



## LJMU Research Online

Noonan, R, Christian, D, Boddy, LM, Saint-Maurice, P, Welk, G, Hibbing, P and Fairclough, S

**Accelerometer and self-reported measures of sedentary behaviour and associations with adiposity in UK youth**

<http://researchonline.ljmu.ac.uk/id/eprint/10510/>

### Article

**Citation** (please note it is advisable to refer to the publisher's version if you intend to cite from this work)

**Noonan, R, Christian, D, Boddy, LM, Saint-Maurice, P, Welk, G, Hibbing, P and Fairclough, S (2019) Accelerometer and self-reported measures of sedentary behaviour and associations with adiposity in UK youth. *Journal of Sports Sciences*. 37 (16). pp. 1919-1925. ISSN 0264-0414**

LJMU has developed [LJMU Research Online](http://researchonline.ljmu.ac.uk/) for users to access the research output of the University more effectively. Copyright © and Moral Rights for the papers on this site are retained by the individual authors and/or other copyright owners. Users may download and/or print one copy of any article(s) in LJMU Research Online to facilitate their private study or for non-commercial research. You may not engage in further distribution of the material or use it for any profit-making activities or any commercial gain.

The version presented here may differ from the published version or from the version of the record. Please see the repository URL above for details on accessing the published version and note that access may require a subscription.

For more information please contact [researchonline@ljmu.ac.uk](mailto:researchonline@ljmu.ac.uk)

<http://researchonline.ljmu.ac.uk/>

1 Title: Accelerometer and self-reported measures of sedentary behaviour and  
2 associations with adiposity in UK youth.

3

4 Robert J. Noonan<sup>1</sup>, Danielle Christian<sup>1</sup>, Lynne M. Boddy<sup>2</sup>, Pedro F. Saint-Maurice<sup>3</sup>,  
5 Gregory J. Welk<sup>4</sup>, Paul R. Hibbing<sup>5</sup>, & Stuart J. Fairclough<sup>1</sup>

6

7 <sup>1</sup> Movement Behaviours, Health and Wellbeing Research Group, Department of Sport  
8 and Physical Activity, Edge Hill University, United Kingdom.

9 <sup>2</sup> Physical Activity Exchange, Research Institute for Sport and Exercise Sciences,  
10 Liverpool John Moores University, United Kingdom.

11 <sup>3</sup> Division of Cancer Epidemiology and Genetics, National Cancer Institute, United  
12 States.

13 <sup>4</sup> Department of Kinesiology, College of Human Sciences, Iowa State University,  
14 United States.

15 <sup>5</sup> Department of Kinesiology, Recreation, and Sport Studies, University of Tennessee,  
16 United States.

17

18 **Running title:** Sedentary time, screen time, and adiposity

19 **Keywords:** Youth; sedentary time; screen time; adiposity; measurement.

20

21

22

23

24

25

26 **Abstract**

27

28 This study used accelerometer and self-report measures of overall sedentary time (ST)  
29 and screen time behaviours to examine their respective associations with adiposity  
30 among UK youth. Participants (Year groups 5, 8, and 10;  $n=292$ , 148 girls) wore the  
31 SenseWear Armband Mini accelerometer for eight days and completed the Youth  
32 Activity Profile, an online report tool designed to estimate physical activity and ST.  
33 Stature, body mass and waist circumference were measured to classify adiposity  
34 outcomes (overweight/obese and central obesity). One-way between groups ANOVA  
35 and adjusted linear, logistic and multinomial logistic regression analyses were  
36 conducted. There was a significant main effect of age on total ST across the whole  
37 week ( $F(2, 289)=41.64$ ,  $p\leq 0.001$ ). ST increased monotonically across Year 5  
38 ( $581.09\pm 107.81 \text{ min}\cdot\text{d}^{-1}$ ), 8 ( $671.96\pm 112.59 \text{ min}\cdot\text{d}^{-1}$ ) and 10 ( $725.80\pm 115.20 \text{ min}\cdot\text{d}^{-1}$ ),  
39 and all pairwise comparisons were significant at  $p\leq 0.001$ . A steep age-related gradient  
40 to mobile phone use was present ( $p\leq 0.001$ ). ST was positively associated with  
41 adiposity outcomes independent of moderate-to-vigorous intensity physical activity  
42 (MVPA;  $p\leq 0.001$ ). Engaging in  $>3$  hours of video gaming daily was positively  
43 associated with central obesity (OR=2.12,  $p\leq 0.05$ ) but not after adjustment for MVPA.  
44 Results further demonstrate the importance of reducing overall ST to maintain healthy  
45 weight status among UK youth.

46

47 **Keywords:** Youth; sedentary time; screen time; adiposity; obesity; measurement

48 **Introduction**

49

50 There is considerable public health interest in understanding the correlates and health  
51 implications of sedentary behaviour (i.e., activities that involve sitting or reclining  
52 while expending little energy) and standardised approaches and definitions have been  
53 proposed to advance this work (Tremblay et al., 2017). The issue is germane to all  
54 segments of the population, but there are unique considerations and challenges when  
55 studying this behaviour in youth (Welk and Kim, 2016). Studies have documented that  
56 sedentary behaviour is associated with increased risk of poor health among youth,  
57 including adiposity (Marshall & Ramirez, 2011; Saunders, Chaput, & Tremblay,  
58 2014); however, results depend on the nature of the study design and how sedentary  
59 behaviour is measured (Welk and Kim, 2016). Recent evidence also suggests that the  
60 sedentary behaviour and adiposity relationship is partly mediated by cardiorespiratory  
61 fitness (Santos et al., 2018). Thus, the associations are more complex than previously  
62 thought.

63

64 Part of the challenge is due to the many different forms of sedentary behaviour. These  
65 include educational activities such as homework, travelling passively (i.e., motorized  
66 transport), seated hobbies (e.g., reading and talking with friends), and screen time  
67 behaviours (e.g., TV viewing, video games, etc.), with screen time behaviours being  
68 the most common form of leisure-time sedentary behaviours among youth (Biddle,  
69 Marshall, Gorely & Cameron, 2009; Kenney & Gortmaker, 2017). Prominent reviews  
70 have highlighted the high overall prevalence of sedentary behaviours, especially  
71 during leisure-time (Arundell, Fletcher, Salmon, Veitch & Hinkley, 2016), but less is  
72 known about the breakdown of the different types of sedentary behaviour.

