

**Gotta catch 'em all: Impact of Pokémon Go on physical activity, sitting time and perceptions of physical activity and health at baseline and three months follow up**

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1 **Gotta catch ‘em all: Impact of Pokémon Go on physical activity, sitting time and perceptions of**  
2 **physical activity and health at baseline and three months follow up**

3

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5

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9

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15

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19

20 **Abstract**

21 **Objective:** The objective was to examine differences in physical activity, sitting time and perceptions  
22 of physical activity and health between Pokémon Go users' and non-users' at baseline (launch of the  
23 application in the UK) and 3-months follow up.

24 **Materials and Methods:** The self-administered, short version of the 7-day recall, International  
25 Physical Activity Questionnaire was adapted to develop the 'Physical Activity and Pokémon Go  
26 questionnaire' which was distributed using social media. Four weeks after the launch of the  
27 application, 461 participants (n = 193 male, n = 265 female, n = 3 transgender), had completed the  
28 questionnaire. At 3-months follow up, 127 participants repeated the questionnaire.

29 **Results:** At baseline, mixed models ANOVA revealed main effects for Pokémon Go users' versus  
30 non-users' in the amount of days of vigorous physical activity, moderate physical activity and walking  
31 (All  $p < 0.01$ ). Users' reported that they undertook less days of vigorous physical activity than non-  
32 users' but more days of moderate physical activity and walking. There were no differences in BMI,  
33 minutes of vigorous or moderate physical activity, and walking, or sitting on weekdays (All  $p > 0.05$ ).  
34 Repeated measures ANOVA identified increased sitting on weekdays ( $p < 0.05$ ), but maintained  
35 vigorous, moderate and walking physical activity behaviours in users' who remained users'.

36 **Conclusion:** Pokémon Go use can increase the frequency of days of physical activity benefitting  
37 health. Users' at both time points maintained their physical activity behaviour but increased sitting  
38 time on weekdays, highlighting that another intervention to prevent sitting is needed.

39 **Objective**

40

41 Mobile phone applications to increase physical activity and encourage healthy eating behaviour have  
42 been evaluated, with reports that the most effective are those that incorporate virtual avatars, gaming  
43 and social media.<sup>1</sup> The use of technological devices has great potential given the possibility of  
44 reaching large populations at low cost. For instance, Ofcom<sup>2</sup> reported that 93% of UK adults  
45 personally own or use a mobile phone. One such intervention delivered via a smartphone application  
46 is Pokémon Go, which is a free-to-play, location-based augmented reality game that was released  
47 globally in July 2016. Using Global Positioning System (GPS) and the mobile phone camera, the  
48 application encourages users' to collect animated Pokémon characters by moving to locations within  
49 their environment. The aim is to collect as many characters as possible which is encapsulated by the  
50 developer's slogan 'Gotta catch 'em all'. When a user is near a Pokémon character, the mobile phone  
51 vibrates to alert the user to move to the characters location and catch it by throwing a Pokéball. To  
52 level up, users' need to be physically active, travelling 2-10 km, and by doing so, hatch the eggs they  
53 have incubated on the application.

54

55 To date, few articles have examined the impact of Pokémon Go. One study estimated that Pokémon  
56 Go users' have accrued 144 billion steps in the US<sup>3</sup>. Likewise, Xian et al<sup>4</sup> reported an increase in  
57 physical activity from pre- to post-launch and that the number of users' reaching the  $\geq 10,000$  daily  
58 steps recommendation significantly increased from 15.3% to 27.5%. They also reported the greatest  
59 increase in physical activity for those using the application most often, people who are overweight or  
60 with obesity and those with the lowest pre-launch physical activity levels. Similarly, Wong<sup>5</sup> reported  
61 the greatest increases in physical activity amongst users' who were classified as sedentary prior to the  
62 launch of Pokémon Go.

63

64 To the authors' knowledge, only one study has reported data representing the impact of Pokémon Go  
65 over time. Howe et al.<sup>6</sup> examined Pokémon Go's impact on physical activity for 6-weeks. The initial

66 increase in users' steps dissipated and returned to pre-launch levels. As this is the only study to  
67 examine Pokémon Go users' physical activity over time, this has not been confirmed.

68 As sedentary behaviour is an independent risk factor for non-communicable diseases<sup>7</sup>, the potential of  
69 Pokémon Go to reduce sitting time warrants examination. It was hypothesised that Pokémon Go  
70 users' would report higher levels of physical activity than non-users' at baseline (hypothesis 1).  
71 Whilst no research has presented data on sitting time, in line with previous research reporting  
72 increased physical activity, it was hypothesised that sitting time would be lower in Pokémon Go  
73 users' (hypothesis 2). Finally, in line with Howe et al.<sup>6</sup> it was hypothesised that increased physical  
74 activity, would have reduced at 3-months follow up (hypothesis 3).

75

## 76 **Materials and Methods**

77

### 78 **Design**

79 A repeated measures design was used to examine the impact of Pokémon Go on physical activity,  
80 sitting time and perceptions of physical activity and health.

