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

Prolonged sitting is associated with poor mental and physical health and premature death [1–4]. Office workers typically sit for two-thirds of their waking day, so are at particular risk [5, 6]. Offsetting this risk requires displacing sitting with standing or light activity. Expert guidance recommends that workers regularly break up sitting and accumulate 2-4h standing per 8h workday [7]. Sitting-reduction interventions are needed to achieve these 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 90 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.

All those who expressed interest and were eligible attended the Preliminary Session, at which they provided consent and self-reported demographic characteristics (Table 1) and 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 posture-sensitive, and reliably distinguish sitting, standing, and stepping [22]. Participants 136 137 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.

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

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

*Reminders of intervention content:* Participants were given the option of receiving
email reminders over the 12-week intervention period of the key points from the Intervention
Session. Participants specified the desired content and receipt frequency of these emails. All
participants were emailed a summary of key points from the Intervention Session one day
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 11–12week post-intervention, were extracted using specialist software (activPAL<sup>TM</sup> Professional 175 176 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 transcribed verbatim. Across the three timepoints, interview duration ranged from 9 to 188 189 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
- income ranged from £1.5-2.4k to  $\geq$ £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),
- 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
- 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 likely to move to another bit of the office ... because I'm already standing"; P27, I1). For 249 250 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 *since starting [the intervention].* 255 Participants attributed improvements in posture, strength and balance ("since I've 256 257 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). "It's been a lot more tiring than I thought": Physical and practical challenges 262

- 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
- 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).
- Participants reported various practical barriers to SSW use, which many felt could not easily be used with equipment essential for work tasks, or for paper-based tasks. Some were able to adapt to the constraints imposed by the workstation:
- P17, I2: I might put paperwork on the bottom bit of the desk and my keyboard on the
  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 <u>"Everybody's been really interested": Social dynamics</u>
- 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
- 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:
- P15, I1: Everybody's been really interested ... they're saying 'oh, that's cool'. The
  novelty helps in terms of the motivation.
- Some felt more psychologically comfortable being approached by others when standing, which created more equitable power relationships ("*I enjoyed the aspect of being on 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*
- 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
- 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 had gone right back to the beginning again.
- 354
- 355

#### Discussion 356

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 and364 implementation recommendations for workplace sitting-reduction interventions.

Although only a small uncontrolled study, observed reductions in sitting time justify further development and testing of our intervention. Qualitative data pointed to potential reasons for declines in sitting. Device-based feedback raised awareness of sitting, in turn leading people to adopt a 'sit less, move more' mindset both in the workplace and elsewhere (e.g., when commuting; [25]). This testifies to the lack of attention people pay to sitting and 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

tasks to standing may therefore be based on personal preference. Interventions shouldencourage 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	v educated.	which	limits	the re	presentativeness	of the	experiences of	of our sa	mple.
		,								

- 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
- 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
- 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

- 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
- 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

		N (%)
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	A Level, AS Level, CSE, or GCSE	3 (10%)
qualification	Other technical or professional	2 (7%)
	Degree or higher	22 (76%)
	Non-UK qualifications	1 (3%)
	Other	1 (3%)

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

# Table 2. Behaviour change advice delivered in the Intervention Session

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

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	

Table 3. Mi	inutes spent sitting,	standing and	stepping times	per 8h workday.	across study timepoints
	I U	0		1 2	<b>v</b> 1

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