73

74 In the UK, many youths spend more than 2 hours per day engaged in screen time  
75 behaviours (Coombs & Stamatakis, 2015; Sandercock, Ogunleye & Voss, 2012).  
76 While current evidence suggests that sedentary time increases with age (Janssen et al.,  
77 2016; Ruiz et al., 2011; Santos et al., 2018), it is unknown whether these age-related  
78 differences are reflected in specific screen time behaviours among UK youth.  
79 Moreover, to date, very few UK studies have used self-reported measures alongside  
80 device-based measures to provide contextual understanding of a range of youth  
81 sedentary behaviours (Coombs & Stamatakis, 2015). The use of parallel measures of  
82 sedentary behaviour and investigation of these sedentary behaviours across age groups  
83 can highlight specific sedentary behaviours during youth that may benefit from age-  
84 targeted interventions.

85

86 Although a positive association between overall screen time and youth adiposity has  
87 been shown (Bai et al., 2016), few studies have examined the influence of specific  
88 types of screen time behaviours on youth adiposity. Indeed, a recent systematic review  
89 of reviews highlighted the limited number of studies reporting data on mobile screen  
90 use in particular (Stiglic & Viner, 2019). Traditionally, time spent watching TV has  
91 been treated as a representative measure of screen time (Eisenmann, Bartee, Smith,  
92 Welk & Fu 2008; Steffen, Dai, Fulton & Labarthe, 2009; Zhang, Wu, Zhou, Lu &  
93 Mao 2016), leading to the consistent finding that youth who watch high levels of TV  
94 are more likely to be overweight or obese (Carson et al., 2016a; Tremblay et al., 2011a;  
95 2011b). However, TV time alone is no longer adequate as a representative measure of  
96 screen time, since other devices (e.g., computers, games consoles, tablets, mobile  
97 phones) have become prominent elements of youth lifestyle (Ofcom, 2017).

98 Therefore, a greater level of specificity is necessary when assessing sedentary  
99 behaviour, and particularly screen time among youth. To address this need, the aims  
100 of this study were to 1) assess age-related differences in youth sedentary time, screen  
101 time behaviours and adiposity, and 2) examine associations between parallel measures  
102 of youth sedentary behaviour (i.e., accelerometer measured sedentary time and self-  
103 reported screen time behaviours) and adiposity.

104

## 105 **Methods**

106

### 107 **Participants**

108

109 Eleven schools (four primary and seven secondary) situated in North West England  
110 were provided with information regarding the study and were invited to participate.  
111 Four primary (100%) and five secondary schools (71%) agreed to take part.  
112 Participating schools received project and consent information and were scheduled for  
113 data collection. Informed parental consent and child assent was obtained from 401  
114 students (209 boys) in Year groups 5 (aged 9 - 10 years,  $n = 133$ ), 8 (aged 12 - 13  
115 years,  $n = 132$ ), and 10 (aged 14 - 15 years,  $n = 136$ ). Ethical approval was granted  
116 from Liverpool John Moores Research Ethics Committee (14/SPS/012). A financial  
117 incentive of £700 was provided to each participating school and each participant  
118 received a £10 retail voucher for taking part. Data collection took place on school sites  
119 during school-term time between March and July 2017.

120

### 121 **Measures**

122

123 *Adiposity*

124

125 Trained researchers measured stature to the nearest 0.1 cm using a portable  
126 stadiometer (Leicester Height Measure, Seca, Birmingham, UK), and body mass to  
127 the nearest 0.1 kg using the same calibrated scales (Seca, Birmingham, UK). Body  
128 mass index (BMI) was calculated from stature and body mass ( $\text{kg}/\text{m}^2$ ), and BMI z-  
129 scores were assigned to each participant (Cole, Freeman & Preece, 1995). Age- and  
130 gender-specific BMI cut-points were used for normal weight or overweight/obese  
131 classifications (Cole, Bellizzi, Flegal & Dietz 2000). Waist circumference was  
132 measured at the midpoint between the bottom rib and the iliac crest to the nearest 0.1  
133 cm using a non-elastic measuring tape (Seca, Birmingham, UK). Waist-to-height ratio  
134 (WHtR) was used as a measure of central obesity, with a WHtR  $\geq 0.5$  indicating the  
135 presence of central obesity (McCarthy & Ashwell, 2006; Mokha et al., 2010).

136

137 *Device-based sedentary time*

138

139 Each participant wore a SenseWear Armband Mini (SWA) (BodyMedia, Inc.,  
140 Pittsburgh, PA) wireless pattern-recognition device on their upper non-dominant arm.  
141 The SWA estimates energy expenditure by integrating data from multiple sources,  
142 including a bi-axial accelerometer, physiological sensors (e.g. capturing heat flux and  
143 galvanic skin response), and demographic information (i.e., the wearer's age, gender,  
144 and weight) (Arvidsson, Slinde, Larsson & Hulthén, 2007). The SWA has been  
145 validated in youth (Calabro, Welk & Eisenmann, 2009; van Loo et al., 2017), and has  
146 been shown to provide accurate estimates of sedentary time (Ridgers, Hnatiuk,  
147 Vincent, Timperio, Barnett & Salmon, 2016). A key advantage of the SWA for field-

148 based research is its ability to accurately detect non-wear time. The SWA is able to  
149 detect whether the device is in contact with skin, which provides a more refined  
150 estimate of non-wear time and consequently reduces the error within the measure of  
151 sedentary time (Andre et al., 2006).

152

153 The SWA devices were initialized with default 1-minute epochs using the SenseWear  
154 Pro v.8.0 software. Each participant was provided with verbal and written instructions  
155 detailing how to wear the SWA. They were asked to wear the device continuously for  
156 8-days, removing only for water-based activities and contact sports. On return of the  
157 SWA devices, data were downloaded using the SenseWear Pro software (v.8.0), and  
158 files were converted to .xls format to enable initial data screening. Subsequent data  
159 processing was conducted in R (R Core Team, 2017) using custom-written code. To  
160 be included in the analysis, participants needed to wear the SWA for a minimum of  
161 960 minutes per day on at least 3 days (Fairclough et al., 2017; Rowlands et al., 2018;  
162 Slootmaker et al., 2009). SWA data were expressed as METs, which were then  
163 converted to minutes of sedentary time and moderate-to-vigorous intensity physical  
164 activity (MVPA) during waking hours (7am to 11pm) using age- and gender-specific  
165 thresholds (Welk, Morrow & Saint-Maurice, 2017).

