UNIVERSITY *of York*

This is a repository copy of *Stand Out in Class:Restructuring the classroom environment to reduce sitting time – findings from a pilot cluster randomised controlled trial*.

White Rose Research Online URL for this paper:
https://eprints.whiterose.ac.uk/id/eprint/159735/

Version: Accepted Version

White Rose
university consortium
Universities of Leeds, Sheffield & York

eprints@whiterose.ac.uk
https://eprints.whiterose.ac.uk/

1   **Stand Out in Class: Restructuring the classroom environment to reduce sitting time**

2   **– findings from a pilot cluster randomised controlled trial**

3

4   Stacy A Clemes[1,2*], Daniel D Bingham[3], Natalie Pearson[1], Yu-Ling Chen[1], Charlotte L

5   Edwardson[2,4], Rosemary R C McEachan[3], Keith Tolfrey[1,2], Lorraine Cale[1], Gerry

6   Richardson[5], Mike Fray[6], James Altunkaya[5], Stephan Bandelow[1,7], Nishal Bhupendra

7   Jaicim[8], Jo Salmon[9], David W Dunstan[10,11], Sally E Barber[3]

8

9   [1]National Centre for Sport and Exercise Medicine, School of Sport, Exercise and Health

10   Sciences, Loughborough University, Loughborough, UK

11   [2]NIHR Leicester Biomedical Research Centre, Leicester, UK

12   [3]Bradford Institute for Health Research, Bradford Teaching Hospitals Foundation Trust,

13   Bradford, UK

14   [4]Diabetes Research Centre, University of Leicester, Leicester, UK

15   [5]Centre for Health Economics, University of York, Heslington, York, UK

16   [6]Loughborough Design School, Loughborough University, Loughborough, UK

17   [7]Department of Physiology, Neuroscience and Behavioral Sciences, St. George's

18   University, Grenada, West Indies

19   [8]Leicester Clinical Trials Unit, University of Leicester, Leicester, UK

20   [9]Institute for Physical Activity and Nutrition, School of Exercise and Nutrition Sciences,

21   Deakin University, Melbourne, Australia

22   [10]Baker Heart and Diabetes Institute, Melbourne, Australia

23   [11]Mary MacKillop Institute for Health Research, Australian Catholic University, Melbourne,

24   Australia

25

26   *Corresponding author S.A.Clemes@lboro.ac.uk

Abstract

Background: Excessive sedentary behaviour (sitting) is a risk factor for poor health in children and adults. Incorporating sit-stand desks in the classroom environment has been highlighted as a potential strategy to reduce children's sitting time. The primary aim of this study was to examine the feasibility of conducting a cluster randomised controlled trial (RCT) of a sit-stand desk intervention within primary school classrooms.

Methods: We conducted a two-armed pilot cluster RCT involving 8 primary schools in Bradford, United Kingdom. Schools were randomised on a 1:1 basis to the intervention or usual practice control arm. All children (aged 9-10 years) in participating classes were eligible to take part. Six sit-stand desks replaced three standard desks (sitting 6 children) in the intervention classrooms for 4.5-months. Teachers were encouraged to use a rotation system to ensure all pupils were exposed to the sit-stand desks for >1 hour/day on average. Trial feasibility outcomes (assessed using quantitative and qualitative measures) included school and participant recruitment and attrition, intervention and outcome measure completion rates, acceptability, and preliminary effectiveness of the intervention for reducing sitting time. A weighted linear regression model compared changes in weekday sitting time (assessed using the activPAL accelerometer) between trial arms.

Results: School and child recruitment rates were 33% (n=8) and 75% (n=176). At follow-up, retention rates were 100% for schools and 97% for children. Outcome measure completion rates ranged from 63–97%. A preliminary estimate of intervention effectiveness revealed a mean difference in change in sitting of -30.6 minutes/day (95% CI: -56.42 to -4.84) in favour of the intervention group, after adjusting for baseline sitting and wear time. Qualitative measures revealed the intervention and evaluation procedures were acceptable to teachers and children, except for some problems with activPAL attachment.

Conclusion: This study provides evidence of the acceptability and feasibility of a sit-stand desk intervention and evaluation methods. Preliminary evidence suggests the intervention

53 showed potential in reducing children's weekday sitting but some adaptations to the desk

54 rotation system are needed to maximize exposure. Lessons learnt from this trial will inform

55 the planning of a definitive trial.

56 **Trial registration:** ISRCTN12915848 (registered: 09/11/16)

57

58 **Keywords**

59 Standing desks; sit-stand desks; primary/elementary school; sedentary behaviour;

60 Bradford; South Asian; children; health inequalities

Background

Advances in technology and changes to our environments have resulted in sedentary behaviour becoming ubiquitous within all settings of daily life. Sedentary behaviour is distinct from physical (in)activity and is defined as 'any waking behaviour characterised by an energy expenditure ≤1.5 metabolic equivalents (METs) while in a sitting, reclining or lying posture' [1]. In the UK, sitting is the most prevalent behaviour exhibited during waking hours in children, typically accounting for over 65% (~7.5 hours/day) of waking time [2], with some children reportedly sitting for over 10 hours/day [3]. Sedentary time is associated with an increased risk of a number of chronic conditions in adults, including cardiovascular disease, type 2 diabetes and all-cause mortality [4-7]. Whilst evidence of the associations of sedentary time with increased risk of adiposity/weight gain and clustered cardiometabolic risk in children is largely restricted to screen time [8], sedentary behaviours have been shown to increase across key transitions in children's lives (e.g. from primary to secondary school) [9] and track into both adolescence [10] and adulthood [11]. Reducing children's sitting time may therefore be important for the primary prevention of chronic diseases in adulthood [12].

The emergence of an increased cardiometabolic health risk profile in some population groups is evident during the first decade of life [13]. For example, British South Asian children have demonstrated higher glycated haemoglobin, fasting insulin and triglyceride and lower high-density lipoprotein-cholesterol levels compared to white British children as well as higher levels of fat mass percentage [14, 15]. Higher levels of sedentary behaviour (ranging between an additional 28 to 39 minutes/day) have also been observed in South Asian school-aged children (aged 6 – 11 years) in comparison to White British children [16, 17]. Given the links between sedentary behaviour and cardiometabolic risk [8], early interventions in such at risk groups may help reduce health inequalities later in life.

4

87

88   The environments and social norms that children are exposed to have dominant influences

89   on their activity behaviour [18]. Given children spend half of their waking hours at school, it

90   is plausible that the school environment may be a critical influence on their health

91   behaviour patterns [19-21] and be an appropriate setting for interventions [22], particularly

92   in relatively deprived locations with higher levels of health inequalities. Indeed, there has

93   been a growing interest in the use of sit-stand desks (desks which provide children with

94   the opportunity to alternate their posture between sitting and standing) within the

95   classroom environment as a tool to reduce sedentary behaviour. Classroom-based

96   interventions have the potential to target health inequalities because they are accessible to

97   all children [12].

98

99   Systematic and narrative reviews of sit-stand desk interventions within the classroom

100   environment have concluded that this approach shows promise as an effective tool for

101   reducing children's sitting time and increasing movement. However the majority of studies

102   included in these reviews have been feasibility trials or small-scale single-school pilot

103   studies [23-25]. Knowledge of the impact of sit-stand desks on sedentary behaviour,

104   markers of adiposity and pupil behaviour is currently limited by a lack of randomised

105   controlled trials (RCTs) [26, 27], and relatively small samples (median sample size across

106   studies: 45 [24, 26-30]). Furthermore, there has been a limited focus on the acceptability of

107   this intervention approach in the form of qualitative feedback from teachers and pupils, and

108   in understanding pupils' experiences and responses (for example, in-class behaviour) to

109   using sit-stand desks [26, 31, 32]. The above factors will be vital to establish prior to

110   schools agreeing to the longer-term adoption of this strategy [23, 24, 26]. Limited research

111   in this area has also been conducted within relatively deprived locations and/or higher-risk

112   populations, such as South Asian children.

113

We have previously demonstrated the feasibility of incorporating sit-stand desks in the

classroom environment over a 9-week period in a small non-randomised controlled study

conducted within one UK primary school with children aged 9-10 years [33]. In this novel

intervention, three standard desks (sitting six children) were replaced with six sit-stand

desks in one classroom. The teacher (who received training in intervention delivery)

rotated the children in the intervention classroom, using naturally occurring breaks

between lessons to do so, to ensure each child was exposed to the desks for at least one

hour/day. Children in a control group (within the same school) continued with their usual

practice, and no environmental changes were made to their classroom. Reductions in total

daily sitting time of 81 mins/day on weekdays (school days) after 9-weeks were seen in the

intervention group. As part of this feasibility work, changes in sitting observed in the

sample were compared to data from a related feasibility study conducted in a primary

school in Melbourne, Australia [33]. Within the Melbourne-based study, every child in the

intervention classroom had a sit-stand desk. No significant differences in reductions in

weekday total sitting time were observed between studies, demonstrating the potential of

this intervention, over the short-term, to reduce children's daily sitting time irrespective of

the different approaches to sit-stand desk provision employed.

