

Mobile technology usage mediates gender differences in physical activity

WHITEHEAD, A.E., UMEH, K., QUAYLE, L. and MORLEY, David
<<http://orcid.org/0000-0002-4389-8573>>

Available from Sheffield Hallam University Research Archive (SHURA) at:
<http://shura.shu.ac.uk/15206/>

This document is the author deposited version. You are advised to consult the publisher's version if you wish to cite from it.

Published version

WHITEHEAD, A.E., UMEH, K., QUAYLE, L. and MORLEY, David (2017). Mobile technology usage mediates gender differences in physical activity. *International Journal of Sport Psychology*, 48 (6).

Copyright and re-use policy

See <http://shura.shu.ac.uk/information.html>

1 **Mobile Technology Usage Mediates Gender Differences in Physical Activity**

2 Amy E. Whitehead, Kanayo Umeh, Laura Quayle and Dave Morley

3 Liverpool John Moores University

4 Sheffield Hallam University

5
6 Author Note

7 Amy E. Whitehead and Laura Quayle, School of Sport Studies, Leisure and Nutrition, Liverpool

8 John Moores University.

9 Dave Morley, School of Sport, Sheffield Hallam University.

10 Kanayo Umeh, School of Natural Science and Psychology, Liverpool John Moore University.

11 This research was supported by a Sports Coach UK funded tender to Amy E. Whitehead.

12 Correspondence concerning this article should be addressed to Amy E. Whitehead,

13 School of Sport Studies, Leisure and Nutrition, Liverpool John Moores University, IM Marsh

14 Campus, L17 4LH. E-mail: A.E.Whitehead@ljmu.ac.uk

25 **Mobile Technology Usage Mediates Gender Differences in Physical Activity**

26

27

Abstract

28 Gender differences in how technology is used to facilitate physical activity engagement was
29 examined. 578 adults completed a survey assessing gender, mobile device usage, stages of
30 change in physical activity based on the transtheoretical model of behaviour change (TTM) and
31 relevant covariates. Data analysis revealed that both cumulative device types and cumulative
32 reasons for using devices mediated gender differences in stage membership for physical activity.
33 Females used fewer devices and reported fewer reasons for using such devices than male
34 participants. These dispositions predicted a reduced probability of achieving action/maintenance
35 stages for physical activity. Females used fewer mobile devices and perceived fewer incentives
36 for using such devices. As a result they are less likely to enter the action/maintenance stages of
37 physical activity. Interventions to promote female participation in physical activity need to
38 recognise gender differences in the use of mobile technology.

39

40

41

42

43

44

45

46

47

48

49 **Mobile Technology Usage Mediates Gender Differences in Physical Activity**

50 Rates of obesity, diabetes, and cardiovascular disease (CVD) have continued to rise across
51 populations in many Western countries and other parts of the world (Chiu, Maclagan, Tu, &
52 Shah, 2015; Du et al., 2014; Samaranayaka & Gulliford, 2013; Saydah et al., 2014). Previous
53 literature reports a higher rate of obesity in females (Kanter & Caballero, 2012) and, therefore,
54 subsequent research has focused its attention on gender differences in physical activity (Spencer,
55 Rehman, & Kirk, 2015). Moreover, findings from other research suggests females are less
56 physically active than males (Brand et al., 2016; Bronikowski, Laudanska-Krzeminska,
57 Tomaczak, & Morina, 2016; Caperchione, Chau, Walker, Mummery, & Jennings, 2015; Kelly,
58 Edney, Moran, Srikanth, & Callisaya, 2016; Magoc, Tomaka, Shamaley, & Bridges, 2016;
59 McLaughlin, Connell, & Janevic, 2016; Viciano, Mayorga-Vega, & Martinez-Baena, 2016). For
60 example, Brand et al. (2016) found that even amongst adolescents judged to engage in ‘high’
61 levels of moderate-to-vigorous physical activity (i.e., classified as exercising for 7 hours or 421
62 minutes per week), males were more physically active, reporting an average of 1091.02
63 minutes/week of activity, compared to 922.78 minutes/week of activity for females.