166

#### 167 *Self-reported screen time*

168

169 Participants completed an online physical activity and sedentary behaviour survey  
170 under the supervision of researchers and teachers. We used a UK-specific version of  
171 the Youth Activity Profile (YAP). The YAP is a 7-day recall tool that consists of 15  
172 items relating to in-school activity (five items), out-of-school physical activity (five



173 items), and sedentary behaviours (five items). Among US youth, YAP estimates of  
174 weekly physical activity and sedentary time have previously demonstrated agreement  
175 with estimates derived from objective monitors (Saint-Maurice & Welk, 2015; Saint-  
176 Maurice, Kim, Hibbing, Oh, Perna, & Welk, 2017). Participants answered each item  
177 using a 5-point Likert scale representing the frequency of the behaviour. A critical  
178 aspect of the items that addressed sedentary behaviour was the presence of separate  
179 items inquiring about time spent in the following screen time behaviours: watching  
180 TV, playing video games, using computers or tablets, and using a mobile/cell phone.  
181 Participants were asked to indicate how much time in the previous 7-days they had  
182 spent engaging in each screen time behaviour. The survey does not distinguish  
183 between school and leisure screen time. Response choices were: no use, less than 1-  
184 hour per day, 1-2 hours per day, 2-3 hours per day, and more than 3 hours per day.  
185 Responses were clustered, so we collapsed the responses, and created two  
186 dichotomized variables for each screen time behaviour representing > 2 hours per day  
187 and > 3 hours per day engagement. Only data from these four questions are reported  
188 in this study. On completion of the survey, researchers checked the responses with the  
189 participants before they were submitted. Each participant's electronic YAP responses  
190 were collated in school- and class-specific .csv files, which were subsequently cleaned  
191 and merged with the other data.

192

### 193 *Covariates*

194

195 Potential confounding factors were selected *a priori* based on previous evidence  
196 (Coombs, Shelton, Rowlands & Stamatakis, 2013; LeBlanc et al., 2016; Saunders &  
197 Vallance, 2017). Participant age, gender and home postcode were self-reported. Area-

198 level deprivation was calculated from home postcodes using the 2015 Indices of  
199 Multiple Deprivation (IMD; Department for Communities and Local Government,  
200 2015). The IMD is a UK Government measure comprising seven areas of deprivation  
201 including income, employment, health, education, housing, environment and crime.  
202 Home postcodes were entered into the GeoConvert (<http://geoconvert.mimas.ac.uk/>)  
203 application (MIMAS, 2018) to generate deprivation scores. Higher deprivation scores  
204 represented higher deprivation. Missing responses were imputed with the variable  
205 mean score ( $n = 26$ ) to prevent further data loss. This imputation approach has been  
206 used previously in physical activity studies involving children (Corder et al., 2010).  
207 MVPA measured from the SWA was also included as a covariate as MVPA is known  
208 to be associated with adiposity in youth (Schwarzfischer et al., 2017).

209

## 210 Analyses

211

212 All analyses were conducted using SPSS v. 24 (SPSS Inc; Chicago, IL) and statistical  
213 significance was set at  $p \leq 0.05$ . Descriptive statistics were calculated for all measured  
214 variables.

215

216 Research aim 1 was to assess age-related differences in youth sedentary time, screen  
217 time behaviours and adiposity. To address this aim, a one-way between groups  
218 analysis of variance (ANOVA) with Bonferroni post-hoc test was performed to  
219 examine differences in device-based measured sedentary time between Year groups.  
220 Multinomial logistic regression analyses examined differences in adiposity outcomes  
221 and self-reported screen time behaviours between Year groups. The Year 5 group was

222 chosen as the reference category. Analyses were adjusted for gender, deprivation and  
223 MVPA.

224

225 Research aim 2 was to examine associations between parallel measures of youth  
226 sedentary behaviour (i.e., accelerometer measured sedentary time and self-reported  
227 screen time behaviours) and adiposity. To address this aim, linear and logistic  
228 regression analyses assessed associations between device measured sedentary time  
229 and adiposity outcomes, and self-reported screen time behaviours and adiposity  
230 outcomes, respectively. Analyses were adjusted for gender, Year group, deprivation,  
231 and MVPA.

232

## 233 **Results**

234

235 Forty-nine participants were absent on data collection days or did not provide all  
236 required data for the analyses, which meant YAP, IMD, and SWA data were available  
237 from 353 participants. Fifty-two participants did not achieve the SWA wear time  
238 criteria, and a further nine participants had incomplete questionnaire data. These  
239 participants were subsequently removed from analyses, which resulted in a final  
240 analytical sample of 292 participants (148 girls) (72.8% response rate). The  
241 descriptive characteristics of the sample are presented in Table 1.

242

243 [TABLE 1 NEAR HERE]

244

### 245 *Research aim 1*

246

247 Daily SWA wear time (mean  $\pm$  SD) for Year 5, 8 and 10 children was  $1225.10 \pm$   
248  $150.44 \text{ min}\cdot\text{d}^{-1}$ ,  $1271.84 \pm 126.70 \text{ min}\cdot\text{d}^{-1}$ , and  $1289.45 \pm 110.86 \text{ min}\cdot\text{d}^{-1}$ ,  
249 respectively. There was a significant main effect of age on total sedentary time across  
250 the whole week ( $F(2, 289) = 41.64, p < 0.001$ ). Bonferroni post-hoc testing showed a  
251 monotonic increase in sedentary time with increasing age, and all pairwise differences  
252 were significant with  $p < 0.001$ . The most dramatic increase occurred between Year 5  
253 ( $581.09 \pm 107.81 \text{ min}\cdot\text{d}^{-1}$ ) and Year 8 ( $671.96 \pm 112.59 \text{ min}\cdot\text{d}^{-1}$ ), whereas the increase  
254 was more modest between Year 8 and Year 10 ( $725.80 \pm 115.20 \text{ min}\cdot\text{d}^{-1}$ ).

255

256 Compared to Year 5 children, Year 10 children were more likely to engage in  $> 3$   
257 hours of video gaming (Odds Ratio, OR = 3.34;  $p \leq 0.05$ ; Table 2),  $> 2$  hours of  
258 computer/tablet time (OR = 5.02;  $p \leq 0.001$ ),  $> 3$  hours of computer/tablet time (OR  
259 = 29.81;  $p \leq 0.001$ ),  $> 2$  hours of mobile phone use (OR = 11.73;  $p \leq 0.001$ ), and  $> 3$   
260 hours of mobile phone use (OR = 10.71;  $p \leq 0.001$ ). Compared to Year 5 children,  
261 Year 8 children were more likely to engage in  $> 2$  hours of mobile phone use (OR =  
262 2.90;  $p \leq 0.001$ ), and  $> 3$  hours of mobile phone use (OR = 2.54;  $p \leq 0.01$ ).