131

This paper reports the findings of a pilot cluster RCT, conducted in a relatively socially

deprived location within the UK. Rapid increases in sedentary time have been observed in

children aged 11 years and above [34]. This study therefore targeted year 5 classrooms

and involved children aged 9-10 years, with the goal of mitigating the typical rise in

sedentary time seen during the transition into adolescence [9]. The aim of this study was

to examine the feasibility of a protocol for a cluster RCT of a sit-stand desk intervention

within primary school classrooms. If deemed feasible, a fully powered cluster RCT could

provide valuable evidence on the effectiveness and cost-effectiveness of a sit-stand desk

intervention within primary school classrooms, incorporating device-based measures of

sitting and activity and a range of health and behaviour-related outcomes. The breadth and

findings of the present study are essential to inform a full trial and the potential longer-term

adoption of sit-stand desks in primary schools. Objectives of this pilot trial included: 1)

evaluating the feasibility and acceptability of recruiting schools and children into the trial; 2)

determining attrition in the trial (schools and children); 3) evaluating the acceptability of the

intervention and randomisation to teachers and children; 4) determining the acceptability

and completion rates of the outcome measures; 5) monitoring the occurrence of any

adverse events of the intervention (or a sit-stand desk); and 6) exploring the potential of

the intervention to reduce children's device-based measurement (activPAL) of weekday

sitting time (the proposed primary outcome in a full trial), and describing the proposed

secondary outcome measures collected at baseline and follow-up (device-based

measurement of physical activity, adiposity, blood pressure, in-class behaviour, and

learning engagement).

Methods

Design

The detailed protocol for this pilot trial has been reported elsewhere [12]. The study was a

school-based, two-armed pilot cluster RCT. Individuals (children aged 9-10 years) were

the unit of analysis and schools (clusters) were stratified according to predominant pupil

ethnicity (either >50% White British pupils, or >% South Asian pupils) and randomly

assigned to one of two conditions: 1) six manually adjustable sit-stand desks incorporated

into the classroom environment (intervention condition), or 2) current practice (control

condition). Given the intervention was delivered at the classroom level, rather than

individual level, a cluster design was considered appropriate. Baseline measurements

165   (November 2016) preceded randomisation (December 2016), and the sit-stand desks were

166   installed into the intervention classrooms following this (February 2017, remaining until

167   July 2017). An identical set of outcome measurements were taken from all participants

168   approximately 7-months after baseline testing at the end of the year 5 school term (July

169   2017). The reporting of this trial follows the CONSORT extension statement for cluster

170   trials [35] and the CONSORT checklist is provided as supplementary material.

171

172   ***Study setting***

173   The study was conducted in primary schools in Bradford, a northern city in England,

174   chosen as the study location given its ethnic composition (predominantly South Asian and

175   White British) and high levels of deprivation, health inequalities and childhood morbidity

176   [36]. Half of all babies born in Bradford are of South Asian origin and 60% are born into the

177   poorest 20% of the population [36]. The study setting was deemed fundamental in

178   addressing the important issue of health inequalities, with classroom-based interventions

179   being accessible to all children [12].

180

181   ***Sample size***

182   A recruitment target of eight primary schools, each with at least 15 child participants per

183   class (approximately 50% of a typical class size) was set, giving a minimum total sample

184   of 120. This exceeds the target minimum sample size recommended for pilot trials [37]. It

185   was also assumed that this sample size should be sufficient to provide clear estimates of

186   recruitment and follow-up to inform a full RCT [12].

187

188   ***School and participant recruitment and eligibility criteria***

189   Government-funded primary schools located in the City of Bradford were invited to

190   participate in the study. Private and designated special educational needs schools and

191 schools with fewer than 25 pupils in year 5 (ages 9-10 years) were not eligible. The aim

192 was to recruit four schools with predominantly South Asian pupils (>50%) and four with

193 predominantly White British pupils (>50%). Information on the ethnic composition of the

194 schools' pupil population was determined using local school census data [12].

195

196 The following three-stage recruitment process was adopted for schools: 1) head

197 teachers/senior teachers were sent an email detailing the study, which included a copy of

198 an Information Sheet for Schools; 2) two days after sending the email, the schools were

199 contacted via telephone and the reception team were asked to confirm receipt of the email;

200 3) a follow-up telephone call was made to establish the schools' interest or otherwise in

201 participating in the study. A designated lead teacher was identified for each interested

202 school who was then given full details of the study and what their involvement would entail.

203

204 Consenting schools were asked to nominate a year 5 class and were provided with

205 invitation packs for the parents/guardians of children within these classes. All children

206 within participating classes were eligible to take part in the evaluation. The invitation pack

207 contained a detailed Information Sheet for Parents/Guardians, an opt-in consent form for

208 the parent/guardian to complete and return if they were happy for their child to participate

209 in the evaluation, and an Information Sheet for Children. Completed consent forms were

210 returned by pupils to their teacher, who informed the research team of the children who

211 were to be involved in the evaluation measures. At the beginning of the baseline

212 measurement session, all methods were fully explained to children by a member of the

213 research team at which time they were asked to provide verbal and written assent. This

214 was requested again at the start of the follow-up measurement sessions.

215

216

217 ***The 'Stand Out in Class' intervention***

218 Six height-adjustable sit-stand desks (LearnFit, Ergotron Inc, USA) were placed in a year 5

219 classroom (replacing three standard desks sitting 6 children) in each intervention school

220 for two school terms, spanning 4.5 months. The research team supported teachers in the

221 development of a classroom rotation plan to ensure all children in their class were exposed

222 to the sit-stand desks for at least one hour/day on average across the week. Stools or

223 chairs remained in the classroom and while children were free to choose whether they sat

224 or stood when using the sit-stand desks, they were encouraged to stand by teachers, as

225 well as through the use of nudge prompts displayed on the desks and standing champions

226 (i.e. one child in a class who was given the responsibility of reminding the teacher about

227 the rotation plan) (see Figure 1)[12].

228

229 Teachers and pupils in the intervention classrooms received training on sit-stand desk use

230 by the research team and teachers also received a 'Professional Development Manual'

231 containing information on the health benefits of reducing prolonged sitting and on correct

232 posture when standing at the desks. The teacher manual and training focussed on

233 encouraging adoption of the intervention, targeting key barriers and facilitators to sit-stand

234 desk use. These were identified from: our previous work [33, 38]; the Capability,

235 Opportunity, and Motivation to perform a Behaviour (COM-B) model within the Behaviour

236 Change Wheel [39]; and the Theoretical Domains Framework [40] (e.g. self-efficacy,

237 motivation and knowledge). Standardised behaviour change techniques (e.g. goal setting,

238 instruction) [41] were also used during the training with teachers and pupils [12]. Further

239 details of the intervention, including an overview of the intervention components and

240 potential barriers, solutions, and hypothesised mediating processes informed by the above

241 theoretical frameworks are reported elsewhere [12]. A logic model for the Stand Out in

242 Class intervention, applicable for a definitive trial, is presented in Figure 1.

Insert Figure 1 about here

244 ***The usual practice control arm***

245 To compare the effects of the intervention against usual practice (i.e. the provision of

246 standard classroom desks), schools assigned to the control arm were requested to

247 continue with their usual practice and lesson delivery; no environmental changes were

248 made to their classrooms [12].

249

250 ***Allocation to treatment groups***

251 Schools were stratified based on the ethnic composition of their pupils. Following baseline

252 measurements, schools within each stratum were randomised into the two study arms

253 using an allocation ratio of 1:1, employing a randomisation list in SAS software, by an

254 independent statistician at the Leicester Clinical Trials Unit (CTU). Two schools with

255 predominantly South Asian pupils (>50%) and two schools with predominantly White

256 British pupils (>50%) were randomised into the intervention and control arms (4 schools in

257 each arm).

258

259 ***Outcome measurements***

260 The primary outcomes of this pilot trial were the feasibility and acceptability of the research

261 procedures (including recruitment, data collection, randomisation, acceptability of the

262 intervention, retention, and the presence of any adverse events) to inform the planning of a

263 full RCT. A detailed process evaluation describing teachers' and children's experiences of

264 the intervention is reported elsewhere [42]. Study uptake was monitored by recording the

265 number of schools and pupils approached, and the number agreeing to participate

266 (objective 1). Withdrawal rates of schools and children were recorded (objective 2). The

267 acceptability of recruitment (objective 1), the intervention and randomisation (objective 3),

268 and the acceptability of outcome measures (objective 4) were determined via focus groups

11

269 with children and interviews with teachers. Furthermore, completion rates of the outcome

270 measures were recorded (objective 4), along with the occurrence of any study-related

271 adverse events (objective 5).

272

273 Interviews with teachers and focus groups with children from both trial arms were

274 conducted approximately 1 month following randomisation to explore the acceptability of

275 recruitment (example question: '*What did you think about the way that you were asked to*

276 *take part in the Stand Out in Class Study?')*, randomisation (example question: '*What did*

277 *you think about being randomised to one of the 2 school groups in the study*

278 *[control/intervention]?'*), and the measurement instruments (example question to children:

279 *'What was your view about wearing the thigh worn device for 7 days?*'). The acceptability

280 of the intervention was determined through a further set of interviews (with teachers) and

281 focus groups (with children) from the 4 intervention schools during the final month of the

282 intervention. An example question to intervention teachers and children included: '*What*

283 *has been your experience so far of the sit-stand desks being part of your classroom?'*.

284

285 Four male (3 control group, 1 intervention) and 4 female (1 control, 3 intervention)

286 teachers participated in the study. A total of 43 children, 22 boys and 21 girls, took part in

287 the focus groups following randomisation (8 focus groups were conducted, 1 per school)

288 and 24 children, 10 boys and 14 girls, participated in the focus groups towards the end of

289 the trial (4 intervention schools only). Teachers selected children in their class for

290 participation in the focus groups. Within the intervention classes, there may have been

291 some overlap between children participating in the first and second focus groups (at the

292 end of the trial). All interviews and focus groups, across both phases, used semi-structured

293 topic guides to ensure consistency. The focus group topic guides were written in child

294 friendly language. All interviews and focus groups were audio-recorded digitally.