64 The reported deficit in physical activity in females has been attributed to a range of social
65 and cultural factors including the complex relationships between physical activity, feminine
66 ideals, and body-image factors (Spencer et al., 2015). Further research by Martins, Marques,
67 Sarmiento, and da Costa (2015) has identified how the majority of studies that have looked at the
68 perceptions of physical activity have focused on adolescent females. Their systematic review
69 concluded that the main barriers to physical activity were attitudes toward physical activity;
70 motivation; perceptions of competence and body image; fun; influence of friends, family and
71 physical education teachers; and environmental physical activity opportunities. Fun was the most
72 frequently cited reason for female physical activity enegagement in most studies within the

73 review (Martins et al., 2015) and elsewhere (Yungblut, Schinke, & McGannon, 2012), however,
74 when searching for further meaning around this variable it is important to consider participants'
75 perceptions of fun. For example, research has found that fun is related to the specific physical
76 activity (e.g. yoga) (Azzarito & Hill, 2013). Furthermore, it is important that the activity is
77 challenging yet not competitive (Brooks & Magnusson, 2007), with autonomy (Yungblut et al.,
78 2012), social support from family members and a high perception of competence being
79 important (Azzarito & Hill, 2013).

80 Although recent research has implicated a newly-found barrier to physical activity participation
81 – the use of electronic devices (Pawlowski, Tjornhoj-Thomsen, Schipperijn, & Troelsen, 2014)
82 there is uncertainty regarding the role of mobile technology and the extent to which it mediates
83 gender differences in physical activity. Research has shown gender differences in the use of
84 mobile devices such as smart phones and tablets (Baron & Campbell, 2012). For example,
85 researchers exploring the use of video gaming technology have reported technology being
86 specially designed for the needs of male gamers (Ivory, 2006). Rehbein, Kliem, Baier, Mößle,
87 and Petry (2015) found significantly higher gender differences amongst a large German
88 adolescent sample, suggesting that boys were involved in 162 minutes of gaming per day
89 compared to the girls' gaming time of 27 minutes. Additionally, research suggests mobile devices
90 can offer incentives that affect levels of physical activity (Pawlowski et al., 2014), whereby
91 access to particular fitness apps have encouraged an active lifestyle (Direito et al., 2014). By
92 contrast, excessive dependence on mobile technology (e.g., for gaming, social networking) can
93 precipitate a sedentary lifestyle (Lepp, Barkley, Sanders, Rebold, & Gates, 2013). Therefore,
94 device use may operate as both a barrier (e.g. encouraging sedentary living through gaming) and a
95 facilitator (e.g. through sharing exercise results with others). Given that previous research has

96 found more males use technological devices in comparison to females, there does seem to be a
97 potential gender barrier.

98 Despite evidence linking mobile technology to variable usage related to both gender and
99 physical activity, no study has examined the extent to which the use of mobile technology
100 mediates (i.e., explains) the physical activity deficit in females, using appropriate analytic
101 protocols (e.g., bootstrapping) (Hayes, 2013). Research in this area will have implications for the
102 development of interventions to promote physical activity in females. Previous research has used
103 behaviour change models such as the transtheoretical model (TTM) proposed by Prochaska and
104 Velicer (1997) to understand gender differences in physical activity and possible mediating
105 factors. According to this model, behaviour change unfolds through five distinct stages:
106 precontemplation (no intention to engage in physical activity), contemplation (the intention to
107 engage in activity within the next 6 months), preparation (preparing to engage in the next 6
108 months), action (engaging in physical activity but for less than 6 months) and maintenance
109 (engaging in physical activity for 30 or more minutes a day on 5 or more days per week for more
110 than 6 months). Studies have found significant gender differences in stages of change for
111 physical activity (Garber, Allsworth, Marcus, Hesser, & Lapane, 2008).

112 The aim of this study was to assess the direct relationship between gender and stages of
113 change in physical activity, and also the extent to which this association is *indirect*, mediated by
114 the use of mobile devices. The following hypotheses were tested:

115
116 a) There are gender differences in stages of change for physical activity, with males more
117 likely to achieve action/maintenance stages

118

119 b) Gender differences in stages of change for physical activity are mediated by individual
120 differences in the use of mobile devices.