263

264 [TABLE 2 NEAR HERE]

265

266 *Research aim 2*

267

268 Adjusted linear regression analyses revealed a positive association between sedentary  
269 time and BMI z-score ( $B = 0.01, p \leq 0.001$ ; Table 3) and waist circumference ( $B =$   
270  $0.03, p \leq 0.001$ ). Associations between sedentary time and BMI z-score and waist  
271 circumference remained significant at  $p \leq 0.01$  after adjustment for MVPA.

272

273

[TABLE 3 NEAR HERE]

274

275 Table 4 presents OR for associations between screen time behaviours and adiposity.  
276 Children who reported engaging in more than 3 hours of video gaming daily (OR =  
277 2.28, 95% CI = 1.04 – 5.02) were more likely to be classified as centrally obese  
278 compared with children who reported engaging in less than 3 hours of video gaming  
279 daily, respectively. However, the association was attenuated after adjustment for  
280 MVPA.

281

282

[TABLE 4 NEAR HERE]

283

## 284 **Discussion**

285

286 This study represents the first in the UK to use device-based and self-report measures  
287 of youth sedentary behaviour to assess age-related differences and associations with  
288 adiposity. The study revealed significant age-related differences in device measured  
289 sedentary time and self-reported computer/tablet time and mobile phone use. Device  
290 measured sedentary time was positively associated with adiposity independent of  
291 MVPA, but none of the self-reported screen time behaviours were associated with  
292 adiposity outcomes after adjustment for MVPA.

293

294 Consistent with prior UK (Janssen et al., 2016) and European research (Ruiz et al.,  
295 2011) this study evidenced an age-related gradient to device measured sedentary time.  
296 Here we extend beyond earlier studies by revealing an age-related gradient to some

297 self-reported screen time behaviours, namely computer/tablet time and mobile phone  
298 use. One possible explanation for this finding is that adolescents often have more  
299 autonomy on how they spend their free time (Haberstick et al., 2014) in comparison  
300 to younger children, and this unstructured time is often spent engaged in video gaming,  
301 computer/tablet time and/or mobile phone use. Moreover, adolescents may spend  
302 more time on computers in their leisure-time compared to younger children because  
303 they are completing homework (Sheldrick et al., 2018). Such productive screen time  
304 behaviours can be perceived as positive for development and wellbeing (e.g.,  
305 academic attainment, school functioning; Carson et al., 2016b), and may not  
306 necessarily displace more ‘healthy behaviours’ such as physical activity (Sheldrick et  
307 al., 2018). Further work exploring age-related variability in screen time behaviours  
308 will help inform the timing and targeting of sedentary behaviour and wellbeing  
309 interventions. Moreover, although age-related differences were observed for device-  
310 based and self-report measures of sedentary behaviour, we found no statistically  
311 significant differences in adiposity outcomes between young and older youth, which  
312 is consistent with previously reported English population level data (Conolly, 2016).

313

314 In this study, device measured sedentary time was positively associated with adiposity  
315 in UK youth. This finding is consistent with a recent systematic review of reviews  
316 (Stiglic & Viner, 2019), and some individual studies (De Bourdeaudhuij et al., 2013),  
317 but not all (Atkin et al., 2013; Marques et al., 2016). Notably, the strength of  
318 associations between sedentary time and adiposity outcomes were small, which is  
319 consistent with the findings of a 2017 review of reviews and analysis of causality  
320 (Biddle, García Bengoechea, Wiesner, 2017). Such modest associations may be  
321 attributable to the varied methodological approaches employed. For example, different

322 measurement methods influence the observed strength of association between  
323 sedentary time and youth adiposity. Moreover, the combined effect of sedentary time,  
324 physical activity, dietary behaviour and sleep on adiposity is currently not well  
325 understood (Leech, McNaughton & Timperio, 2014). For example, health enhancing  
326 behaviours (i.e., regular physical activity and healthy food intake) may compensate  
327 for unhealthy behaviours (i.e., high sedentary time) which would offer some  
328 explanation for the inconsistency across the literature (Grgic et al., 2018; Sheldrick et  
329 al., 2018). Further research examining the concurrent effect of sedentary time,  
330 physical activity, diet and sleep behaviour on adiposity in youth is warranted.

331

332 A novel aspect of this study was the examination of associations between a range of  
333 screen time behaviours and youth adiposity. Almost all associations between screen  
334 time behaviours and adiposity were in a positive direction, but few were statistically  
335 significant. Again, this finding may be primarily reflective of the complexity of youth  
336 adiposity but may also be due to the low prevalence of excessive screen time behaviour  
337 when TV viewing was included (> 2 hours daily; 18.90%, 36.20% and 23.40% of Year  
338 5, 8 and 10 youth, respectively) compared to previous European (57.2%-85.8%; Jago  
339 et al., 2008) and US research (29% to 35%; Fulton et al., 2009). Furthermore, the  
340 increased availability of 'on demand' TV options means that youth may also be  
341 watching television programmes online using computers or tablet devices. Such  
342 modes of screen use require further exploration in future studies. Although TV  
343 viewing is currently the most widely studied screen behaviour associated with youth  
344 adiposity (Carson et al., 2016a; Tremblay et al., 2011a), future research should  
345 continue to work towards differentiating the health impact of different screen time

346 behaviours. This is especially the case with video gaming, since playing video games  
347 for more than 3 hours per day in this study was associated with central obesity risk.

348

#### 349 *Strengths and limitations*

350

351 This study represents the first in the UK to use device-based and self-reported  
352 measures of total sedentary time and screen time behaviour to assess age-related  
353 differences and associations with adiposity. We considered multiple measures of  
354 adiposity, measured sedentary time using a validated device, and adjusted the analyses  
355 for known confounding factors. There were also limitations in this study. We used  
356 validated measures to assess screen time behaviours, but the data derived from these  
357 self-report measures may have been prone to some forms of measurement error, such  
358 as social desirability bias from participants. To protect against this, surveys were  
359 completed independently under the supervision of researchers and teachers, and  
360 participants verified their responses before submitting. Our self-report measure was  
361 unable to capture whether youth engaged in concurrent sedentary behaviours (i.e.,  
362 screen stacking) which may influence associations with adiposity. The SWA 1-minute  
363 epoch may not have been sensitive enough to capture short episodes of higher intensity  
364 activity and thus may have biased MVPA estimates (Edwardson & Gorely, 2010). The  
365 study design was cross-sectional, and we are therefore unable to determine causality.