295

296   Device-based sitting was measured for 7 consecutive days during each measurement

297   period using the activPAL3 micro accelerometer (PAL Technologies, UK). This device has

298   been shown to provide a valid measure of posture in children [43]. All activPALs were

299   initialised and downloaded using manufacturer proprietary software (activPAL Professional

300   v.7.2.32) and data were processed using the freely available ProcessingPAL Software

301   (https://github.com/UOL-COLS/ProcessingPAL, version 1.1, University of Leicester,

302   (Leicester UK)). The activPAL3 was waterproofed (using a nitrile sleeve and

303   hypoallergenic Hypafix [BSN Medical] dressing) and participants were requested to wear

304   the device continuously (24 hours/day) on the anterior aspect of their right thigh. The

305   device was attached using Hypafix dressing. Participants were provided with a brief diary

306   during each monitoring period in which they were requested to document time in bed and

307   any periods of non-wear [12]. Periods of prolonged non-wear and time in bed were

308   removed from the data using the default algorithm rules within Processing PAL [44].

309   Briefly, the algorithm searches within event files (created in the activPAL Professional

310   software) to identify prolonged bouts of behaviour (sitting, standing) within a noon-noon

311   period. If they meet the criteria they are coded as time in bed/non-wear (no distinction). To

312   accommodate fragmented sleep patterns, the algorithm searches around these identified

313   bouts for other prolonged bouts of behaviour occurring after brief upright activity. If they

314   meet the criteria, the identified bouts and the upright activity are also coded as time in

315   bed/non-wear. Once time in bed and non-wear were excluded, a day was considered

316   valid if it consisted of ≥8 hours of waking wear data, <95% of time spent in any one

317   behaviour (e.g., sitting, standing, or stepping) and ≥500 single leg steps (i.e., ≥1000 steps)

318   [44]. Due to the exploratory nature of this study, children were included in the analysis

319   relating to objective 6 (exploring the potential of the intervention to reduce children's

320 weekday sitting time) if they had worn the activPAL for at least 8 hours on at least 1

321 weekday at baseline and follow-up.

322

323 Proposed secondary outcomes for a future full trial included device-based measured

324 physical activity, using the ActiGraph GT3X+ accelerometer (ActiGraph, Pensacola, FL)

325 worn on an elasticated belt at the waist continuously (24 hours/day) for 7 consecutive

326 days, concurrently with the activPAL. The feasibility of collecting ActiGraph data, in

327 addition to activPAL data, was examined to inform a full trial, where this device could be

328 used as a secondary outcome to examine any positive or negative (i.e. compensatory)

329 effects of the intervention on physical activity either during or after school hours.

330 ActiGraphs were initialised to record data at 60 Hz. The devices were initialised and

331 downloaded using ActiLife version 6.13.3, and the data (reintegrated into 15 second

332 epochs) were processed using specifically developed and commercially available software

333 (KineSoft version 3.3.20, Loughborough UK). Time spent in light (26 – 573 counts per 15

334 second epoch) and moderate-to-vigorous intensity (≥574 counts per 15 second epoch)

335 activity were determined using the Evenson cut-points [45]. Due to the 24-hour wear

336 protocol of the ActiGraphs, a blanket removal of sleep time between 11pm and 5.59am

337 was undertaken when processing these data. However, to identify periods of sleep and/or

338 non-wear occurring outside of this time period (i.e. after 6am and before 11pm), the 3-axis

339 acceleration data from the ActiGraph were used to detect periods of no movement. If these

340 periods exceeded 20 minutes of zero counts, then this additional period was excluded as

341 non-wear/sleep time. The same wear time criteria as applied to the activPAL data (a

342 minimum of 8 hours of wear on at least one weekday) was also applied to the ActiGraph

343 data.

344

345   At each measurement point children's height and body mass (without shoes) were

346   measured directly using standard procedures by trained research staff. Body composition

347   was assessed using bio-impedance analysis scales, suitable for use with children (Tanita

348   DC-360S). Blood pressure was measured from the left arm after at least a five minute

349   period of quiet sitting using a semi-automated recorder (Omron HEM-907) with a

350   paediatric cuff, in accordance with current recommendations [46]. Three assessments

351   were taken with each measurement separated by a two-minute rest period and the mean

352   systolic and diastolic blood pressures recorded from the second and third assessments

353   were calculated.

354

355   The impact of the intervention on participants' behaviour was assessed using the

356   Strengths and Difficulties questionnaire [47], a measure of pro-social behaviour, emotional

357   symptoms, conduct problems, hyperactivity and peer problems, completed by teachers at

358   baseline and follow-up. The questionnaire consists of 25 items, with five items per scale,

359   which receive a score from 0 to 2. A total difficulties score is calculated by summing the

360   scores from the first four scales, with higher scores indicating increased behavioural

361   difficulties [47]. In addition, children self-reported their engagement and disaffection with

362   their own learning via the Engagement Versus Disaffection with Learning questionnaire

363   [48]. This questionnaire assesses behavioural engagement and behavioural disaffection,

364   using five items each, along with emotional engagement, using five items, and emotional

365   disaffection, using 12 items. Each item is scored on a 1 to 4 scale, with higher values

366   indicating increased levels of engagement and reduced disaffection. Mean scores are

367   calculated across the two engagement and disaffection categories to provide an overall

368   indication of engagement and disaffection levels [49].

369

370 Children furthermore completed the Paediatric Quality of Life Inventory (PEDS-QL) [50]

371 and EuroQol 5-dimension Youth (EQ-5D-Y) [51] at each measurement point to provide a

372 measure of self-reported quality of life to inform an economic analysis in a full trial. Basic

373 demographic information (sex, age, ethnicity) were reported by children at baseline. Full

374 details of all measurement instruments, along with information on their validity has been

375 reported elsewhere [12].

376

377 ***Quantitative and qualitative analyses***

378 *Trial feasibility and acceptability*

379 As this was a pilot trial, the primary analyses (the purpose of which was to assess the

380 feasibility of conducting a cluster RCT of a sit-stand desk intervention within primary

381 school classrooms) mainly utilised descriptive statistics summarising: the number of

382 schools approached, the number agreeing to participate, and the proportion of children

383 within each school with parental/guardian consent, and giving their assent, to participate in

384 the study evaluation (objective 1); retention rates (schools and children) (objective 2);

385 outcome measure completion rates and compliance (objective 4); and the documentation

386 of any study-related adverse events (objective 5).

387

388 The acceptability of recruitment (objective 1), randomisation and the intervention (objective

389 3), along with the acceptability of the outcome measures (objective 4) were determined

390 through qualitative analyses of the pupil focus groups and teacher interview data. Audio

391 recordings were transcribed verbatim with anonymisation of all personal data. To address

392 the objects within the present paper, sample quotes which reflect common responses

393 across the questions asked are provided (a detailed process evaluation is reported

394 elsewhere[42]). Extracts from the focus groups and interviews are labelled to indicate the

395 participant (Child/Teacher), group (I = intervention, C = control) and school (number 1-4

396 within each trial arm).

397

398 *The potential of the intervention to reduce children's weekday sitting time, and a summary*

399 *of the proposed secondary outcomes for inclusion in a full trial (objective 6)*

400 An objective of this study was to examine the potential of the intervention to reduce

401 children's weekday sitting time (the proposed primary outcome in a full trial). As the

402 number of clusters was low, cluster summary statistics were used rather than multi-level

403 modelling [52, 53]. A weighted linear regression model compared the change in mean

404 weekday sitting time between follow-up and baseline between control and intervention arm

405 participants. The model was adjusted for baseline total daily sitting time on school days

406 and average weekday wear time across the two measurement points. Subsequent models

407 adjusted for the season in which the baseline and follow-up measures were taken. Since

408 the variables in the regression model reflect cluster means rather than individual

409 observations, an analytically weighted least squares method of estimation was used,

410 where cluster sizes were the weights. The results from this analysis should, however, be

411 treated as preliminary and interpreted with caution given the lack of statistical power [54,

412 55]. Statistical analyses were undertaken using Stata version 15.1 (StataCorp, Texas,

413 USA), and were validated by an independent trial statistician at the Leicester CTU.

414

415 Descriptive statistics were calculated to summarise the proposed secondary outcomes

416 (device-based measured time spent in light intensity and moderate-to-vigorous intensity

417 activity on weekdays, adiposity, blood pressure, behaviour, and learning engagement)

418 measured at baseline and follow-up.

419

420

Results

Trial feasibility and acceptability

Twenty-four eligible schools were approached and of these the target number of eight schools consented to participate, with the overall recruitment rate being 33% (95% CI: 16 to 55%). Twelve schools did not consent to join the study (50%) and four did not respond to the initial email (17%). All eight participating schools completed the trial (100% retention). Data from the 2016-2017 school census [56] show that the proportion of children eligible for free school meals was similar across the recruited schools and the declined schools (mean: 17.1% [range: 2.3%, 26.4%] vs. 17.4% [9.6%, 28.5%]), with these values being higher than the national average of 14.8% in 2016-2017.

The proportion of pupils at the eight schools with parental consent to participate in the trial evaluation was 75% (176 out of 234), exceeding the target minimum sample of 120 [12]. At follow-up, retention of participating children was 97% (170 out of 176). A CONSORT flow diagram is shown in Figure 2. Two pupils in the control group were unable to provide follow-up measures as they were absent from school on the days they were taken. Three children (1 control, 2 intervention) moved away from the area during the study and hence changed schools. One control group participant withdrew their assent prior to the follow-up measures. The demographic characteristics of the participating children at baseline are shown in Table 1.