121

122 **Methods**

123 **Participants**

124 Surveys were completed by a range of participants (n=578, 301 males and 277 females) from
125 across the United Kingdom. The age of respondents was 16-25 years (n=140), 26-34 years
126 (n=101), 35-44 years (n=136), 45-54 years (n=127), 55-64 years (n=56), 65+ years (n=18). The
127 only eligibility criteria specified was that all respondents had to be over the age of 16 years.

128

129 **Materials and Procedure**

130 The web-based survey was created using Bristol Online Survey (BOS) software (BOS, 2016)
131 and captured data related to stages of change in technology use, physical activity participation,
132 type of device used and perceived benefits of the device. The survey was disseminated via local
133 sports networks and web-based social media for a period of eight weeks (December – January,
134 2015). The host institution granted ethical approval and participants gave informed consent on-
135 line prior to completing the questions.

136

137 **Stages of Change**

138 The Transtheoretical model of behaviour change (Prochaska & Velicer, 1997) uses 5 stages to
139 represent an individual's behaviour in a given domain; these stages are (i) pre-contemplation, (ii)
140 contemplation, (iii) preparation, (iv) action and (v) maintenance. Using National Health Service
141 (2015) guidelines, respondents were classified into one of these stages of change, based on their

142 response to the following question: 'Do you currently engage in any form of sport or physical
143 activity?':

144 *'I do not participate in sport or physical activity in any way and I do not intend to do so in the
145 future'* (Pre-contemplation)

146 *'I have been thinking about participating in sport and physical activity but I have not done any
147 yet'* (Contemplation)

148 *'I have started preparing to engage in sport or physical activity but I am not yet active'
149 (Preparation)*

150 *'I am engaging in sport or physical activity on a regular basis (30 or more minutes a day on 5 or
151 more days per week) and have been doing so for less than six months'* (Action)

152 *'I am engaging in sport or physical activity on a regular basis (30 or more minutes a day on 5 or
153 more days per week) and have done so for the last six months or more'* (Maintenance)

154 Consistent with previous research using this model, in which progression into the
155 Action/Maintenance for physical activity (and other behaviours) depicts successful behaviour
156 change (Johnson et al., 2008; Prochaska et al., 2005), participants in the present study were
157 dichotomised into two stages: pre-Action/Maintenance (coded 0) and post-Action/Maintenance
158 (coded 1).

159

160 **Type of device**

161 The type of device being used by participants was assessed by asking respondents what sort of
162 technology they used (sports coach UK, 2016). Participants responded by ticking one or more
163 items from a list of up to six items: *Applications downloaded onto a smart phone or tablet,*
164 *Online web-based information, GPS-enabled devices, Social media, wearable technology, and*
165 *'other'* (please specify). Each ticked item was coded as '1'. The total number of items ticked was

166 then summed to generate an index, with scores ranging from 0 to 6; the higher the score, the
167 greater the number of device types used.

168

169 **Reasons for device use**

170 Following the question about technology types, participants were asked to identify their
171 motivations (i.e., reasons) for device use, using a previously used conceptual framework (op den
172 Akker, et al., 2013). In response to the question ‘What do you use the technology for?’, a list of
173 items was provided, including ‘*Collect physical data on myself*’ Yes(1)/No(0) , ‘*Compare my*
174 *results with others*’ Yes(1)/No(0), ‘*As a tool to motivate myself*’ Yes(1)/No(0), ‘*As a group*
175 *training tool*’ Yes(1)/No(0), ‘*For fitness purposes*’ Yes(1)/No(0), ‘*Communicate with a*
176 *coach/instructor*’ Yes(1)/No(0), ‘*Other*’ Yes(1)/No(0). Responses to these items were summed
177 to generate a ‘reasons for tech use’ index (scores ranging from 0 to 7 – a higher scored indicated
178 more reasons or greater motivation for technology use).