81

### 82 **Participants**

83 Participants could complete the 'Physical Activity and Pokémon Go Questionnaire' during a four-  
84 week period after Pokémon Go was released in the UK. After 4 weeks, 461 participants (n = 193  
85 male, n = 265 female, n = 3 transgender), predominantly white (n = 420), not self-reporting a  
86 disability (n = 443) completed the questionnaire. No participants reporting a disability were excluded  
87 as it was deemed the disability would not impact on their physical activity. Users' and non-users'  
88 mean  $\pm$  SD age, height, body mass and body mass index (BMI) at baseline is highlighted in Table 1

89

90 When invited to participate in future research, 234 participants provided their email addresses. At  
91 follow up, 127 (55%; n = 54 male, n = 72 female, n = 1 transgender), predominantly white (n = 117),  
92 not self-reporting a disability (n = 122), provided consent and repeated the questionnaire at 3-months.

93 Users' and non-users' mean  $\pm$  SD age, height, body mass and BMI at 3-months is also highlighted in  
94 Table 1.

95 There were 23 users' and 104 non-users'; 56 were users' at baseline and 71 were non-users'. Thus, 33  
96 participants ceased using Pokémon Go within 3-months and nobody became users'.

97

## 98 **Measures**

99 The self-administered, short version of the 7-day recall, International Physical Activity Questionnaire  
100 (IPAQ)<sup>8</sup> was adapted to develop the 'Physical Activity and Pokémon Go Questionnaire' and was  
101 distributed using Qualtrics<sup>TM</sup>.<sup>9</sup> Questions were presented in four sections as follows:

102

103 1) Demographics, anthropometrics and confirmation of whether participants had used Pokémon Go -  
104 completed by all participants.

105

106 2) IPAQ, with the addition of the weekend sitting time question taken directly from the self-  
107 administered long version of the 7-day recall IPAQ<sup>8</sup> - completed by all participants.

108

109 3) IPAQ adapted to ascertain the amount of physical activity undertaken solely when using Pokémon  
110 Go. Thus, for each item of the IPAQ, the statement, 'because you used the Pokémon Go<sup>TM</sup> app' was  
111 added. Questions were developed in-house to examine perceptions of the benefits of Pokémon Go on  
112 physical activity and health. Likert scales were used ranging from 'Strongly Disagree' to 'Strongly  
113 Agree' - completed by Pokémon Go users' only.

114

115 4) Perceptions of the benefits of Pokémon Go on physical activity and health. (as in section 3) -  
116 completed by non-users' only.

117

## 118 **Procedures**

119 Following approval from Sheffield Hallam University's Faculty of Health and Wellbeing ethics  
120 committee, the questionnaire was distributed through social media from 22<sup>nd</sup> July 2016 using a

121 bespoke link.<sup>10</sup> Participants were informed not to complete the questionnaire if during the last 7 days  
122 they had not been able to undertake their typical amount of physical activity due to injury, illness or  
123 for any other reason. After 3-months, participants **who provided an email** were contacted again.

124

## 125 **Data Analysis**

126 Mixed models Analysis of Variance (ANOVA) examining between subject factors (e.g. user versus  
127 non- user) and within subject factors (e.g. baseline versus 3-months) were used. Bonferroni correction  
128 for confidence interval adjustment and follow up post-hoc tests with Scheffé correction were used to  
129 examine the impact of Pokémon Go use and gender on self-reported BMI, days and minutes of  
130 vigorous and moderate physical activity and walking, sitting on weekdays and weekends, and  
131 perceptions of the impact of Pokémon Go on physical activity and health, at baseline and 3-months  
132 follow up.

133

134 Mann-Whitney U tests were used to examine gender differences in users' perceptions of the specific  
135 impact that using the application had on physical activity and sitting time at baseline and 3-months  
136 follow up.

137

138 Repeated measures ANOVA with Bonferroni correction for confidence interval adjustment and  
139 follow up post-hoc tests with Scheffé correction were used to examined gender differences in self-  
140 reported BMI, days of vigorous and moderate physical activity and walking, and minutes of vigorous  
141 and moderate physical activity and walking, sitting on weekdays and weekends at baseline compared  
142 to 3-months follow up for: 1) users' who remained users'; 2) users' who became non-users'; and 3)  
143 non-users' who remained non-users'. Follow up independent t-tests examined significant gender  
144 effects.

145

146 Statistical significance was accepted if  $p < 0.05$ . Effect sizes were quantified using partial eta squared  
147 ( $\eta^2$ ), with 0.01, 0.03, and  $> 0.05$  considered small, medium, and large effects, respectively. Data are  
148 presented as mean  $\pm$  standard deviation unless otherwise stated.

149

## 150 **Results**

151

152 Descriptive statistics for study population physical activity and sitting time at baseline are shown in  
153 Table 2; study population physical activity and sitting time at 3-months are shown in Table 3; and  
154 users' physical activity and reduced sitting time reported specifically due to Pokémon Go use  
155 are shown in Table 4.