366

#### 367 **Conclusion**

368

369 This study evidences an age-related gradient to device measured sedentary time and  
370 some self-reported screen time behaviours among UK youth. The results highlight the



371 importance of limiting total sedentary time in youth to reduce risk of adiposity. None  
372 of the self-reported screen time behaviours were associated with adiposity outcomes  
373 after adjustment for MVPA. Given the complexity of youth adiposity it is important  
374 for future research to explore the concurrent effect of a range of lifestyle behaviours  
375 including multiple modes of sedentary behaviour.

376

### 377 **Acknowledgments**

378

379 The authors would like to thank the schools, children, and teachers involved in the  
380 study. We are grateful to West Lancashire Sport Partnership for its support with this  
381 work, and to the Physical Education and School Sport students at Edge Hill University  
382 for their assistance with data collection.

383

### 384 **Disclosure statement**

385

386 No potential conflict of interest was reported by the authors.

387

### 388 **Funding**

389

390 This study was funded by the Youth Sport Trust and Edge Hill University. The Youth  
391 Sport Trust provided feedback on the study design but had no involvement in the  
392 collection, analysis or interpretation of the data, and in writing the manuscript. The  
393 study was supported by Edge Hill University and Liverpool John Moores University.  
394 Pedro Saint-Maurice was partially funded by an individual fellowship grant awarded

395 by the Fundacao para a Ciencia e Tecnologia (FCT; Portugal)  
396 (SFRH/B1/114330/2016) under the POPH/FSE programme.

397

## 398 **References**

399

400 Andre, D., Pelletier, R., Farrington, J., Safier, S., Talbott, W., Stone, R., Vyas, N., ...  
401 Teller, A. (2006). The Development of the SenseWear® armband, a Revolutionary  
402 Energy Assessment Device to Assess Physical Activity and Lifestyle. Pittsburgh,  
403 United States: BodyMedia Inc.

404

405 Arundell, L., Fletcher, E., Salmon, J., Veitch, J., & Hinkley, T. (2016). A systematic  
406 review of the prevalence of sedentary behavior during the after-school period among  
407 children aged 5-18 years. *International Journal of Behavioral Nutrition and Physical*  
408 *Activity*, 13, 93.

409

410 Arvidsson D, Slinde F, Larsson S, Hulthén L. (2007). Energy Cost of Physical  
411 Activities in Children: Validation of SenseWear Armband. *Medicine & Science in*  
412 *Sports & Exercise*, 39(11), 2076-2084.

413

414 Atkin, A. J., Ekelund, U., Moller, N. C., Froberg, K., Sardinha, L. B., Andersen, L. B.,  
415 & Brage, S. (2013). Sedentary time in children: influence of accelerometer processing  
416 on health relations. *Medicine & Science in Sports & Exercise*, 45, 1097–1104.

417

418 Bai, Y., Chen, S., Laurson, K. R., Kim, Y., Saint-Maurice, P. F., & Welk, G. J. (2016).  
419 The Associations of Youth Physical Activity and Screen Time with Fatness and

420 Fitness: The 2012 NHANES National Youth Fitness Survey. *PLoS ONE*, 11(1),  
421 e0148038.

422

423 Biddle, S. J. H., García Bengoechea, E., Wiesner, G. (2017). Sedentary behaviour and  
424 adiposity in youth: a systematic review of reviews and analysis of causality.  
425 *International Journal of Behavioral Nutrition and Physical Activity*, 14, 43.

426

427 Biddle, S. J. H., Gorely, T., Marshall, S. J., Cameron, N. (2009). The prevalence of  
428 sedentary behavior and physical activity in leisure time: a study of Scottish adolescents  
429 using ecological momentary assessment. *Preventive Medicine*, 48, 151–155.

430

431 Biddle, S. J. H., Marshall, S. J., Gorely, T., & Cameron N. (2009) Temporal and  
432 environmental patterns of sedentary and active behaviors during adolescents' leisure  
433 time. *International Journal of Behavioral Medicine*, 16(3), 278–286.

434

435 Calabro, M. A., Welk, G. J., & Eisenmann, J. C. (2009). Validation of the SenseWear  
436 Pro Armband algorithms in children. *Medicine and Science in Sports and Exercise*,  
437 41(9), 1714-1720.

438

439 Carson, V., Hunter, S., Kuzik, N., Gray, C. E., Poitras, V. J., Chaput, J. P., ...  
440 Tremblay, M. S. (2016a). Systematic review of the relationships between sedentary  
441 behaviour and health indicators in school-aged children and youth: an update. *Applied*  
442 *Physiology, Nutrition, and Metabolism*, 41, S240–265.

443

444 Carson, V., Tremblay, M. S., Chaput, J.-P., & Chastin, S. F. M. (2016b). Associations  
445 between sleep duration, sedentary time, physical activity, and health indicators among  
446 Canadian children and youth using compositional analyses. *Applied Physiology,*  
447 *Nutrition, and Metabolism*, 41(6 (Suppl. 3), S294-S302.

448

449 Cole, T. J., Freeman, J. V., & Preece, M. A. (1995). Body mass index reference curves  
450 for the UK, 1990. *Archives of Disease in Childhood*, 73, 25–29.

451

452 Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a  
453 standard definition for child overweight and obesity worldwide: International survey.  
454 *BMJ*, 320, 1240–1243.

455

456 Conolly, A. (2016). *Health Survey for England 2015: Children's body mass index,*  
457 *overweight and obesity*. Leeds: Health and Social Care Information Centre.

458

459 Coombs, N., Shelton, N., Rowlands, A., & Stamatakis, E. (2013). Children's and  
460 adolescents' sedentary behaviour in relation to socioeconomic position. *Journal of*  
461 *Epidemiology and Community Health*, 67, 868–874.

462

463 Coombs, N. A., & Stamatakis, E. (2015). Associations between objectively assessed  
464 and questionnaire-based sedentary behaviour with BMI-defined obesity among  
465 general population children and adolescents living in England. *BMJ Open*, 5, e007172.