179

180 **Covariates**

181 A number of factors may confound gender differences in physical activity including age
182 (Molanorouzi, Khoo, & Morris, 2015), perceived incentives in use of technology use (Yau &
183 Cheng, 2012), coaching (Etnier, 2011), and participation in organised sporting activity (e.g.,
184 club-based events) (Vilhjalmsson & Kristjansdottir, 2003). Thus, the following variables were
185 treated as potential confounding factors in this study: age, exposure or access to a coach (‘Are
186 you currently being coached either individually or in a team setting?’ ‘Yes – I’m being coached’
187 (1) or ‘No – I’m not being coached’ (0)), and organising participation in sporting activities
188 (‘Please indicate who organises this [list of various sporting events provided] and whether it is
189 competitive or recreational?’ ‘Club’ Yes(1)/No(0), ‘Another organisation but not a sports club’

190 Yes(1)/No(0), 'Gym or other health/fitness centre' Yes(1)/No(0), 'Myself (I do it on my own)'
191 Yes(1)/No(0), 'With friends' Yes(1)/No(0). Responses to these organisational items were
192 totalled to give an 'organisation' index (scores ranging from 0 to 4, with a higher score denoting
193 more organising activity). Another covariate was the perceived benefits of technology use
194 ('What do you perceive to be the benefits of using technology to support participation in sports
195 and physical activity? Please select any applicable terms' – 'Enhance performance'
196 Yes(1)/No(0), 'Provide useful data on performance' Yes(1)/No(0), 'Helps with motivation'
197 Yes(1)/No(0), 'None', 'Other'. Responses to the first three benefit items were summed to
198 produce a 'perceived benefits' index (scores ranged from 0 to 3 – the higher the score, the
199 greater the perceived benefits of technology use.

200

201 **Statistical analysis**

202 The direct and indirect effects of gender on stages of change for physical activity were assessed
203 using a bootstrapping SPSS dialogue (Hayes, 2009; Hayes, 2013). Mediation analysis involves
204 testing the significance of three key regression pathways (see *Figures 1 & 2*); (i) relationship
205 between variable X (predictor) and variable M (mediator), known as *path a*; (ii) relationship
206 between variable M (mediator) and variable Y (outcome), called *path b*; (iii) direct relationship
207 between variable X (predictor) and variable Y (outcome), or *path c*.

208 Gender was treated as variable X (predictor), while stage membership (pre- versus post
209 action/maintenance) for physical activity was evaluated as variable Y (outcome). Cumulative
210 (i.e., total number of) device types used and cumulative reasons (i.e., total number of incentives
211 or motivations) for using mobile devices were both treated as variables M (mediators).

212 Additionally, age, receiving coaching, organisation of sporting events, and perceived benefits of
213 technology use, were treated as covariates. The bootstrapping strapping SPSS dialogue allowed

214 for the inclusion. Unadjusted bootstrapping models were first generated, in which covariates
215 were excluded. Bootstrapping was then repeated adjusting for the various covariates.

216

217 **Results**

218 **Descriptive statistics**

219 The vast majority of respondents (72.3%) were in the Maintenance stage of change for physical
220 activity, followed by Action (1.9%), Preparation (2.7%), Contemplation (2.1%), and Pre-
221 contemplation (0.5%). The remaining 20.5% participants were categorised as non-responders
222 (i.e., missing data) and excluded from subsequent data analysis. On average, respondents used
223 about two ($M = 1.75$, $SD = 1.65$) different types of technological devices, with a maximum of 6
224 and a minimum of zero. The most frequently cited reasons or motivations for device use were to
225 collect physical or performance data (36.9%) and compare results with others (36.7%), followed
226 by motivating oneself (31.6%), physical fitness (24.8%), communication with coach (10.7%),
227 training tool (9.7%), and finally ‘other’ (3.6%). Of three possible benefits of using technology,
228 respondents cited an average of two ($M = 1.98$, $SD = 1.05$). The most commonly cited benefit
229 was receiving ‘useful feedback’ (74.4%), followed by ‘motivates me’ (66.4%), and finally
230 ‘enhance performance’ (57.8%). The most frequently used specified technology was mobile apps
231 (44.9%), followed by GPS (41%), wearable devices (32.5%), online websites (30%), and finally
232 social media (24.6%). Just under 3% of respondents used ‘other’ (i.e., unspecified) forms of
233 technology.

