SSW use (e.g.  
383 making calls from a wired phone [25]), we also observed important psychological barriers.  
384 The perceived mental effort involved in raising the SSW was, for some, only deemed  
385 worthwhile for lengthy tasks, and some participants preferred to stand only for less  
386 cognitively involved tasks. This supports the perspective that the postural allocation system  
387 that regulates standing draws on the same finite resources as mental processes, such that  
388 standing impairs performance of cognitively demanding tasks [27]. People can perform  
389 simple motor tasks (e.g., typing) as effectively when standing or sitting [28], but the impact  
390 on more mindful tasks (e.g., writing reports) has not been evaluated. Interestingly, some  
391 participants reported becoming able to perform more demanding tasks while standing. This  
392 suggests either that, as people grow accustomed to standing, they can incorporate tasks that  
393 are inherently more difficult to perform while standing, or that there is no inherent  
394 disadvantage to completing such tasks while standing. Some people valued breaking up  
395 sitting as a means of achieving mental ‘space’ to solve problems. The perceived suitability of

396 tasks to standing may therefore be based on personal preference. Interventions should  
397 encourage workers to identify tasks they feel most able to complete while standing.

398         Some moments may be more opportune for standing. Participants prioritised work  
399 tasks over sitting or standing and preferred to change posture upon completing discrete tasks.  
400 Theory offers two possible reasons for this preference: people may be more likely to attend to  
401 their surroundings at the boundary between one task and another, making the need to stand  
402 more salient, or they may be less willing to stand mid-task because they find it distracting  
403 [29, 30]. Interventions should acknowledge how people segment their day or workload into  
404 discrete ‘units’, as these may represent ‘natural break points’ for standing. We identified  
405 several such points, such as the completion of a period involving ‘clearing’ work accrued  
406 since the previous workday or returning from time away from the desk. Interventions will be  
407 less intrusive, and perhaps more effective, if they promote sit-to-stand transitions at points at  
408 which workers are most psychologically capable of standing. Identifying reliable contexts for  
409 consistent standing may also foster habit, whereby standing at opportune moments becomes  
410 an automatic response that requires little forethought or conscious effort [31].

411         Although participants voiced trepidation about others’ responses [11, 12, 32], these  
412 concerns were typically not realised. Standing conferred some unexpected social benefits:  
413 some found it empowering, and the SSW facilitated social interactions and collaborations  
414 [25], though some deployed the SSW to create personal space and minimise distractions.  
415 Although further work is however needed to more comprehensively document the social  
416 functions of SSWs, concerns about others’ responses may be minimised via obtaining  
417 organisational support for sitting-reduction interventions, to demonstrate explicit social  
418 approval for attempts to sit less and stand more [14].

419         Limitations must be acknowledged. Our participants’ experiences were specific to our  
420 intervention prototype and may have varied had we adopted different intervention content or  
421 delivery methods. In particular, the SSW used – a desk-mounted unit that allows for the  
422 computer keyboard and monitor to be raised, rather than an adjustable sit-stand desk that  
423 raises the entire desk-top – limited the appeal of standing for tasks that required desk space  
424 [13]. We focused only on the experiences of intervention recipients, but successful  
425 implementation also requires addressing concerns among management, which typically focus  
426 on the effects of standing on productivity [12, 14, 33]. There is growing recognition of the  
427 importance of targeting sitting-reduction at both individual and organisational levels [14, 18].

428         Sample characteristics may also reduce generalisability. Many participants entered the  
429 study to trial an SSW, suggesting prior sitting-reduction motivation, and most were female,

430 and highly educated, which limits the representativeness of the experiences of our sample.  
431 While anecdotal feedback from participants suggested that few were consciously motivated  
432 by the incentive of a £100 voucher conditional on study completion, this may nonetheless  
433 have sustained engagement with the intervention. Additionally, the same researcher delivered  
434 the intervention and conducted interviews, so participants may have been unwilling to  
435 disclose negative views or non-adherence. The intervention was delivered face-to-face, a  
436 time- and resource-intensive format unlikely to be scalable ([12]). Our subsequent work will  
437 refine intervention content for delivery in an alternative format.

## 438 **Conclusions**

439 This study showed our intervention prototype to be promising, and moreover yielded  
440 insight into experiences of implementing sitting-reduction advice into workplace routines.  
441 Next, we will refine our intervention for self-administration as an online staff-training  
442 module, a common workplace education and training delivery format. Future interventions  
443 should acknowledge the barriers and facilitators of sitting-reduction we have documented.

444

## 445 **List of abbreviations**

446 I = Interview number, P = Participant, SSW = sit-stand workstation.

447

## 448 **Declarations**

449 *Ethics approval and consent to participate*

450 Ethical approval for this study was obtained from the King's College London Psychiatry,  
451 Nursing and Midwifery Ethics Panel (LRS-16/17-3718). All participants gave full, written  
452 informed consent.

453

454 *Consent for publication*

455 All participants gave full, written informed consent for anonymised versions of their data to  
456 be published.

457

458 *Availability of data and material*

459 Study data are available from the corresponding author on request.

460

461 *Competing interests*

462 Funding has been received by SJHB since 2013 for consultancy work from Fitness First,  
463 Nuffield Health and Unilever. None of this work is currently active. Funding was received in



464 2016 for consultancy work for Halpern PR Limited. In-kind support through the provision of  
465 a sit-to-stand desk was provided by Ergotron from 2012 to 2014. Advice has been requested  
466 by and offered to Active Working, Get Britain Standing and Bluearth, none with funding.  
467 All other authors declare that they have no competing interests.