466

467 Corder, K., van Sluijs, E. M., McMinn, A. M., Ekelund, U., Cassidy, A., & Griffin, S.  
468 J. (2010). Perception versus reality awareness of physical activity levels of British  
469 children. *American Journal of Preventive Medicine*, 38, 1–8.

470

471 De Bourdeaudhuij, I., Verloigne, M., Maes, L., Van Lippevelde, W., Chinapaw, M. J.,  
472 Te Velde, S. J., ... Brug, J. (2013). Associations of physical activity and sedentary  
473 time with weight and weight status among 10- to 12-year-old boys and girls in Europe:  
474 a cluster analysis within the ENERGY project. *Pediatric Obesity*, 8, 367–375.

475

476 Department for Communities and Local Government. (2015). *The English indices of*  
477 *deprivation 2015*. Wetherby: Communities and Local Government Publications.

478

479 Edwardson, C. L., & Gorely, T. (2010). Epoch length and its effect on physical activity  
480 intensity. *Medicine & Science in Sports & Exercise*, 42(5), 928–934.

481

482 Eisenmann, J. C., Bartee, R. T., Smith, D. T., Welk, G. J., & Fu, Q. (2008). Combined  
483 influence of physical activity and television viewing on the risk of overweight in US  
484 youth. *International Journal of Obesity*, 32(4), 613-618.

485

486 Fairclough, S. J., Dumuid, D., Taylor, S., Curry, W., McGrane, B., Stratton, G., Maher,  
487 C., & Olds, T. (2017). Fitness, Fatness and the Reallocation of Time between  
488 Children's Daily Movement Behaviours: An Analysis of Compositional Data.  
489 *International Journal of Behavioral Nutrition and Physical Activity*, 14:64.

490

491 Fulton, J. E., Wang, X., Yore, M. M., Carlson, S. A., Galuska, D. A., & Caspersen, C.  
492 J., (2009). Television Viewing, Computer Use, and BMI Among U.S. Children and  
493 Adolescents. *Journal of Physical Activity and Health*, 6(Suppl 1), S28-35.  
494

495 Grgic, J., Dumuid, D., Bengoechea, E. G, Shrestha, N., Bauman, A., Olds, T., &  
496 Pedisic, Z. (2018). Health outcomes associated with reallocations of time between  
497 sleep, sedentary behaviour, and physical activity: a systematic scoping review of  
498 isotemporal substitution studies. *International Journal of Behavioral Nutrition and*  
499 *Physical Activity*, 15:69.  
500

501 Habersick, B. C., Zeiger, J. S., & Corley, R. P. (2014). Genetic and Environmental  
502 Influences on the Allocation of Adolescent Leisure Time Activities. *BioMed Research*  
503 *International*, 2014, 805476.  
504

505 Jago, R., Page, A., Froberg, K., Sardinha, L. B., Klasson-Heggebø, L., & Andersen,  
506 L. B. (2008). Screen-viewing and the home TV environment: The European Youth  
507 Heart Study. *Preventive Medicine*, 47, 525–529.  
508

509 Janssen, X., Mann, K. D., Basterfield, L., Parkinson, K. N., Pearce, M. S., Reilly, J.  
510 K., ... Reilly, J. J. (2016). Development of sedentary behavior across childhood and  
511 adolescence: longitudinal analysis of the Gateshead Millennium Study. *International*  
512 *Journal of Behavioral Nutrition and Physical Activity*, 13, 88.  
513

514 Kenney, E. L., & Gortmaker, S. L. (2017). United States Adolescents' Television,  
515 Computer, Videogame, Smartphone, and Tablet Use: Associations with Sugary  
516 Drinks, Sleep, Physical Activity, and Obesity. *Journal of Pediatrics*, 182, 144-149.  
517

518 LeBlanc, A. G., Katzmarzyk, P. T., Barreira, T. V., Broyles, S. T., Chaput, J. P.,  
519 Church, T., S., ... Tremblay, M. S. (2016). Correlates of Total Sedentary Time and  
520 Screen Time in 9–11-Year-Old Children around the World: The International Study  
521 of Childhood Obesity, Lifestyle and the Environment. *PLoS ONE*, 10(6), e0129622.  
522

523 Leech, R. M., McNaughton, S. A., Timperio, A. (2014). The clustering of diet,  
524 physical activity and sedentary behavior in children and adolescents: a review.  
525 *International Journal of Behavioral Nutrition and Physical Activity*, 11, 4.  
526

527 Marques, A., Minderico, C., Martins, S., Palmeira, A., Ekelund, U., & Sardinha, L. B.  
528 (2016). Cross-sectional and prospective associations between moderate to vigorous  
529 physical activity and sedentary time with adiposity in children. *International Journal*  
530 *of Obesity*, 40, 28–33.  
531

532 Marshall, S. J., & Ramirez, E., (2011). Reducing sedentary behavior: a new paradigm  
533 in physical activity promotion. *American Journal of Lifestyle Medicine*, 5, 518–530.  
534

535 McCarthy, H. D., & Ashwell, M. (2006). A study of central fatness using waist-to-  
536 height ratios in UK children and adolescents over two decades supports the simple  
537 message – ‘keep your waist circumference to less than half your height’. *International*  
538 *Journal of Obesity*, 30, 988–992.

539

540 Mokha, J. S., Srinivasan, S. R., DasMahapatra, P., Fernandez, C., Chen, W., Xu, J., &  
541 Berenson, G. S. (2010). Utility of waist-to-height ratio in assessing the status of central  
542 obesity and related cardiometabolic risk profile among normal weight and  
543 overweight/obese children: The Bogalusa Heart Study. *BMC Pediatrics*, 10(1), 73.

544

545 MIMAS. Available online: <http://geoconvert.mimas.ac.uk/> (accessed on 17 May  
546 2018).

547

548 Ofcom. (2017). *Children and Parents: Media Use and Attitudes Report*. London:  
549 Ofcom.

550

551 R Core Team. (2017). *R: A language and environment for statistical computing*. R  
552 Foundation for Statistical Computing. Vienna, Austria. URL [https://www.R-](https://www.R-project.org/)  
553 [project.org/](https://www.R-project.org/).

554

555 Ridgers, N. D., Hnatiuk, J. A., Vincent, G. E., Timperio, A., Barnett, L. M., & Salmon,  
556 J. (2016). How many days of monitoring are needed to reliably assess SenseWear  
557 Armband outcomes in primary school-aged children? *Journal of Science and Medicine*  
558 *in Sport*, 19(12), 999–1003.