156

### 157 *Baseline*

158 Mixed model ANOVA highlighted main effects for Pokémon Go users' or non-users' on the amount  
159 of days of vigorous and moderate physical activity and walking ( $F(1, 418) = 24.52, p < 0.01, \eta_p^2 =$   
160  $0.03; F(1, 418) = 4.25, p < 0.05, \eta_p^2 = 0.01; F(1, 418) = 10.52, p < 0.01, \eta_p^2 = 0.03$  respectively).  
161 Users' reported less days of vigorous physical activity than non-users'. However, users' also reported  
162 they undertook more days of moderate physical activity and walking compared to non-users'. There  
163 were no differences in BMI, minutes of vigorous and moderate physical activity or walking between  
164 Pokémon Go users' and non-users' ( $p > 0.05$ ). Likewise, there were no differences in sitting time on  
165 weekdays or weekends ( $p > 0.05$ ).

166

167 Main effects of gender were observed on the amount of days participants reported undertaking  
168 vigorous and moderate physical activity and walking ( $F(2, 418) = 6.56, p < 0.01, \eta_p^2 = 0.03; F(2,$   
169  $418) = 3.26, p < 0.05, \eta_p^2 = 0.01; F(2, 418) = 4.76, p < 0.01, \eta_p^2 = 0.02$  respectively), and the  
170 amount of minutes of vigorous physical activity ( $F(2, 418) = 8.02, p < 0.01, \eta_p^2 = 0.03$ ). Males  
171 reported more days of vigorous and moderate physical activity, and walking and more minutes of  
172 vigorous physical activity than females. There were no gender differences for BMI, minutes of  
173 moderate physical activity or walking ( $p > 0.05$ ). There were also no gender differences for sitting  
174 time on weekdays or weekends ( $p > 0.05$ ).



175 There was an interaction between using Pokémon Go and gender on BMI and minutes of moderate  
176 physical activity ( $F(1, 418) = 4.08, p < 0.05, \eta_p^2 = 0.10$ ;  $F(1, 418) = 7.11, p < 0.01, \eta_p^2 = 0.02$   
177 respectively). The interactions demonstrated that female users' reported a higher BMI than non-  
178 users', whilst male users' reported a lower BMI compared to non-users'. The interaction also  
179 demonstrated that male users' reported more minutes of moderate physical activity than non-users',  
180 whilst female users' reported less minutes of moderate physical activity compared to non-users'.  
181 There were no interaction effects for Pokémon Go use and gender on the amount of days of vigorous  
182 physical activity and walking, or minutes of vigorous physical activity and walking ( $p > 0.05$ ).  
183 Likewise, there were no interactions for sitting time on weekdays or weekends ( $p > 0.05$ ).

184

#### 185 *Perceptions of whether Pokémon Go use can increase physical activity and improve health*

186 Perceptions of whether Pokémon Go use can increase physical activity and improve health at baseline  
187 are highlighted in Figure 1. Mixed models ANOVA revealed a main effect for using Pokémon Go or  
188 not on perceptions of whether Pokémon Go can increase physical activity and improve health at  
189 baseline ( $F(1, 422) = 5.95, p < 0.05, \eta_p^2 = 0.01$ ;  $F(1, 422) = 4.32, p < 0.05, \eta_p^2 = 0.01$  respectively).  
190 Users' had a stronger perception that Pokémon Go use can increase physical activity and improve  
191 health compared to non-users' at baseline ( $p < 0.05$ ).

192

193 There was a main effect of gender on perceptions of whether Pokémon Go can improve health ( $F(2,$   
194  $422) = 3.65, p < 0.05, \eta_p^2 = 0.02$ ), where males reported a stronger perception that Pokémon Go use  
195 can improve health compared to females ( $p < 0.05$ ). There was no main effect at baseline for gender  
196 on perceptions that Pokémon Go use can increase physical activity ( $p > 0.05$ ). There was no  
197 interaction between Pokémon Go use and gender for perceptions of whether Pokémon Go use can  
198 increase physical activity and improve health ( $p > 0.05$ ).

199

#### 200 *Physical activity and reduced sitting time specifically due to Pokémon Go*

201 When users' were specifically asked how the application impacted their physical activity and sitting  
202 time, Mann-Whitney U tests revealed that there was no gender difference for the days or minutes of  
203 vigorous and moderate physical activity, and walking ( $p > 0.05$ ). Likewise, there was no gender  
204 difference on sitting time on weekdays and weekends ( $p > 0.05$ ).

205

### 206 **Three month follow up**

207 Mixed models ANOVA highlighted main effects for Pokémon Go use or not on days of vigorous  
208 physical activity, minutes of vigorous physical activity, and minutes walking ( $F(1, 104) = 4.71, p <$   
209  $0.05, \eta_p^2 = 0.04$ ;  $F(1, 104) = 4.24, p < 0.05, \eta_p^2 = 0.04$ ;  $F(1, 104) = 4.48, p < 0.05, \eta_p^2 = 0.04$   
210 respectively). Users' reported less days and minutes of vigorous physical than non-users'. Users'  
211 reported more minutes of walking compared to non-users'. There were no significant differences for  
212 BMI, days of moderate physical activity or walking between users' and non-users' ( $p > 0.05$ ).  
213 Likewise, there was no significant differences in sitting time on weekdays or weekends between  
214 users' and non-users' ( $p > 0.05$ ).