468

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472 interpretation of data, nor in writing the manuscript or the decision to submit for publication.

473

#### 474 *Authors' contributions*

475 SD and BG drafted the manuscript, which was iteratively refined following feedback from all  
476 authors. Intervention and study procedures were developed by SD, LS, JB, SJHB, LM, and  
477 BG. SD administered the intervention, conducted interviews, analysed the quantitative data  
478 and preliminarily analysed the qualitative data, under supervision of BG. In-depth qualitative  
479 analysis was conducted by BG. JH inspected the qualitative data to verify the appropriateness  
480 of analysis. All authors read and approved the final manuscript.

481

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484

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579

580 Table 1. Summary of participant characteristics

		<i>N</i> (%)
Gender	Male	8 (28%)
	Female	21 (72%)
Age	18-24	3 (10%)
	25-29	5 (17%)
	30-34	6 (21%)
	35-39	2 (7%)
	40-44	3 (10%)
	45-49	3 (10%)
	50-54	4 (14%)
	55-59	3 (10%)
	60+	0
Ethnicity	White	21 (72%)
	Black / Black British / African / Caribbean	3 (10%)
	Asian / Asian British	3 (10%)
	Mixed ethnic background	2 (7%)
Monthly income	£1,500-2,400	8 (28%)
	£2,400-3,900	14 (48%)
	>£3,900	6 (21%)
	Not reported	1 (3%)
Highest qualification	A Level, AS Level, CSE, or GCSE	3 (10%)
	Other technical or professional	2 (7%)
	Degree or higher	22 (76%)
	Non-UK qualifications	1 (3%)
	Other	1 (3%)

581

Table 2. Behaviour change advice delivered in the Intervention Session

<i>Behavioural determinant targeted</i>	<i>Behaviour change strategy</i>	<i>Description of advice</i>	<i>Frequency with which chosen (Total N = 29)</i>
Capability	<i>Goal setting</i>	Guidance in setting specific and achievable behavioural goals for time spent sitting, standing and/or in light activity	14 (48%)
	<i>Action Planning</i>	Guidance in identifying specific contexts most conducive to sitting less, and developing 'if-then' plans for reducing sitting	10 (35%)
	<i>Habit Formation</i> <i>(only offered to those selecting Action Planning)</i>	Summary of psychological theory and evidence around how actions (e.g. sitting) become habitual via context-dependent repetition of the action	10 <i>(100% of those choosing Action Planning)</i>
	<i>Problem Solving</i>	Guidance on shielding an intended action (e.g. standing) from derailment in specific contexts, e.g., by identifying barriers and developing strategies to overcome them	1 (3%)
	<i>Habit Disruption</i> <i>(only offered to those selecting Problem Solving)</i>	Summary of psychological theory and evidence around how to obstruct unwanted habitual responses, either by avoiding cues (e.g. putting barriers in place) or adopting strategies to	1 <i>(100% of those choosing Problem Solving)</i>

		enhance likelihood of wanted response to habit cues (e.g., point-of-decision reminders)	
Motivation	<i>Information on Health Consequences</i>	Detailed summary of evidence around health risks of sitting and benefits of standing and light activity	1 (3%)
	<i>Information on Others' Experiences</i>	Testimonies from workers who had attempted to reduce sitting and increase standing in the workplace, derived from previous qualitative studies of sitting reduction, and descriptions of famous standing-workers (e.g. Dickens, Hemingway)	3 (10%)
	<i>Common Misconceptions</i>	List of potentially detrimental misconceptions about reducing sitting in the workplace, paired with evidence-based rebuttals	1 (3%)
Opportunity	<i>Tips for Standing</i>	Tips for incorporating more standing in to the workday: speaking to colleagues in person rather than emailing; standing in meetings; standing on the phone; walking during lunch; taking the stairs	4 (14%)
Various	<i>Tips for SSW use</i>	Tips for increasing likelihood of (ergonomically-sound) SSW use: leave the unit in standing position when leaving the office; move office	<i>Compulsory (delivered to all participants)</i>

		chair away or cover with objects; increase SSW use gradually; ensure correct standing posture; shift weight from foot to foot; wear flat shoes or go barefoot while standing	
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Table 3. Minutes spent sitting, standing and stepping times per 8h workday, across study timepoints

	<b>Baseline (-1-0 weeks) N = 29</b>	<b>Post-intervention 1 (0-1 weeks) N = 21</b>			<b>Post-intervention 2 (5-6 weeks) N = 18</b>			<b>Post-intervention 3 (11-12 weeks) N = 16</b>		
	<i>Mean (SD)</i>	<i>Mean (SD)</i>	<i>Mean difference from baseline* (SD)</i>	<i>Cohen's d</i>	<i>Mean (SD)</i>	<i>Mean difference from baseline* (SD)</i>	<i>Cohen's d</i>	<i>Mean (SD)</i>	<i>Mean difference from baseline* (SD)</i>	<i>Cohen's d</i>
<b>Sitting</b>	355 (14)	305 (18)	-47 (82)	-0.50	237 (17)	-101 (103)	-1.13	245 (20)	-100 (100)	-1.08
<b>Standing</b>	82 (13)	131 (17)	51 (75)	0.56	198 (16)	101 (94)	1.17	194 (20)	101 (99)	1.11
<b>Stepping</b>	43 (3)	4 (21)	-5 (21)	-0.22	45 (4)	0 (18)	-0.01	40 (4)	0 (14)	0.03

\* Mean differences from baseline pertain to participants for whom data were available at each timepoint. For this reason, values do not correspond to the difference between the mean of each baseline timepoint (Ns<29) and the baseline mean where N = 29.