559

560 Rowlands, A. V., Harrington, D. M., Bodicoat, D. H., Davies, M. J., Sherar, L. B.,  
561 Gorely, T., ... Edwardson, C. L. (2018). Compliance of Adolescent Girls to Repeated  
562 Deployments of Wrist-Worn Accelerometers. *Medicine & Science in Sports &*  
563 *Exercise*, 50(7), 1508-17.



564

565 Ruiz, J. R., Ortega, F. B., Martínez-Gómez, D., Labayen, I., Moreno, L. A., De  
566 Bourdeaudhuij, I., ... Sjöström, M. (2011). Objectively measured physical activity and  
567 sedentary time in European adolescents. *American Journal of Epidemiology*, 174, 173-  
568 184.

569

570 Saint-Maurice P. F., Kim, Y., Hibbing, P., Oh, A. Y., Perna, F. M., & Welk, G. J.  
571 Calibration and Validation of the Youth Activity Profile: The FLASHE Study.  
572 *American Journal of Preventive Medicine*, 52(6), 880-887.

573

574

575 Saint-Maurice, P. F., & Welk, G. J. (2015). Validity and Calibration of the Youth  
576 Activity Profile. *PLoS ONE*, 10(12), e0143949.

577

578 Sandercock, G. R. H., Ogunleye, A., & Voss, C. (2012). Screen Time and Physical  
579 Activity in Youth: Thief of Time or Lifestyle Choice? *Journal of Physical Activity and*  
580 *Health*, 9, 977-984.

581

582

583 Santos, D. A., Júdice, P. B., Magalhães, J. P., Correia, I. R., Silva, A. M., Baptista, F.,  
584 & Sardinha, L. B. (2018). Patterns of accelerometer-derived sedentary time across the  
585 lifespan. *Journal of Sports Sciences*, 36(24), 2809-2817.

586

587 Santos, D. A., Magalhães, J. P., Júdice, P. B., Correia, I. R., Minderico, C. S., Ekelund,  
588 U., & Sardinha, L. B. (2018). Fitness Mediates Activity and Sedentary Patterns

589 Associations with Adiposity in Youth. *Medicine & Science in Sports & Exercise*.  
590 doi:10.1249/MSS.0000000000001785.

591

592 Saunders, T. J., Chaput, J. P., & Tremblay, M. S. (2014). Sedentary behaviour as an  
593 emerging risk factor for cardiometabolic diseases in children and youth. *Canadian*  
594 *Journal of Diabetes*, 38(1), 53–61.

595

596 Saunders, T. J., & Vallance, J. K. (2017). Screen Time and Health Indicators Among  
597 Children and Youth: Current Evidence, Limitations and Future Directions. *Applied*  
598 *Health Economics and Health Policy*, 15, 323–331.

599

600 Sheldrick, M. P. R., Tyler, R., Mackintosh, K. A., & Stratton, G. (2018). Relationship  
601 between Sedentary Time, Physical Activity and Multiple Lifestyle Factors in Children.  
602 *Journal of Functional Morphology and Kinesiology*, 3, 15.

603

604 Slootmaker, S. M., Schuit, A. J., Chinapaw, M. J., Seidell, J. C., & van Mechelen, W.  
605 (2009). Disagreement in physical activity assessed by accelerometer and self-report in  
606 subgroups of age, gender, education and weight status. *International Journal of*  
607 *Behavioral Nutrition and Physical Activity*, 6:17.

608

609 Steffen, L. M., Dai, S., Fulton, J. E., & Labarthe, D. R. (2009). Overweight in children  
610 and adolescents associated with TV viewing and parental weight: Project HeartBeat!  
611 *American Journal of Preventive Medicine*, 37(1 Suppl), S50-5.

612

613 Stiglic, N., & Viner, R. M. (2019). Effects of Screen time on the Health and Well-  
614 Being of Children and Adolescents: A Systematic Review of Reviews. *BMJ Open*,  
615 9:e023191.

616

617 Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-  
618 Cheung, A. E., ... Chinapaw, M. J. M. (2017). Sedentary Behavior Research Network  
619 (SBRN) – Terminology Consensus Project process and outcome. *International*  
620 *Journal of Behavioral Nutrition and Physical Activity*, 14, 75.

621

622 Tremblay, M. S., LeBlanc, A. G., Kho, M. E., Saunders, T. J., Larouche, R., Colley,  
623 R. C., ... Gorber, S. C. (2011a). Systematic review of sedentary behaviour and health  
624 indicators in school-aged children and youth. *International Journal of Behavioral*  
625 *Nutrition and Physical Activity*, 8, 98.

626

627 Tremblay, M. S., LeBlanc, A. G., Janssen, I, Connor Gorber, S., Dinh, T., Duggan,  
628 M., ... Zehr, L (2011b). Canadian sedentary behaviour guidelines for children and  
629 youth. *Applied Physiology, Nutrition, and Metabolism*, 36, 59–64.

630

631 van Loo CMT, Okely AD, Batterham MJ, Hinkley, T., Ekelund, U., Brage, S., ...  
632 Cliff, D. P. (2017). Validation of the SenseWear Mini activity monitor in 5–12-year-  
633 old children. *Journal of Science and Medicine in Sport*, 20(1), 55-59.

634

635 Welk, G.J.; Kim, Y. (2016). Sedentary Behavior in Youth. In: Zhu, W and Owen, N.  
636 (Eds.) *Sedentary Behavior and Health: Concepts, Assessment & Intervention*. Human  
637 Kinetics, Champaign. IL

638

639 Welk, G., Morrow, J. R. Jr., & Saint-Maurice, P. F. (2017). *Measures Registry User*  
640 *Guide: Individual Physical Activity*. Washington DC: National Collaborative on  
641 Childhood Obesity Research.

642

643 Zhang, G., Wu, L., Zhou, L., Lu, W., & Mao, C. (2016). Television watching and risk  
644 of childhood obesity: a meta-analysis. *European Journal of Public Health*, 26(1), 13-  
645 18.