215

216 There were no significant gender differences for BMI, or days and minutes of vigorous and moderate  
217 physical activity and walking ( $p > 0.05$ ). Likewise, there were no significant gender differences for  
218 sitting time on weekdays or weekends ( $p > 0.05$ ).

219

220 There was a significant interaction between using Pokémon Go or not and gender on BMI and the  
221 amount of days of walking ( $F(1, 104) = 4.76, p < 0.05, \eta_p^2 = 0.04$ ;  $F(1, 104) = 5.45, p < 0.05, \eta_p^2 =$   
222  $0.05$  respectively). The interactions demonstrated that female users' reported a higher BMI than non-  
223 users', whilst male users' reported a lower BMI compared to non-users'. Interactions also  
224 demonstrated that male users' reported more days of walking than non-users', whilst female users'  
225 reported less days of walking compared to non-users'. There were no interactions between Pokémon  
226 Go use and gender for the amount of days or minutes of vigorous and moderate physical activity ( $p >$

227 0.05). Likewise, there were no interactions between Pokémon Go use and gender for sitting time on  
228 weekdays and weekends ( $p > 0.05$ ).

229

### 230 *Perceptions of whether Pokémon Go use can increase physical activity and improve health*

231 Perceptions of whether Pokémon Go use can increase physical activity and improve health at 3-  
232 months are highlighted in Figure 1. Mixed models ANOVA highlighted a main effect of Pokémon Go  
233 use on perceptions of whether Pokémon Go can increase physical activity and improve health at 3-  
234 months ( $F(1, 102) = 6.67, p < 0.05, \eta_p^2 = 0.06$ ;  $F(1, 102) = 4.50, p < 0.05, \eta_p^2 = 0.04$  respectively).  
235 Users' had a stronger perception that Pokémon Go use can increase physical activity and improve  
236 health compared to non-users' ( $p < 0.05$ ). At 3-months, there was no main effect of gender on  
237 perceptions of whether Pokémon Go use can increase physical activity or improve health ( $p > 0.05$ ).  
238 There were no interactions between gender and Pokémon Go use at 3-months ( $p > 0.05$ ).

239

### 240 *Physical activity and reduced sitting time specifically due to Pokémon Go*

241 When users' were specifically asked how the application impacted their physical activity and sitting  
242 time, Mann-Whitney U tests revealed that there was no gender difference for the days or minutes of  
243 vigorous physical activity, moderate physical activity, and walking ( $p > 0.05$ ). Likewise, there was no  
244 gender difference for sitting on weekdays or weekends ( $p > 0.05$ ).

245

### 246 **Comparison of Pokémon Go users' at baseline and 3-months**

247 Repeated measures ANOVA revealed that there was a main effect of sitting time on a weekday from  
248 baseline to 3-months, where participants reported more sitting at 3-months ( $F(1, 20) = 5.37, p < 0.05,$   
249  $\eta_p^2 = 0.21$ ). Repeated measures ANOVA highlighted that there was no main effect of time (baseline vs  
250 3-months) on BMI, days or minutes of vigorous and moderate physical activity, and walking ( $p >$   
251  $0.05$ ). Likewise, there was no main effect of time (baseline vs 3-months) on sitting time at weekends  
252 ( $p > 0.05$ ).

253

254 There were no gender differences at baseline compared to 3-months follow up for BMI, the amount of  
255 days or minutes of vigorous and moderate physical activity, and walking ( $p > 0.05$ ). Likewise, there  
256 were no gender differences at baseline compared to 3-months follow up for sitting time on weekdays  
257 and weekends ( $p > 0.05$ ).

258

259 There were no gender interactions of Pokémon Go use and time (baseline vs 3-months) for BMI, the  
260 amount or days or minutes of vigorous and moderate physical activity, and walking ( $p > 0.05$ ).  
261 Likewise, there were no gender interactions of Pokémon Go use and time (baseline vs 3-months) for  
262 sitting time on weekdays and weekends ( $p > 0.05$ ).

263

264 *Physical activity and reduced sitting time specifically due to Pokémon Go*

265 When users' were specifically asked how the application impacted their physical activity and sitting  
266 time, repeated measures ANOVA revealed that there were no main effects, gender differences or  
267 interactions for the impact of Pokémon Go and gender between baseline and 3-months on the days or  
268 minutes of vigorous and moderate physical activity, and walking ( $p > 0.05$ ). Likewise, there were no  
269 main effects, gender differences or interactions for the impact of Pokémon Go and gender between  
270 baseline and 3-months for sitting time on weekdays and weekends ( $p > 0.05$ ).