Insert Figure 2 about here

446   **Table 1**. Demographic characteristics of the participating children, by group and total

447   sample.

		Control (n = 90)	Intervention (n = 86)	Overall (n = 176)
Sex, n (%)	Male	50 (55.6%)	48 (55.8%)	98 (55.7%)
	Female	44 (44.4%)	38 (44.2%)	78 (44.3%)
Ethnicity, n (%)	White British	18 (20.0%)	45 (52.3%)	63 (35.8%)
	South Asian	59 (65.6%)	26 (30.2%)	85 (48.3%)
	Other	13 (14.4%)	15 (17.4%)	28 (15.9%)
Age	Mean (SD)	9.3 (0.5)	9.3 (0.4)	9.3 (0.5)

448

449

450   Completion rates of the proposed outcome measures for inclusion in a full RCT at baseline

451   and follow-up are shown in Table 2. The table also displays the proportion of children

452   providing valid activPAL and ActiGraph data on at least 1, 2, 3, 4 and all 5 weekdays.

453

454

455

456

457

458

459

460

461

462

463

464 **Table 2.** Total sample outcome measure compliance and completion rates at baseline and
465 follow-up

	Baseline	Follow-up	Both baseline and follow-up
activPAL data on weekdays*			
≥1 valid day	80.1%	76.1%	63.1%
≥2 valid days	74.4%	66.5%	51.7%
≥3 valid days	65.3%	53.4%	39.2%
≥4 valid days	54.5%	42.6%	27.3%
5 valid days	18.2%	16.5%	5.7%
ActiGraph data on weekdays*			
≥1 valid day	94.3%	87.5%	83.5%
≥2 valid days	89.8%	78.4%	73.3%
≥3 valid days	85.2%	65.3%	58.0%
≥4 valid days	75.0%	50.0%	42.6%
5 valid days	25.6%	11.4%	5.1%
Anthropometric measures	98.9%	95.5%	94.3%
Body composition	98.9%	94.9%	93.8%
Blood pressure	77.8%	89.8%	70.5%
Engagement vs Disaffection with Learning (child reported)	97.7%	96.0%	93.8%
Strength and Difficulties questionnaire (teacher reported)	91.5%	94.9%	90.3%
PEDS-QL	83.0%	93.2%	83.0%
EQ-5D-Y	94.6%	94.6%	94.6%

466 *A valid day for the activPAL and ActiGraph constituted at least 8 hours of wear on a
467 weekday
468

469   No serious adverse events were reported throughout the duration of the trial. Specifically,

470   there were no adverse effects associated with the intervention that related to

471   musculoskeletal discomfort and/or disruption to the classroom or to reported learning.

472

473   All eight teachers expressed high satisfaction with the recruitment protocol, with all stating

474   the study had been clearly explained:

475   *"Yeah, it was very well explained and the ideas and the concept behind what you*

476   *were doing, so I had no hesitation accepting really."* (Teacher, C1)

477

478   Teachers also commented that the recruitment approach was appropriate and suitable for

479   children:

480   *"It worked well. I think you got quite a good uptake…as a class, so obviously what*

481   *you were sending out and the conversations you were having with the children got*

482   *them quite enthused. I think with them, with the children they're doing something*

483   *scientific because they all sort of really love science, the idea of doing something*

484   *scientific with scientists is like "yay!" So they jumped on that."* (Teacher, C2).

485

486   Children across all focus groups reported that recruitment had been positive for them, the

487   study made clear, and that everyone had a choice to participate:

488   *"It was good because once I got the letter, I didn't understand what it was.*

489   *[Researchers] told us about the letter and our teachers told us about it and told us*

490   *to tell our mum if we want to go or not because you first need permission off your*

491   *mum, and that's why it was a good process because you got told three times."*

492   (Child, I1).

493

494   *"It's more like you get to choose to take part and if you don't want to then it doesn't*

495   *matter."* (Child, I3).

496

497 When asked about the acceptability of randomisation, all teachers and children expressed

498 a clear understanding of why randomisation had occurred. Whilst control group teachers

499 and children were disappointed not to have worked with the sit-stand desks, they

500 considered their participation in the trial to be positive and important:

501   *"Well, I completely understand why you need to have a control. You know, we teach*

502   *the children, that certain investigations need a control, you need something to*

503   *compare it against…"* (Teacher, C3).

504

505   *"Because then you can look at the schools that have the tables and the schools that*

506   *didn't and look at the difference on health."* (Child, I3).

507

508 With regards to the acceptability of the activPAL (as a primary outcome measure for a full

509 trial), the most common theme identified from the responses related to issues with the

510 medical dressing used (Hypafix® transparent) to attach the monitor. This reportedly caused

511 a minority of children to suffer from itchiness, soreness and discomfort, and led to some

512 class disruption:

513   *"Yeah, it was a bit faffy. Some of the children did complain about getting a bit of a*

514   *rash, but they like to complain anyway, so it was a bit... I don't want to use the word*

515   *chaotic, but that was more to do with the fact that the kids were constantly*

516   *interested by them so they were focused on them…"* (Teacher, I1)

517

518 However, other teachers did not perceive the medical dressing to be particularly

519 problematic as only a few children had been affected:

22

520   *"…there were only a few complaints [about the dressing]…",* (Teacher, C2)

521

522   *"Only a couple of them had a little reaction to it."* (Teacher, I4*)*

523

524   During the focus groups with children, 10 out of 43 reported feeling some discomfort

525   related to the activPAL:

526   *"When you tried to take it off it really hurt."* (Child, C3)

527

528   *"When I took it off I had a bit of like a little rash or a few spots, from the underneath*

529   *because my leg got quite sweaty."* (Child, C1).

530

531   In contrast to the activPAL, the ActiGraph was regarded as a more acceptable device for

532   children to wear by all teachers and most children (38/43):

533   *"It didn't really annoy me at all and it felt like nothing was even there.*" (Child, C4)

534

535   The focus groups and interviews with intervention children and teachers conducted

536   towards the end of the study period revealed that the intervention was generally well

537   accepted by children and teachers. All teachers expressed that the desks had become

538   part of their classroom, and that any initial concerns they had had regarding the desks

539   causing a distraction had not materialised:

540   *"Yeah, well for me I'm now used to them so before, I think for the first month or so, I*

541   *was kind of looking at them as to how would they work, how well would they work*

542   *with the children, would it just be a distraction for them, but now it's, it's kind of just*

543   *the norm for the children, and we're kind of, we're used to them and every week*

544   *when we rotate round we, we just do it steadily."* (Teacher, I2).

545

546 The children felt having the desks in their classroom had been very positive, with key

547 themes including changing behaviour for the better, liking having the option to stand, and

548 appreciating the increased personal working space afforded by the desks:

549   *"they really change boys' behaviours because some boys, not me, are fidgety so it's*

550   *good for them to stand up."* (Child I4)

551

552   *"I like it because, like, every time you don't feel comfortable while sitting down, you*

553   *could just stand up and then you might feel more comfortable."* (Child, I3).

554

555   *"It's like it's a lot better than our tables because when we do our work, sometimes*

556   *Miss says, sit down to do our work but then now with the stand-up-sit-down tables*

557   *we can stand up more because I like working when I stand up especially when it's*

558   *stuff like art and stuff like that where you have to draw."* (Child, I4).

559

560   *"I liked it because it was only for one person to sit on, for each table. Because*

561   *normally, when we have to share a table, there's not enough space."* (Child, I2).

562

563 ***The potential of the intervention to reduce children's weekday sitting time***

564 An objective of this pilot trial was to examine preliminary evidence of the effectiveness of

565 the intervention in changing mean weekday sitting time, as the intervention was school

566 based. Total school day/weekday sitting time was chosen as this encompasses school

567 hours and out of school hours, and factors in any potential compensatory effects of the

568 intervention (i.e. increases in sitting after school). Table 3 displays the descriptive statistics

569 for all activPAL variables recorded throughout waking hours on weekdays for the control

570 and intervention groups.

571

572 **Table 3**. Descriptive statistics for the activPAL variables measured throughout waking

573 hours on weekdays.

Waking hours on weekdays	Baseline		Follow-up		Change	
	Control (n = 57)	Intervention (n = 52)	Control (n = 57)	Intervention (n = 52)	Control (n = 57)	Intervention (n = 52)
Wear time (min/day)	836.3	843.8	830.9	835.4	-3.7	-8.4
	(88.5)	(47.8)	(78.6)	(64.2)	(121.6)	(62.3)
Time spent sitting (mins/day)	520.1	514	504.4	472.0	-15.2	-42.0
	(83.6)	(61.5)	(94.0)	(73.5)	(107.5)	(76.6)
Time spent standing (mins/day)	179.9	195.4	176.5	197.1	-3.0	1.6
	(58.6)	(38.7)	(45.7)	(49.4)	(50.2)	(52.0)
Time spent stepping (min/day)	136.3	134.4	150.0	166.4	14.4	32.0
	(44.9)	(30.4)	(42.1)	(41.9)	(44.8)	(41.1)
Percentage of wear time spent sitting (%)	62.4	60.9	60.5	56.5	-2.0	-4.3
	(8.8)	(5.9)	(8.6)	(8.2)	(8.7)	(8.6)
Percentage of wear time spent standing (%)	21.4	23.2	21.5	23.6	0.1	0.4
	(6.3)	(4.5)	(6.1)	(5.7)	(5.9)	(5.8)
Percentage of wear time spent stepping (%)	16.2	15.9	18.1	19.9	1.9	3.9
	(4.7)	(3.5)	(4.8)	(4.6)	(4.6)	(4.6)
Number of sit to stand transitions	102.5	106.4	104.1	106.2	1.6	0.2
	(28.7)	(23.6)	(26.5)	(21.4)	(25.0)	(20.5)
Number of days worn	3.7	3.5	3.2	3.5	-0.5	0.0
	(1.3)	(0.9)	(1.2)	(1.4)	(1.4)	(1.8)

574 Data are presented as the mean (SD). This table includes data from participants who wore

575 the activPAL device with a minimum valid wear time of 8 hours each day on at least one

576 weekday at baseline and at 7-months follow-up.