646

647

648

649

650

651

652

653

654

655

656

657

658

659

660

661

662

663 Table 1. Descriptive characteristics of sample

Variable	Year 5 ( <i>n</i> = 93)	Year 8 ( <i>n</i> = 94)	Year 10 ( <i>n</i> = 105)
	Mean (SD) or %	Mean (SD) or %	Mean (SD) or %
Gender			
Boy	50.50	40.40	56.20
Girl	49.50	59.60	43.80
Age (years)	10.18 (0.33)	13.17 (0.34)	15.23 (0.33)
Stature (cm)	141.37 (6.20)	157.16 (9.10)	167.61 (8.59)
Body mass (kg)	36.08 (7.81)	51.04 (11.44)	63.26 (12.15)
BMI (kg/m <sup>2</sup> )	17.93 (2.91)	20.69 (4.62)	22.55 (4.22)
BMI z-score	0.46 (1.08)	-0.12 (8.03)	0.85 (1.13)
Overweight/obese	26.90	27.70	33.30
WC (cm)	64.38 (7.23)	72.61 (9.66)	76.80 (9.83)
WHtR	0.46 (0.05)	0.46 (0.07)	0.46 (0.06)
WHtR >0.50	15.10	22.30	21.90
Sedentary time (min/day)	581.09 (107.81)	671.96 (112.59)	725.80 (115.20)
MVPA (min/day)	158.50 (70.77)	137.29 (64.77)	138.74 (64.39)
Deprivation score	16.26 (10.20)	20.55 (14.21)	19.63 (13.72)

664 BMI, body mass index; WC, waist circumference; SD, standard deviation; WHtR,  
665 waist-to-height-ratio; MVPA, moderate-to-vigorous physical activity.

666

667

668

669

670

671

672 Table 2. Multinomial logistic regression associations between Year group and  
 673 adiposity outcomes and screen time behaviours.

674

Variable	Year 5	Year 8	Year 10
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
<b>Adiposity outcomes</b>			
Overweight/obese	(Ref)	1.37 (0.72 - 2.61)	1.02 (0.53 - 1.95)
Central obesity	(Ref)	0.92 (0.46 - 1.87)	1.20 (0.55 - 2.58)
<b>Screen time behaviours</b>			
TV > 2 hrs/day	(Ref)	0.61 (0.32 - 1.14)	1.13 (0.56 - 2.26)
TV > 3 hrs/day	(Ref)	0.92 (0.31 - 2.66)	0.80 (0.29 - 2.22)
Video > 2 hrs/day	(Ref)	0.58 (0.30 - 1.13)	1.52 (0.77 - 3.03)
Video > 3 hrs/day	(Ref)	0.85 (0.39 - 1.87)	3.34 (1.28 - 8.71) **
Computer > 2 hrs/day	(Ref)	1.58 (0.88 - 2.85)	5.02 (2.43 - 10.40) ***
Computer > 3 hrs/day	(Ref)	1.54 (0.75 - 3.15)	29.81 (3.93 - 46.37) ***
Phone > 2 hrs/day	(Ref)	2.90 (1.60 - 5.26) ***	11.73 (5.81 - 23.69) ***
Phone > 3 hrs/day	(Ref)	2.54 (1.39 - 4.6) **	10.71 (4.50 - 25.47) ***

675 Adjusted for gender, deprivation and MVPA in all analyses; Year 5 group were  
 676 reference category; CI, confidence interval; \*\*  $p \leq 0.01$ ; \*\*\*  $p \leq 0.001$ .

677

678

679

680

681

682 Table 3. Adjusted linear regression associations between device assessed sedentary time and adiposity outcomes.

683

Variable	Model 1 †				Model 2 ††			
	B (95% CI)	SE	$\beta$	<i>p</i>	B (95% CI)	SE	$\beta$	<i>p</i>
BMI z-score	0.01 (0.00 – 0.01)	0.00	0.19	0.005	0.01 (0.00 – 0.01)	0.00	0.21	0.008
Constant	-2.50 (-5.79 - 0.80)	1.68		0.14	-3.32 (-8.09 - 1.44)	2.42		0.17
Waist circumference	0.03 (0.02 - 0.03)	0.00	0.30	>0.001	0.02 (0.01 - 0.03)	0.01	0.22	>0.001
Constant	46.23 (40.10 - 52.35)	3.11		>0.001	54.22 (45.46 - 62.97)	4.45		>0.001

684 † Analyses adjusted for gender, Year group and deprivation; † Analyses adjusted for gender, Year group, deprivation and MVPA; B,  
 685 unstandardised  $\beta$  coefficient;  $\beta$ , standardised  $\beta$  coefficient; BMI, body mass index; CI, confidence interval; SE, Standard error.

686

687

688

689

690

691

692

693 Table 4. Adjusted logistic regression associations between screen time behaviours and adiposity outcomes.

694

Variable	Overweight/obese †	Overweight/obese ††	Central obesity †	Central obesity ††
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
TV > 2 hrs/day	1.08 (0.60 - 1.93)	1.10 (0.60 - 2.02)	1.20 (0.62 - 2.29)	1.26 (0.64 - 2.48)
TV > 3 hrs/day	0.65 (0.23 - 1.85)	0.63 (0.21 - 1.88)	0.83 (0.27 - 2.56)	0.81 (0.25 - 2.64)
Video > 2 hrs/day	1.31 (0.72 - 2.38)	1.24 (0.67 - 2.31)	1.64 (0.84 - 3.19)	1.55 (0.78 - 3.08)
Video > 3 hrs/day	1.39 (0.67 - 2.90)	1.21 (0.56 - 2.61)	2.28 (1.04 - 5.02) *	1.99 (0.87 - 4.55)
Computer > 2 hrs/day	1.41 (0.80 - 2.47)	1.27 (0.71 - 2.29)	1.61 (0.86 - 3.01)	1.44 (0.75 - 2.77)
Computer > 3 hrs/day	1.55 (0.76 - 3.17)	1.30 (0.62 - 2.74)	1.66 (0.76 - 3.62)	1.37 (0.61 - 3.07)
Phone > 2 hrs/day	1.45 (0.82 - 2.58)	1.43 (0.79 - 2.58)	1.14 (0.60 - 2.17)	1.12 (0.57 - 2.19)
Phone > 3 hrs/day	1.36 (0.75 - 2.46)	1.25 (0.68 - 2.31)	1.36 (0.70 - 2.63)	1.25 (0.63 - 2.48)

695 † Adjusted for gender, Year group, deprivation; †† Adjusted for gender, Year group, deprivation and MVPA; Year 10 children were the

696 reference group; CI, confidence interval; \*  $p \leq 0.05$ .