271

272 **Comparison of Pokémon Go users' at baseline who became non-users' at 3-months**

273 Repeated measures ANOVA highlighted that there was a main effect of time (baseline vs 3-months)  
274 where participants reported more sitting at weekends at 3-months ( $F(1, 31) = 6.97, p < 0.05, \eta_p^2 =$   
275  $0.18$ ). However, there was no main effect of time on BMI, the days or minutes of vigorous and  
276 moderate physical activity, and walking, ( $p > 0.05$ ). Likewise, there was no main effect of time for  
277 sitting time on weekdays ( $p > 0.05$ ).

278

279 There were no gender differences between baseline and 3-months for BMI, the amount or days or  
280 minutes of vigorous and moderate physical activity, and walking ( $p > 0.05$ ). Likewise, there were no

281 gender differences between baseline and 3-months for sitting time on weekdays or weekends ( $p >$   
282 0.05).

283

284 There were interactions between baseline and 3-months for gender and days of vigorous physical  
285 activity and sitting time on weekends ( $F(1, 31) = 5.52, p < 0.05, \eta_p^2 = 0.15; F(1, 31) = 6.97, p < 0.05,$   
286  $\eta_p^2 = 0.18; F(1, 31) = 7.35, p < 0.05, \eta_p^2 = 0.19$  respectively). Males reported more days of vigorous  
287 physical activity and maintained their sitting time on weekends at 3-months compared to baseline,  
288 whilst females reported more days of vigorous physical activity and less sitting time on weekends at  
289 baseline compared to 3-months follow up. There were no gender interactions between baseline and 3-  
290 months for BMI, the amount or days of moderate physical activity, and walking, or minutes of  
291 vigorous and moderate physical activity and walking ( $p > 0.05$ ). Likewise, there were no gender  
292 interactions between baseline and 3-months for sitting time on weekdays ( $p > 0.05$ ).

293

#### 294 **Comparison of non-users' at baseline and at 3-months**

295 Repeated measures ANOVA highlighted that there was no main effect of time (baseline vs 3-months)  
296 on BMI, the days or minutes of vigorous and moderate physical activity, and walking ( $p > 0.05$ ).  
297 Likewise, there was no main effect of time for sitting time on weekdays and weekends ( $p > 0.05$ ).

298

299 Repeated measures ANOVA highlighted that there was a gender effect of BMI, days of vigorous  
300 physical activity from baseline to 3-months ( $F(1, 69) = 6.36, p < 0.05, \eta_p^2 = 0.09; F(1, 69) = 7.97, p <$   
301  $0.05, \eta_p^2 = 0.10$ ). Follow up independent t-tests revealed males reported a higher BMI at baseline and  
302 at 3-months compared to females ( $t(67) = 2.92, p < 0.01; t(65) = 2.14, p < 0.05$ ). There was no  
303 difference at baseline between males and females for the amount of days of vigorous physical activity  
304 ( $p > 0.05$ ), however, there was a difference at 3-months follow up ( $t(69) = 3.00, p < 0.01$ ). There were  
305 no gender differences between baseline and 3-months follow up for days of moderate physical  
306 activity, and walking, or minutes of vigorous and moderate physical activity and walking ( $p > 0.05$ ).

307 Likewise, there were no gender differences between baseline and 3-months follow up for sitting time  
308 on weekdays or weekends ( $p > 0.05$ ).

309

310 There was a gender interaction between baseline and 3-months for minutes of moderate physical  
311 activity ( $F(1, 69) = 4.55, p < 0.05, \eta_p^2 = 0.06$ ). Females reported more minutes of moderate physical  
312 activity at baseline compared to 3-months, whilst males reported less minutes of moderate physical  
313 activity compared to 3-months. There were no gender interactions between baseline and 3-months for  
314 BMI, the amount of days of vigorous and moderate physical activity, and walking, or minutes of  
315 vigorous physical activity and walking ( $p > 0.05$ ). Likewise, there were no gender interactions  
316 between baseline and 3-months for sitting time on weekdays or weekends ( $p > 0.05$ ).

317

## 318 **Discussion**

319 This study examined the impact of Pokémon Go on physical activity, sitting time and perceptions of  
320 the physical activity and health benefits. It was hypothesized that users' would report higher levels of  
321 physical activity and less sitting time than non-users' at baseline. Significant differences were  
322 identified for the amount of days of vigorous physical activity, moderate physical activity and walking  
323 at baseline. Users' reported more days of moderate physical activity and days of walking compared to  
324 non-users'. However, they also reported less days of vigorous physical activity, which only partially  
325 supports hypothesis 1. This is understandable, given that the objective of using Pokémon Go is to find  
326 Pokémon characters, which is unlikely to involve vigorous physical activity. The exploratory nature  
327 of the application, where users' need to search to find characters, means there is a greater likelihood  
328 of moderate physical activity or walking.

329

330 There was a significant interaction between using Pokémon Go or not and gender, where BMI and  
331 moderate physical activity differed for males and females. Interestingly, female users' had a higher  
332 BMI than the non-users', whilst male users' had a lower BMI than non-users'. In both instances, a  
333 lower BMI was associated with more minutes of moderate physical activity, which in this case was

334 evident for male users' and female non-users'. This suggests that Pokémon Go use is not determined  
335 by BMI.