577

578   The weighted linear regression model applied revealed the mean difference in change in

579   sitting time was -30.6 minutes/day (95% CI: -56.42 to -4.83) for the intervention group,

580   relative to the control group. The addition of baseline season of activPAL data collection to

581   the weighted linear regression model did not affect the difference in sitting time between

582   groups. When follow-up season was included in the model the adjusted difference in sitting

583   time between groups was -26.64 minutes/day (95% CI: -73.08 to 19.79).

584

585   Table 4 displays the descriptive statistics for all ActiGraph variables recorded throughout

586   waking hours on weekdays for the control and intervention groups. Both groups

587   demonstrated small changes in light intensity physical activity and moderate-to-vigorous

588   intensity physical activity (MVPA) over the follow-up period. Descriptive statistics for the

589   anthropometric, blood pressure and questionnaire measures (Engagement and

590   Disaffection with Learning and the Strengths and Difficulties questionnaire) collected from

591   participants at baseline and follow-up are shown in Table 5. The changes seen in the

592   anthropometric measurements over the follow-up period are reflective of typical growth-

593   related changes in children of this age. There were no noticeable between-group

594   differences in the mean changes in learning engagement and disaffection scores over the

595   trial period, and a small decrease in the total difficulties score (indicating improved

596   behaviour) in the intervention group relative to the control group over the follow-up period.

597

598

599

600

601

602

603   **Table 4**. Descriptive statistics for the ActiGraph variables measured throughout waking

604   hours on weekdays.

Waking hours on weekdays	Baseline		Follow-up		Change	
	Control (n = 74)	Intervention (n = 72)	Control (n = 74)	Intervention (n = 72)	Control (n = 74)	Intervention (n = 72)
Wear time (min/day)	885.1 (90.5)	882.6 (84.5)	827.7 (134.1)	852.9 (106.8)	-57.4 (125.9)	-29.7 (118.0)
Time spent in light PA (mins/day)	378.2 (61.9)	383.5 (68.6)	364.3 (81.2)	392.7 (70.8)	-13.9 (74.4)	9.3 (78.3)
Time spent in MVPA (min/day)	40.0 (20.5)	37.4 (17.9)	40.7 (30.9)	45.7 (24.7)	0.7 (24.5)	8.3 (20.0)
Percentage of wear time spent in light PA (%)	43 (6.4)	43.4 (6.2)	44.0 (6.9)	46.0 (6.0)	1.1 (5.5)	2.6 (5.6)
Percentage of wear time spent in MVPA (%)	4.6 (2.3)	4.3 (2.1)	5.0 (3.8)	5.4 (2.7)	0.5 (2.8)	1.1 (2.2)
Number of days worn	3.8 (1.4)	3.6 (1.3)	2.8 (1.5)	3.2 (1.6)	-1.0 (1.3)	-0.4 (1.3)

605   Data are presented as the mean (SD). This table includes data from participants who wore

606   the ActiGraph device with a minimum valid wear time of 8 hours each day on at least one

607   weekday at baseline and at 7 months follow-up.

608

609

610

611

612

613

614

615   **Table 5**. Anthropometric, blood pressure and questionnaire measurements

	Baseline		Follow-up		Change	
	Control (n = 90)	Intervention (n = 84)	Control (n = 85)	Intervention (n = 83)	Control (n = 85)	Intervention (n = 81)
Height (cm)	140.5 (6.6)	138.3 (6.2)	144.0 (6.8)	141.3 (6.4)	3.3 (1.7)	2.9 (1.0)
Body mass (kg)	36.3 (9.5)	35.0 (7.8)	39.2 (10.6)	37.7 (8.7)	3.0 (1.7)	2.7 (1.7)
Percent body fat – Girls[§]	24.4 (8.4)	23.6 (8.1)	23.7 (9.1)	25.0 (8.3)	-0.7 (2.1)	0.5 (2.8)
Percent body fat - Boys[§]	20.6 (8.9)	19.9 (6.9)	20.7 (8.9)	19.0 (6.6)	0.4 (2.6)	-0.9 (2.4)
BMI (kg/m^2)	18.2 (4.0)	18.2 (3.3)	18.7 (4.1)	18.8 (3.5)	0.6 (0.8)	0.6 (0.7)
Systolic blood pressure (mmHg)*	102.5 (11.8)	102.8 (15.2)	107.3 (11.7)	110.5 (11.2)	5.1 (15.8)	10.2 (17.8)
Diastolic blood pressure (mmHg)*	66.1 (10.2)	67.3 (14.1)	66.3 (9.5)	68.4 (9.7)	0.2 (12.1)	2.4 (16.2)
Engagement and Disaffection with Learning questionnaire sub-scale scores (child reported)						
	Control (n = 90)	Intervention (n = 82)	Control (n = 86)	Intervention (n = 83)	Control (n = 86)	Intervention (n = 80)
Overall Engagement	3.4 (0.5)	3.4 (0.5)	3.3 (0.6)	3.3 (0.5)	-0.1 (0.6)	-0.1 (0.5)
Overall Disaffection	3.1 (0.7)	3.1 (0.7)	3.2 (0.7)	3.1 (0.6)	0.1 (0.7)	0.0 (0.6)
Strengths and Difficulties questionnaire (teacher reported)						
	Control (n = 83)	Intervention (n = 78)	Control (n = 83)	Intervention (n = 84)	Control (n = 81)	Intervention (n = 78)
Total difficulties score	6.2 (5.7)	9.2 (7.6)	6.9 (6.0)	7.8 (6.6)	0.6 (4.6)	-1.3 (4.5)

616   Data are reported as the mean (SD). [§]Percent body fat sample sizes: girls, control n = 40,

617   intervention n = 35; boys, control n = 50; intervention n = 49. *The sample size for the

618   change in blood pressure measurements reduced to 54 control participants and 49

619   intervention participants.

620

621   **Discussion**

622   The purpose of this study was to undertake a pilot cluster RCT to test the feasibility and

623   acceptability of conducting and evaluating a school-based sit-stand desk intervention. The

624   findings confirmed that recruitment and attrition rates were acceptable to support

625   progression to a full trial, most outcome measures were acceptable, and the intervention

626   was well received. However, improvements to compliance with protocols for assessing the

627   proposed primary outcome (activPAL-determined sitting time) are needed. Furthermore,

628   preliminary evidence demonstrated the potential of the intervention in reducing children's

629   weekday sitting time, although the changes observed were not as large as those seen

630   previously within the same setting within a 9-week non-randomised controlled study

631   conducted in just one school [33].

632

633   The uptake into the study by schools (33% of those approached) is similar to recruitment

634   rates seen in other primary school-based interventions located in the same region [57] and

635   elsewhere in England [58]. Whilst all eight recruited schools were located predominantly in

636   urban areas within the Bradford metropolitan district, the study was effective in recruiting a

637   diverse range of schools in terms of the ethnic composition of their pupils within a relatively

638   deprived setting. Within the participating schools, parental consent and pupil assent to

639   participate was obtained for 75% (n = 176) of eligible pupils, exceeding our target

640   minimum sample size (120 participants) [12]. Furthermore, school and participant retention

641   rates within the trial were high (100% and 97% respectively). Overall, these findings

642   demonstrate the feasibility of recruiting and retaining schools and participants into a

643   school-based sit-stand desk RCT and suggest good interest and recognition of the

644 importance of the study by participating schools. Whilst schools have been identified as

645 important environments for health promoting interventions [22], the challenges of recruiting

646 schools and children, particularly via opt-in consent procedures (as adopted herein), and in

647 retaining participants, have been highlighted [59].

648

649 Most outcome measures were regarded as acceptable by children and teachers. Of the

650 physiological measures, lower compliance rates were seen for blood pressure, with some

651 children stating during the assessments that they found this measure uncomfortable.

652 Whilst modest (63%), the proportion of children providing valid activPAL data in the

653 present study is higher than that observed previously in the same study setting [33], and

654 similar to that in a recent sit-stand desk RCT in Belgian children [26]. The main issue faced

655 was with the medical dressing (Hypafix [BSN Medical]) used to attach the activPAL, with

656 this reportedly causing irritation on the leg for some children. In the present study we

657 adopted a 24-hour wear protocol with the anticipation that the hypoallergenic dressing

658 would stay on the skin for a number of days, and not require children to frequently remove

659 the device (and dressing), with the purpose of reducing participant burden. However, this

660 did not prove to be very effective as a number of children requested additional medical

661 dressing throughout the monitoring periods to enable them to re-attach the activPAL after

662 removal. Other researchers have enclosed the activPAL in a small pocket in an adjustable

663 elasticised belt worn at the mid-anterior position of the thigh throughout waking hours only,

664 removing it for water-based activities. This approach has been used successfully (85%

665 compliance) in cross-sectional research [60] and is worth exploring ahead of a full trial.