336

337 At baseline, there was a gender difference in perceptions of whether Pokémon Go can improve health,  
338 where males reported a stronger perception that the application can improve health compared to  
339 females. Whilst males had a more favourable perception compared to females, both genders reported  
340 positive perceptions of the potential impact of Pokémon Go. A systematic review of physical activity  
341 applications, reported that there is high potential for such technology to encourage physical activity  
342 based on positive user perceptions of their usefulness and viability.<sup>11</sup>

343

344 At 3-months, only 18% of participants continued to use Pokémon Go, 56% were non-users' at  
345 baseline and at 3-months follow up, and 26% were users' that became non-users'. Zero participants  
346 were non-users' that became users'. Thus, the number of users' from baseline to 3-months follow up  
347 decreased. Despite this, for users' who remained users', there were no differences in physical activity  
348 at baseline compared to 3-months follow up. Thus, any impact of Pokémon Go on physical activity  
349 was sustained over time. Our study lends support for previous work that has also identified the  
350 potential benefits of utilising smartphone applications to encourage behaviour change over time.<sup>12-13</sup>  
351 However, participants reported an increase in sitting time on weekdays at 3-months compared to  
352 baseline, suggesting that any benefit in reducing sitting time on weekdays dissipates. There were no  
353 significant gender differences in physical activity or sitting time when comparing baseline to 3-  
354 months follow up suggesting males and females respond and interact the same with Pokémon Go.

355

356 There was no difference in physical activity or sitting time amongst users' at baseline who became  
357 non-users' at 3-months follow up. Thus, ceasing Pokémon Go use did not significantly effect physical  
358 activity or sitting time. This suggests that these participants have replaced Pokémon Go with another  
359 form of physical activity given that at baseline users' reported more physical activity than non-users'.

360

361 At 3-months, there were no significant gender differences in physical activity, sitting time or  
362 perceptions of whether Pokémon Go can increase physical activity and improve health. However,  
363 there was an interaction between using Pokémon Go or not and gender on BMI and days of walking.  
364 Akin to baseline, female users' reported a higher BMI than non-users', whilst male users' reported a  
365 lower BMI than non-users' at 3-months follow up. Thus, Pokémon Go usage at both baseline and 3-  
366 months was evident for males with a lower BMI and females with a higher BMI. Male users' reported  
367 more days of walking compared to non-users', whilst female users' reported less days of walking  
368 compared to non-users' at 3-months. Thus, Pokémon Go use appears to have a beneficial impact on  
369 the amount of days' that males engaged in walking, but this effect was not observed in females where  
370 they engaged in significantly less days of walking compared to non-users'. The findings of this study  
371 therefore suggest that Pokémon Go can therefore be a useful application to encourage walking  
372 behaviour in males.

373

374 This study is the first to examine the impact of Pokémon Go on sitting time. Given the evidence  
375 demonstrating the importance of reducing sitting time, particularly in people who are already inactive,  
376 interventions are warranted and require evaluation. This study has also reported the longest follow up  
377 period, providing an indication of use and impact of Pokémon Go and compared to Howe et al.<sup>6</sup>,  
378 collected data at two time points rather than assessing drop off. The only significant difference  
379 between baseline and 3-months, was in the minutes of sitting time on weekdays for users' who  
380 remained users' at 3-months. Thus, physical activity was maintained, yet users' reported sitting more  
381 at 3-months compared to baseline. Increased sitting time suggests that users' are replacing light  
382 intensity physical activity with more sitting, which the IPAQ<sup>8</sup> does not measure.

383

384 Pokémon Go is a fad where the number of users' has reduced over time. Therefore, the potential of  
385 Pokémon Go to be an effective intervention to increase physical activity, as seen in the current study,  
386 is likely to be short lived. Once participants have collected all Pokémon characters, they would no  
387 longer be motivated to continue using the application for this reason. This would make sense given  
388 that the motivation to continue using Pokémon Go is likely to be low, as the application does not



389 evolve, and the challenge of the application is lost when the objective has been completed. However,  
390 with timely evolution, Pokémon Go might encourage behaviour change and continued motivation,  
391 and this should be a focus for future work. Future work should also examine the use of Pokémon Go  
392 in younger people, given the likely appeal to children and adolescents.

393

394 This study is not without its limitations including self-selection bias which was unavoidable due to  
395 collecting the data using an online questionnaire. There is also a reliance on participants accurately  
396 self-reporting their physical activity (which is typically prone to over-reporting) and body mass  
397 (which is typically prone to under reporting). The physical activity and sitting time data was recalled  
398 for the week prior to completion rather than a continuation of data collection. Objective measures of  
399 physical activity and sitting time could have provided more valid data, although such measures have  
400 their own limitations. Whilst the IPAQ has strong psychometric properties we acknowledge that  
401 results specifically from the adapted section need to be interpreted with caution since validity and  
402 reliability may have been compromised. We are confident that including the weekend sitting time  
403 item was appropriate to measure overall sitting time for the week. Finally, whilst the sample size of  
404 users' who continued to be users' was small it was pleasing that there was an even representation of  
405 users' and non-users' at baseline and attrition of participants was favourable compared to other  
406 research utilising online questionnaires.

407

## 408 **Conclusion**

409 This is the first study to examine the use of Pokémon Go to reduce sitting time and both users' and  
410 non-users' perceptions on whether the application can benefit physical activity and health.  
411 Additionally, the follow up is greater compared to other studies examining Pokémon Go use. Key  
412 findings are that users' spent less days engaging in vigorous physical activity but more days engaging  
413 in moderate physical activity and walking compared to non-users'. Despite the number of users'  
414 declining, there was no change in physical activity over the 3-months follow up period for users', and  
415 thus, physical activity was maintained from baseline. Importantly, this sustained physical activity  
416 level was evident for users' who maintained use, but also those who stopped using the application

417 suggesting that an alternative means of engaging in physical activity was found. Finally, the study  
418 demonstrated that users' at baseline who remained users' at 3-months follow up, reported more sitting  
419 time on weekdays at 3-months compared to baseline. Thus, the application did not prevent increased  
420 sitting time on weekdays highlighting the need for other interventions.

421

#### 422 **Abbreviations**

423 ANOVA: Analysis of Variance; BMI: Body Mass Index

424

#### 425 **Acknowledgements**

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429 and Physical Activity (ISBNPA) 2017 conference who provided ideas for analysis during question  
430 time.

431

#### 432 **Author Disclosure Statement**

433 The authors declare no conflicts of interest and have received no funding for this research.

434

#### 435 **Availability of data**

436 Data will be deposited in SHURA and is available on request.

437

#### 438 **Author contributions**

439 DRB conceived the idea and developed the initial questionnaire. Both DRB and SWF then contributed  
440 equally to all remaining aspects of the development of the research and the manuscript and agree to be  
441 accountable.

442

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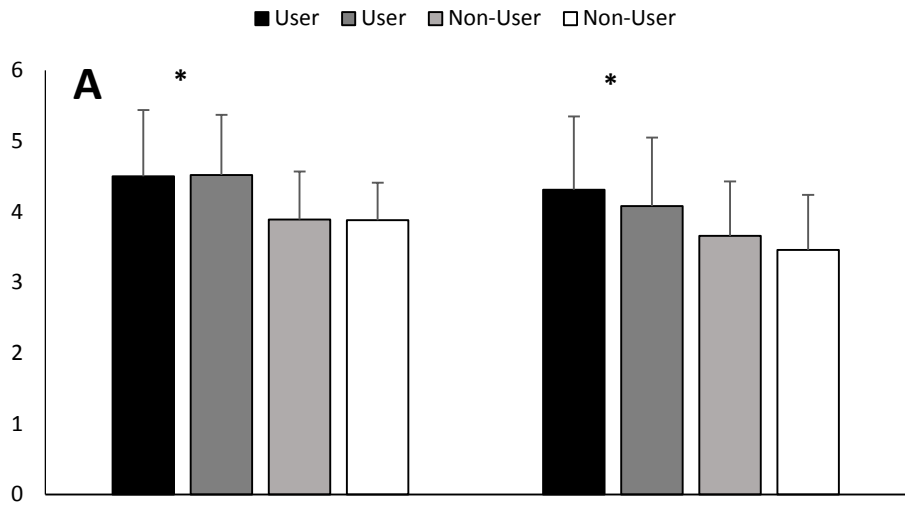
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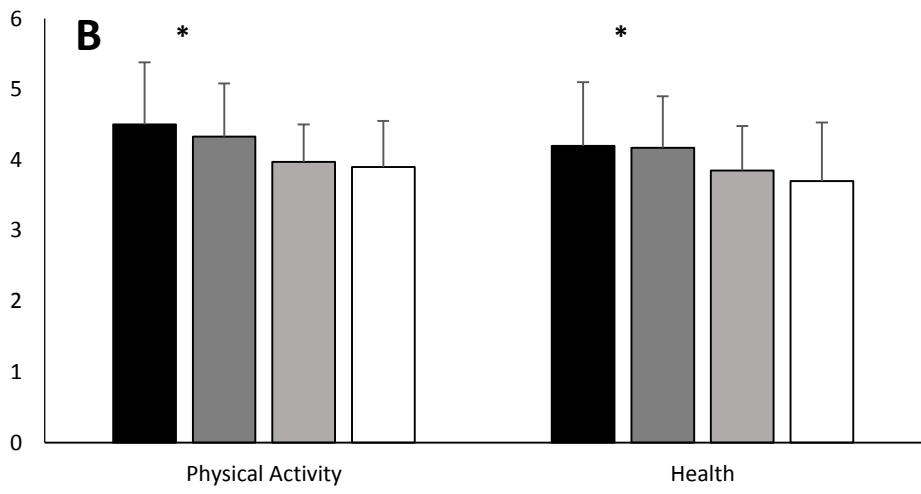
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501 Figure 1