666 Evidently, further research is needed on the attachment options for the activPAL in

667 children to improve compliance. In comparison to the activPAL, compliance rates for the

668 waist-worn ActiGraph were higher (83%) and this device was reasonably well accepted by

669 children.

The intervention was well received by teachers and children, and towards the end of the intervention teachers commented on how the desks were regarded as part of the norm within their classrooms. This positive finding suggests teachers are both prepared and capable of adapting their teaching style and willing to make modifications to their classroom environments. Some children reported that they felt the desks improved behaviour within the classroom. These findings are consistent with others who have concluded that sit-stand desks can be introduced into the classroom environment without having a negative impact on student learning, behaviour, musculoskeletal comfort, or causing classroom disruption [28, 29, 31, 61, 62]. The absence of any negative impacts of sit-stand desks on these outcomes are likely to be of particular interest to schools considering adopting these desks in the future. Further, the potential positive effects observed within this study on pupil behaviour and increases in pupil autonomy (having the choice of sitting or standing) are even more encouraging and support further testing of this intervention.

Preliminary analyses demonstrated the potential of the intervention in reducing children's weekday sitting time, with the intervention group reducing their total weekday sitting time by more than 30 minutes/day relative to the control group. No data currently exist in children to inform the magnitude of a reduction in sitting time needed to bring about changes in health markers. This information will be vital in the future to inform public health messaging. Data from adults however have indicated that reallocating just 30 minutes of sedentary time per day to light movement is associated with a 2–4% improvement in cardiometabolic biomarkers [63]. An earlier meta-analysis of RCTs and non-RCTs delivered in the school or home environment reported an overall decrease in children's sedentary behaviour of 18 mins/day [64]. The preliminary findings from this study hold

696   promise, therefore, and support the need for further RCTs examining the impact of sit-

697   stand desks in the classroom environment. The reduction in sitting time observed in the

698   current pilot RCT is also greater than that reported in a recent sit-stand desk RCT

699   conducted in primary school children in Belgium where, relative to the control group, the

700   intervention group experienced a reduction in daily sitting of 13.5 minutes/day over the 8-

701   12 week intervention period [26]. In the Belgian study however, only three sit-stand desks

702   were placed in the intervention classrooms and pupils were exposed to these desks for an

703   average of 60 minutes/week, which likely explains the differences in findings.

704

705   When a bank of sit-stand desks are included within the classroom environment, as in the

706   present study, the Belgian study [26] and in our earlier study [33], the creation and

707   successful implementation of a regular rotation plan is important in order to maximise pupil

708   exposure to the sit-stand desks. In our previous small study, the teacher was very effective

709   in rotating pupils daily around the classroom to ensure equal exposure to the desks of

710   approximately one hour/day on average, and this led to a large reduction in mean

711   weekday sitting time (81 mins/day). In the present study, our intervention instructed

712   teachers to rotate children daily, however some intervention teachers trialled different

713   rotation options which may have reduced the overall exposure to the desks and the

714   subsequent impact of the intervention and explain the differences between our study

715   findings. This has been explored further as part of the process evaluation (reported

716   elsewhere) [42]. It was observed in the present study that daily sitting time appeared to be

717   replaced predominately with stepping time, as opposed to standing time, in the

718   intervention group at follow-up. This finding contrasts to that seen in adult samples within

719   RCTs implementing sit-stand desks in the workplace, where sitting time is predominately

720   replaced with standing time [65, 66]. A possible explanation for this finding could be that

721   children may be less likely to stand still when using a sit-stand desk, and hence some

722 stepping movement could be recorded by the activPAL. Furthermore, rotating children

723 around the class to facilitate their exposure to the sit-stand desks may also increase

724 overall movement levels.

725

726 ***Study limitations and strengths***

727 Delays experienced at the start of the study meant that the duration of the intervention was

728 shorter than originally proposed (2 school terms as opposed to 3 terms). Nevertheless, the

729 overall duration was deemed appropriate to provide evidence of the feasibility and

730 acceptability of the study protocol to inform the planning of a full trial. A further limitation

731 was the relatively poor compliance to the activPAL protocol. Despite schools being

732 stratified by their pupils ethnicity (either >50% South Asian pupils, or >50% White British

733 pupils) with two schools from each stratum being randomised into the intervention and

734 control arms, the balance between South Asian and White British participants across the

735 two arms was not equal. This discrepancy was likely due to the ethnic composition of

736 children in the individual classes involved in the trial, and discrepancies in consent from

737 the individuals rather than an overall imbalance across the schools.

738

739 A key strength of this study includes the multi-method approach which enabled a thorough

740 evaluation of all trial procedures. Other strengths are that the intervention was based on a

741 theoretical framework, and its development was informed by the literature [23-25], our

742 early work [33, 38], and public involvement (including focus groups with children and

743 interviews with teachers and head teachers during the planning stages, along with ongoing

744 consultation with teachers throughout the trial). The study setting, in terms of its location,

745 associated demographics and school context, was a further strength of the trial. As noted

746 earlier, Bradford was purposely chosen as the study location given its ethnic composition

747 (predominantly South Asian and White British) and high levels of deprivation, health

748 inequalities and childhood morbidity [36]. The characteristics of the participating schools

749 suggest they were largely representative of schools within the Bradford metropolitan

750 district which enabled us to pilot this intervention under challenging circumstances. The

751 acceptability and feasibility findings of this study therefore suggest that this trial would

752 likely be feasible within other schools. The accessibility of the classroom-based setting to

753 all children is furthermore important for addressing health inequalities. Forty-eight percent

754 of the present sample were of South Asian ethnic origin. With the emergence of an

755 increased cardiometabolic health risk profile observed in British South Asian children, in

756 comparison to white British children [15], early health promotion interventions like this in

757 such higher-risk groups, could be an important strategy for reducing ethnicity-related

758 health inequalities later in life.

759

760 ***Conclusions and recommendations***

761 The present study demonstrated that recruitment and retention rates were adequate, and

762 randomisation, the measurement procedures and intervention were generally acceptable

763 to participants. Some modifications to the protocol are needed to ensure the successful

764 conduct of a future RCT, particularly around improvements to the activPAL wear protocol.

765 Preliminary evidence from this study has demonstrated the potential of the intervention to

766 reduce children's weekday sitting time but more work is needed with teachers to create an

767 acceptable classroom rotation plan to ensure pupil exposure to the sit-stand desks is

768 maximised. The findings from this pilot cluster RCT therefore support the conduct of a full

769 trial designed to evaluate the effectiveness and cost-effectiveness of a sit-stand desk

770 intervention within the primary school setting on children's sedentary behaviour, markers

771 of health and behavioural outcomes. As suggested elsewhere [26, 31], a full trial should be

772 conducted over a minimum of one academic year. Such a trial could provide novel and

773 robust evidence of the longer-term health and education impacts of this intervention.

774

List of abbreviations

776 RCT - randomised controlled trial; CI – confidence interval; METs - metabolic equivalents;

777 UK - United Kingdom; CONSORT - Consolidated Standards of Reporting Trials; USA –

778 United States of America; COM-B - Capability, Opportunity, and Motivation to perform a

779 Behaviour; CTU - Clinical Trials Unit; Hz – Hertz; PEDS-QL - Paediatric Quality of Life

780 Inventory; EQ-5D-Y - EuroQol 5-dimension Youth; SD – Standard deviation; MVPA -

781 moderate-to-vigorous physical activity; cm – centimetres; kg – kilograms; BMI – body

782 mass index.

783

Declarations

785 ***Ethics approval and consent to participate***

786 Ethical approval for the research was obtained from Loughborough University's Ethical

787 Advisory Committee (reference: R16-P027). Head teachers, or a nominated senior

788 teacher, provided written informed consent for their school to participate in the study.

789 Teachers provided written informed consent for their participation, parents/guardians

790 provided written informed consent for their child to participate in the trial evaluation, and

791 participating children provided verbal and written assent.

792

793 ***Consent for publication***

794 Not applicable

795

796 ***Availability of data and materials***

797 Data supporting the results reported in this paper are stored at Loughborough University

798 and are available upon request by contacting the first author.

799

Authors' contributions

SC, SaB, CE, RME, LC, KT, GR, MF and StB obtained funding for the research, JS and DD were named collaborators on the funding application and supported the study throughout. DB, NP and YLC were the trial Research Associates. NBJ was the trial statistician and JA and GR undertook the health economics component of the study. All authors contributed to the development of the intervention and study methods, and all contributed to the reviewing and editing of the manuscript. All authors accept full responsibility for and have read and approved the final version of the manuscript.

836

837   **List of Figures**

841

842   **References**

843   1.   Tremblay MS, Aubert S, Barnes JD, Saunders TJ, Carson V, Latimer-Cheung AE,

844   Chastin SFM, Altenburg TM, Chinapaw MJM, Participants STCP. Sedentary Behavior

845   Research Network (SBRN) - Terminology Consensus Project process and outcome.

846   Int J Behav Nutr Phys Act 2017;14(1):75.

847   2.   Steele RM, van Sluijs EM, Cassidy A, Griffin SJ, Ekelund U. Targeting sedentary time

848   or moderate- and vigorous-intensity activity: independent relations with adiposity in a

849   population-based sample of 10-y-old British children. Am J Clin Nutr. 2009;90(5):1185-

850   92.

851   3. Sherry AP, Pearson N, Ridgers ND, Barber SE, Bingham DD, Nagy LC, Clemes SA.