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512 Table 1: Demographic characteristics of Pokémon Go users' and non-users' at baseline and 3 months  
 513 follow up. Values are mean (standard deviation)

Participant characteristics	Baseline (n = 461)		3 months (n = 127)	
	Pokémon Go users (n = 236)	Non-users (n = 225)	Pokémon Go users (n = 23)	Non-users (n = 104)
Age (years)	26.8 (8.2)	31.0* (11.0)	31.4 (12.1)	29.6 (9.0)
Height (m)	1.7 (0.1)	1.7 (0.1)	1.7 (0.1)	1.7 (0.1)
Body mass (kg)	74.9 (16.4)	71.5* (16.7)	78.5 (15.4)	72.0 (15.5)
BMI (kg/m <sup>2</sup> )	25.2 (5.4)	24.1* (4.6)	27.0 (6.7)	24.3* (4.1)

514 \* $p = < 0.05$

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533 **Table 2:** Study population physical activity and sitting time at baseline

	Whole sample (n = 461)					Pokémon Go users' (n = 236)					Non-users' (n = 225)				
	Vig	Mod	Walk	Sitting	Sitting	Vig	Mod	Walk	Sitting	Sitting	Vig	Mod	Walk	Sitting	Sitting
	(n = 304)			WKD	WKE				WKD	WKE				WKD	WKE
<b>Min</b>	66.58	64.57	105.51	372.52	312.99	64.24	69.45	111.97	386.04	328.33	69.03	59.44	98.73	358.27	297.02
	(71.03)	(103.00)	(126.18)	(208.77)	(181.23)	(74.14)	(117.98)	(117.47)	(200.50)	(188.92)	(67.68)	(77.50)	(134.63)	(216.67)	(171.84)
<b>Days</b>	2.53	2.26	5.85	-	-	2.07	2.12	6.18	-	-	3.02	2.41	5.50	-	-
	(2.07)	(2.28)	(1.88)			(2.06)	(2.33)	(1.56)			(1.97)	(2.21)	(2.12)		

534

535 Mean and standard deviation of the whole sample, Pokémon Go users' and non-users' vigorous physical activity, moderate physical activity,  
 536 walking, sitting on weekdays and sitting on weekends at baseline. Vig = Vigorous physical activity; Mod = Moderate physical activity; Walk =  
 537 Walking; WKD = Weekday; WKE = Weekend; Min = Minutes

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545 **Table 3:** Study population physical activity and sitting time at 3-months

	Whole sample (n = 127)					Pokémon Go users' (n = 23)					Non-users' (n = 104)				
	Vig	Mod	Walk	Sitting WKD	Sitting WKE	Vig	Mod	Walk	Sitting WKD	Sitting WKE	Vig	Mod	Walk	Sitting WKD	Sitting WKE
<b>Min</b>	61.73 (55.33)	59.68 (83.35)	80.08 (81.87)	403.70 (172.70)	338.94 (176.00)	42.17 (46.61)	61.74 (83.22)	100.00 (91.70)	446.09 (174.06)	336.87 (176.32)	66.06 (56.36)	59.23 (83.77)	75.59 (79.29)	394.33 (171.82)	339.41 (176.80)
<b>Days</b>	2.46 (2.03)	2.28 (2.15)	5.95 (1.77)	-	-	1.78 (1.86)	2.61 (2.27)	5.30 (1.96)	-	-	2.61 (2.04)	2.21 (2.12)	6.10 (1.71)	-	-

546

547 Mean and standard deviation of the whole sample, Pokémon Go users' and non-users' vigorous physical activity, moderate physical activity,  
 548 walking, sitting on weekdays and sitting on weekends at 3-months follow up. Vig = Vigorous physical activity; Mod = Moderate physical  
 549 activity; Walk = Walking; WKD = Weekday; WKE = Weekend; Min = Minutes

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558 **Table 4:** Users physical activity and reduced sitting time reported specifically due to Pokémon Go

	Baseline (n = 236)					3-months follow up (n = 23)				
	Vig	Mod	Walk	Reduced sitting WKD	Reduced sitting WKE	Vig	Mod	Walk	Reduced sitting WKD	Reduced sitting WKE
<b>Min</b>	13.64 (49.30)	27.45 (63.06)	85.93 (100.11)	85.43 (92.53)	97.90 (102.53)	5.87 (15.79)	11.09 (28.05)	53.26 (56.31)	28.26 (46.76)	69.57 (104.61)
<b>Days</b>	0.38 (1.17)	0.84 (1.74)	4.77 (2.20)	-	-	0.17 (0.48)	0.48 (1.21)	3.30 (2.42)	-	-

559

560 Mean and standard deviation of Pokémon Go users' perceptions of the amount of vigorous physical activity, moderate physical activity, walking,  
 561 reduced sitting on weekdays and sitting on weekends due to Pokémon Go use Vig = Vigorous physical activity; Mod = Moderate physical  
 562 activity; Walk = Walking; WKD = Weekday; WKE = Weekend; Min = Minutes

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