852   activPAL-measured sitting levels and patterns in 9-10 years old children from a UK

853   city. J Public Health (Oxf) 2019;41(4):757-764.

854   4. Wilmot EG, Edwardson CL, Achana FA, Davies MJ, Gorely T, Gray LJ, Khunti K,

855   Yates T, Biddle SJ. Sedentary time in adults and the association with diabetes,

856   cardiovascular disease and death: systematic review and meta-analysis. Diabetologia

857   2012;55(11):2895-2905.

858   5. Biswas A, Oh PI, Faulkner GE, Bajaj RR, Silver MA, Mitchell MS, Alter DA. Sedentary

859   time and its association with risk for disease incidence, mortality, and hospitalization in

860   adults: a systematic review and meta-analysis. Ann Intern Med 2015;162(2):123-132.

861   6. Ekelund U, Steene-Johannessen J, Brown WJ, Fagerland MW, Owen N, Powell KE,

862   Bauman A, Lee IM, Lancet Physical Activity Series 2 Executive C, Lancet Sedentary

863   Behaviour Working G. Does physical activity attenuate, or even eliminate, the

864   detrimental association of sitting time with mortality? A harmonised meta-analysis of

865   data from more than 1 million men and women. Lancet 2016;388(10051):1302-1310.

866   7. Patterson R, McNamara E, Tainio M, de Sa TH, Smith AD, Sharp SJ, Edwards P,

867   Woodcock J, Brage S, Wijndaele K. Sedentary behaviour and risk of all-cause,

868   cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review

869   and dose response meta-analysis. Eur J Epidemiol 2018;33(9):811-829.

870   8. Carson V, Hunter S, Kuzik N, Gray CE, Poitras VJ, Chaput JP, Saunders TJ,

871   Katzmarzyk PT, Okely AD, Connor Gorber S et al. Systematic review of sedentary

872   behaviour and health indicators in school-aged children and youth: an update. Appl

873   Physiol Nutr Metab 2016;41(6 Suppl 3):S240-265.

874   9. Pearson N, Haycraft E, J PJ, Atkin AJ. Sedentary behaviour across the primary-

875   secondary school transition: A systematic review. Prev Med 2017;94:40-47.

876   10. Biddle SJ, Pearson N, Ross GM, Braithwaite R. Tracking of sedentary behaviours of

877   young people: a systematic review. Prev Med 2010;51(5):345-351.

878   11. Hancox RJ, Milne BJ, Poulton R. Association between child and adolescent television

879   viewing and adult health: a longitudinal birth cohort study. Lancet 2004;364(9430):257-

880   262.

881   12. Clemes SA, Bingham DD, Pearson N, Chen YL, Edwardson C, McEachan R, Tolfrey

882   K, Cale L, Richardson G, Fray M et al. Stand Out in Class: restructuring the classroom

883   environment to reduce sedentary behaviour in 9-10-year-olds - study protocol for a

884   pilot cluster randomised controlled trial. Pilot Feasibility Stud 2018;4:103.

885   13. Whincup PH, Gilg JA, Papacosta O, Seymour C, Miller GJ, Alberti KG, Cook DG. Early

886   evidence of ethnic differences in cardiovascular risk: cross sectional comparison of

887   British South Asian and white children. BMJ 2002;324(7338):635.

888   14. Nightingale CM, Rudnicka AR, Owen CG, Cook DG, Whincup PH. Patterns of body

889   size and adiposity among UK children of South Asian, black African–Caribbean and

890   white European origin: Child Heart And health Study in England (CHASE Study). Int J

891   Epidemiol 2011;40(1):33-44.

892   15. Whincup PH, Nightingale CM, Owen CG, Rudnicka AR, Gibb I, McKay CM, Donin AS,

893   Sattar N, Alberti KG, Cook DG. Early emergence of ethnic differences in type 2

894   diabetes precursors in the UK: the Child Heart and Health Study in England (CHASE

895   Study). PLoS Medicine 2010;7(4):e1000263.

896   16. Hornby-Turner YC, Hampshire KR, Pollard TM. A comparison of physical activity and

897   sedentary behaviour in 9-11 year old British Pakistani and White British girls: a mixed

898   methods study. Int J Behav Nutr Phys Act 2014;11:74.

899   17. Nagy LC, Faisal M, Horne M, Collings P, Barber S, Mohammed M. Factors associated

900   with accelerometer measured movement behaviours among White British and South

901   Asian children aged 6-8 years during school terms and school holidays. BMJ Open

902   2019;9(8):e025071.

903 18. Dollman J. Social and Environmental Influences on Physical Activity Behaviours. Int J

904   Environ Res Public Health. 2018;15(1).

905 19. Van Sluijs EMF, Jones NR, Jones AP, Sharp SJ, Harrison F, Griffin SJ. School-level

906   correlates of physical activity intensity in 10-year-old children. Int J Pediatr Obes

907   2011;6(2-2):E574-E581.

908 20. Morton KL, Atkin AJ, Corder K, Suhrcke M, van Sluijs EMF. The school environment

909   and adolescent physical activity and sedentary behaviour: a mixed-studies systematic

910   review. Obes Rev 2016;17(2):142-158.

911 21. Bonell C, Humphrey N, Fletcher A, Moore L, Anderson R, Campbell R. Why schools

912   should promote students' health and wellbeing. BMJ 2014;348.

913 22. Clarke J, Fletcher B, Lancashire E, Pallan M, Adab P. The views of stakeholders on

914   the role of the primary school in preventing childhood obesity: a qualitative systematic

915   review. Obes Rev 2013;14(12):975-988.

916 23. Hinckson E, Salmon J, Benden M, Clemes SA, Sudholz B, Barber SE, Aminian S,

917   Ridgers ND. Standing Classrooms: Research and Lessons Learned from Around the

918   World. Sports Med 2016;46(7):977-987.

919 24. Sherry AP, Pearson N, Clemes SA. The effects of standing desks within the school

920   classroom: A systematic review. Prev Med Rep 2016;3:338-347.

921 25. Minges KE, Chao AM, Irwin ML, Owen N, Park C, Whittemore R, Salmon J.

922   Classroom Standing Desks and Sedentary Behavior: A Systematic Review. Pediatrics

923   2016;137(2):e20153087.

924 26. Verloigne M, Ridgers ND, De Bourdeaudhuij I, Cardon G. Effect and process

925   evaluation of implementing standing desks in primary and secondary schools in

926   Belgium: a cluster-randomised controlled trial. Int J Behav Nutr Phys Act

927   2018;15(1):94.

928 27. Wendel ML, Benden ME, Zhao H, Jeffrey C. Stand-Biased Versus Seated Classrooms

929   and Childhood Obesity: A Randomized Experiment in Texas. Am J Public Health

930   2016;106(10):1849-1854.

931 28. Ee J, Parry S, Oliveira BI, McVeigh JA, Howie E, Straker L. Does a Classroom

932   Standing Desk Intervention Modify Standing and Sitting Behaviour and

933   Musculoskeletal Symptoms during School Time and Physical Activity during Waking

934   Time? Int J Environ Res Public Health 2018;15(8).

935 29. Contardo Ayala AM, Salmon J, Timperio A, Sudholz B, Ridgers ND, Sethi P, Dunstan

936   DW. Impact of an 8-Month Trial Using Height-Adjustable Desks on Children's

937   Classroom Sitting Patterns and Markers of Cardio-Metabolic and Musculoskeletal

938   Health. Int J Environ Res Public Health 2016;13(12).

939 30. Swartz AM, Tokarek NR, Lisdahl K, Maeda H, Strath SJ, Cho CC. Do Stand-Biased

940   Desks in the Classroom Change School-Time Activity and Sedentary Behavior? Int J

941   Environ Res Public Health 2019;16(6).

942 31. Erwin H, Beighle A, Routen A, Montemayor B. Perceptions of Using Sit-to-Stand

943   Desks in a Middle School Classroom. Health Promot Pract 2018;19(1):68-74.

944 32. Blake JJ, Benden ME, Wendel ML. Using stand/sit workstations in classrooms:

945   lessons learned from a pilot study in Texas. J Public Health Manag Pract

946   2012;18(5):412-415.

947 33. Clemes SA, Barber SE, Bingham DD, Ridgers ND, Fletcher E, Pearson N, Salmon J,

948   Dunstan DW. Reducing children's classroom sitting time using sit-to-stand desks:

949   findings from pilot studies in UK and Australian primary schools. J Public Health (Oxf).

950   2016;38(3):526-533.

951   34. Craig R, Mindell J, Hirani V. Health Survey for England 2008: Volume 1, Physical

952   activity and fitness. The Health and Social Care Information Centre; 2009.

953   35. Campbell MK, Piaggio G, Elbourne DR, Altman DG, Group C. Consort 2010

954   statement: extension to cluster randomised trials. BMJ 2012;345(e5661).

955   36. Wright J, Small N, Raynor P, Tuffnell D, Bhopal R, Cameron N, Fairley L, Lawlor DA,

956   Parslow R, Petherick ES et al. Cohort Profile: the Born in Bradford multi-ethnic family

957   cohort study. Int J Epidemiol 2013;42(4):978-991.

958   37. Julious SA. Sample size of 12 per group rule of thumb for a pilot study. Pharmaceut.

959   Statist 2005;4(4):287–291.

960   38. Sherry AP, Pearson N, Ridgers ND, Barber SE, Bingham DD, Nagy LC, Dunstan D,

961   Clemes S. The effectiveness of sit-to-stand desks to reduce sitting time within a

962   primary school classroom: an 8 month controlled trial. In the Proceedings of the

963   International Society of Behavioral Nutrition and Physical Activity (ISBNPA) Annual

964   Meeting: 2017; Victoria, Canada.

965   39. Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for

966   characterising and designing behaviour change interventions. Implement Sci

967   2011;6:42.

968   40. Michie S, Johnston M, Abraham C, Lawton R, Parker D, Walker A, Psychological

969   Theory Group. Making psychological theory useful for implementing evidence based

970   practice: a consensus approach. Qual Saf Health Care 2005;14(1):26-33.

971   41. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, Eccles

972   MP, Cane J, Wood CE. The behavior change technique taxonomy (v1) of 93

973   hierarchically clustered techniques: building an international consensus for the

974   reporting of behavior change interventions. Ann Behav Med 2013;46(1):81-95.

975   42. Clemes SA, Bingham DD, Pearson N, Chen YL, Edwardson C, McEachan R, Tolfrey

976   K, Cale L, Richardson G, Fray M *et al*. Sit–stand desks to reduce sedentary behaviour

977   in 9- to 10-year-olds: the Stand Out in Class pilot cluster RCT. Public Health

978   Research, NIHR Journals Library 2020;in press.

979   43. Aminian S, Hinckson EA. Examining the validity of the ActivPAL monitor in measuring

980   posture and ambulatory movement in children. Int J Behav Nutr Phys Act 2012;9:119.

981   44. Winkler EA, Bodicoat DH, Healy GN, Bakrania K, Yates T, Owen N, Dunstan DW,

982   Edwardson CL. Identifying adults' valid waking wear time by automated estimation in

983   activPAL data collected with a 24 h wear protocol. Physiol Meas 2016;37(10):1653-

984   1668.

985   45. Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG. Calibration of two

986   objective measures of physical activity for children. J Sports Sci 2008;26(14):1557-

987   1565.

988   46. O O'Brien E, Asmar R, Beilin L, Imai Y, Mallion JM, Mancia G, Mengden T, Myers M,

989   Padfield P, Palatini P et al. European Society of Hypertension recommendations for

990   conventional, ambulatory and home blood pressure measurement. J Hypertens

991   2003;21(5):821-848.

992   47. Goodman R. The Strengths and Difficulties Questionnaire: a research note. J Child

993   Psychol Psychiatry 1997;38(5):581-586.

994   48. Skinner EA, Marchand G, Furrer C, Kindermann T. Engagement and disaffection in

995   the classroom: Part of a larger motivational dynamic. J Educ Psychol

996   2008;100(4):765–781.

997   49. Skinner EA, Kindermann T, Furrer C. A Motivational Perspective on Engagement and

998   Disaffection. Educational and Psychological Measurement 2009;69(3):493-525.

999   50. Varni JW, Seid M, Kurtin PS. PedsQL 4.0: reliability and validity of the Pediatric

1000   Quality of Life Inventory version 4.0 generic core scales in healthy and patient

1001   populations. Med Care 2001;39(8):800-812.

1002　51. Wille N, Badia X, Bonsel G, Burstrom K, Cavrini G, Devlin N, Egmar AC, Greiner W,

1003　　　 Gusi N, Herdman M et al. Development of the EQ-5D-Y: a child-friendly version of the

1004　　　 EQ-5D. Qual Life Res 2010;19(6):875-886.

1005　52. Bland JM, Kerry SM. Statistics notes. Trials randomised in clusters. BMJ

1006　　　 1997;315(7108):600.

1007　53. Kerry SM, Bland JM. Analysis of a trial randomised in clusters. BMJ

1008　　　 1998;316(7124):54.

1009　54. Arain M, Campbell MJ, Cooper CL, Lancaster GA. What is a pilot or feasibility study?

1010　　　 A review of current practice and editorial policy. BMC Med Res Methodol 2010;10:67.

1011　55. Lancaster GA, Dodd S, Williamson PR. Design and analysis of pilot studies:

1012　　　 recommendations for good practice. J Eval Clin Pract 2004;10(2):307-312..

1013　56. Schools, pupils and their characteristics: January 2017

1014　　　 [https://www.gov.uk/government/statistics/schools-pupils-and-their-characteristics-

1015　　　 january-2017], accessed August 2018.

1016　57. Barber SE, Jackson C, Hewitt C, Ainsworth HR, Buckley H, Akhtar S, Bingham DD,

1017　　　 Routen AC, Summerbell C, Richardson G et al. Assessing the feasibility of evaluating

1018　　　 and delivering a physical activity intervention for pre-school children: a pilot

1019　　　 randomised controlled trial. Pilot Feasibility Stud 2016;2:12.

1020　58. Adab P, Pallan MJ, Lancashire ER, Hemming K, Frew E, Barrett T, Bhopal R, Cade

1021　　　 JE, Canaway A, Clarke JL et al. Effectiveness of a childhood obesity prevention

1022　　　 programme delivered through schools, targeting 6 and 7 year olds: cluster randomised

1023　　　 controlled trial (WAVES study). BMJ 2018;360:k211.

1024　59. Bartlett R, Wright T, Olarinde T, Holmes T, Beamon ER, Wallace D. Schools as Sites

1025　　　 for Recruiting Participants and Implementing Research. J Community Health Nurs

1026　　　 2017;34(2):80-88.

1027   60. Ridgers ND, Timperio A, Cerin E, Salmon J. Within- and between-day associations

1028   between children's sitting and physical activity time. BMC Public Health 2015;15:950.

1029   61. Dornhecker M, Blake JJ, Benden ME, Zhao H, Wendel ML. The effect of stand-biased

1030   desks on academic engagement: an exploratory study. Int J Health Promot Educ.

1031   2015;53(5):271-280.

1032   62. Aminian S, Hinckson EA, Stewart T. Modifying the classroom environment to increase

1033   standing and reduce sitting. Building Research & Information 2015;43(5):631-645.

1034   63. Buman MP, Winkler EA, Kurka JM, Hekler EB, Baldwin CM, Owen N, Ainsworth BE,

1035   Healy GN, Gardiner PA. Reallocating time to sleep, sedentary behaviors, or active

1036   behaviors: associations with cardiovascular disease risk biomarkers, NHANES 2005-

1037   2006. Am J Epidemiol. 2014;179(3):323-334.

1038   64. van Grieken A, Ezendam NP, Paulis WD, van der Wouden JC, Raat H. Primary

1039   prevention of overweight in children and adolescents: a meta-analysis of the

1040   effectiveness of interventions aiming to decrease sedentary behaviour. Int J Behav

1041   Nutr Phys Act 2012;9:61.

1042   65. Edwardson CL, Yates T, Biddle SJH, Davies MJ, Dunstan DW, Esliger DW, Gray LJ,

1043   Jackson B, O'Connell SE, Waheed G *et al*. Effectiveness of the Stand More AT

1044   (SMArT) Work intervention: cluster randomised controlled trial. BMJ 2018;363:k3870.

1045   66. Healy GN, Eakin EG, Owen N, Lamontagne AD, Moodie M, Winkler EA, Fjeldsoe BS,

1046   Wiesner G, Willenberg L, Dunstan DW. A Cluster Randomized Controlled Trial to

1047   Reduce Office Workers' Sitting Time: Effect on Activity Outcomes. Med Sci Sports

1048   Exerc 2016;48(9):1787-1797.

1049

1050

1051

1052

1053

1054

1055

1056

Underpinning theory

Available resources and activities

Short-term outputs/goals

Longer-term outputs/goals

The Stand Out in Class intervention is grounded within the COM-B model and utilises components of the Theoretical Domains Framework (self-efficacy, motivation and knowledge). Theoretical components applied to the intervention include:

Acquisition of knowledge relating to behaviour(s) and behavioural choices

Capability to change behaviour

Opportunity to change behaviour

Motivation and self-efficacy to change behaviour

TEACHERS
Face-to-face meeting with a researcher, and provision of a Professional Development Manual covering the importance of reducing prolonged periods of sitting for longer-term health.

CHILDREN
30-minute workshop delivered by a researcher within the class covering the importance of reducing prolonged periods of sitting for longer-term health and instructions on how to use the sit-stand desks.

TEACHERS
Supported in the creation of a class rotation plan to ensure all children in their class are exposed to the sit-stand desks for at least 1 hour/day on average each week. Fortnightly support provided by the research team.

CHILDREN
Provision of 6 sit-stand desks in the classroom, teacher uses a rotation system to ensure fair exposure to the desks.

CHILDREN
Nudging prompts on desk to encourage standing. Signing of a group contract. Presence of 'standing champions'.

Enhanced knowledge of the importance of reducing prolonged periods of sitting for health benefits

Increased confidence in adjusting the sit-stand desks to enable alterations (sitting/standing) in posture when exposed to the desks.

Increased understanding of, and effective implementation of a classroom rotation plan. Overcoming challenges to rotating children and maintaining teaching practices with the addition of sit-stand desks.

Observational learning and modelling of healthy behaviours (choosing to stand whilst learning when exposed to the sit-stand desks).

Enhanced group motivation and self-efficacy to choose to stand when using the sit-stand desks. Increased social interaction and reinforcement in class.

Children become less sedentary adults having been used to being provided with the opportunity to alternate their postures between sitting and standing. Reducing risk of chronic diseases and premature mortality associated with prolonged sedentary behaviour in adulthood.

Sustained reduction in sedentary behaviour whilst learning, where opportunities exist, as children progress through their education

Children and teachers identify student's having the option to stand whilst learning as a social norm. The classroom is seen as providing both a social and environmental (through the provision of sit-stand desks) opportunity to reduce sedentary behaviour.

1057