234

235 **Insert Table 1 about here**

236

237 **Mediating effect of cumulative device types used**

238 Results are shown in *Table 1*. Gender predicted cumulative device use, with females using fewer
239 device types. Cumulative device type, in turn, predicted stage membership for physical activity,
240 with use of more device types predicting a higher probability of action/maintenance stage
241 membership. Contrary to what was hypothesised, gender did not directly predict stage
242 membership for physical activity. However, as hypothesised, there was a significant indirect
243 effect, whereby cumulative device use mediated the effects of gender on stage membership;
244 females used fewer technological devices, which in turn meant a reduced likelihood of being in
245 the action/maintenance stages of physical activity (*Figure 1*). This indirect effect persisted after
246 controlling for age (older respondents were less likely to be in the action/maintenance stages for
247 physical activity), but was no longer significant after accounting for coaching, followed by other
248 covariates.

249
250 Insert Table 2 about here
251

252
253 **Mediating effect of cumulative reasons for device use**
254 Results are shown in *Table 2*. In the initial bootstrapping model, prior to accounting for
255 covariates, gender showed a near-significant association with cumulative perceived benefits for
256 using mobile devices ($p = 0.05$), with females reporting fewer reasons for using mobile devices
257 in the context of physical activity. In turn, cumulative reasons for using devices predicted stage
258 membership for physical activity, with a higher number of reasons denoting an increased
259 probably of action/maintenance stage membership. Gender did not directly predict stage
260 membership. As expected, a significant indirect effect emerged (*Figure 2*), whereby cumulative
261 reasons for using technological devices mediated the relationship between gender and stage

262 membership; females reported fewer reasons for using mobile devices in the context of physical
263 activity, a disposition that in turn denoted a reduced probability of action/maintenance stage
264 membership. This mediator effect remained significant after adjusting for age differences in
265 stage membership, but was nullified after adjusting for coaching, and other covariates.

266

267 Insert Figure 1 about here

268

269

270 Insert Figure 2 about here

271

272 **Discussion**

273 This study aimed to assess the direct relationship between gender and stages of change in
274 physical activity, and also the extent to which this association is indirect, mediated by the use of
275 mobile devices. Interestingly, and in contravention of our first hypothesis, gender did not predict
276 stage membership. This finding contradicts much of the literature surrounding physical activity
277 and gender differences, however the majority of this research has been focussed on adolescent
278 females (Martins et al., 2015). The majority of the participants within this study were over the
279 age of twenty five and our understanding of the factors associated with physical activity in this
280 specific population is limited (Booth, Owen, Bauman, Clavisi, & Leslie, 2000). Furthermore,
281 within the present study those who may have completed the survey may have had an interest in
282 physical activity (Berry & Spence, 2006), leading to bias and the potential reason why gender
283 difference was not found. Whilst gender did not predict stage membership, males used more
284 device types than females and had more reasons for using technology, which in turn may have
285 had a positive impact on male physical activity, as demonstrated by the prominent positioning of

286 males in the action/maintenance stage of the TTM (DiClemente & Prochaska, 1998; Prochaska
287 & Velicer, 1997). Females used technology less than their male counterparts and this could have
288 a negative consequence on their physical activity levels. Given the proliferation of technology in
289 everyday life (Walshaw, 2015; Wang, Xiang, & Fesenmaier, 2016), it is interesting to note that
290 gender differences in technology use may affect the physical activity behaviours of individuals.
291 Whilst previous research has highlighted both negative (Lepp et al., 2013) and positive effects
292 (Direito et al., 2014) of technology on physical activity and lifestyles, results from this study
293 suggest the patterns of behaviour are more complex and gender differentiated.

294 The finding that technology positively mediates physical activity is an indication that the
295 use of technology could play a critical part in the way that interventions are established to
296 motivate participants to become, and remain, physically active. It is, perhaps, not surprising that
297 technology may affect male participation in this way, as the majority of technology is situated in
298 male dominated environments (Garber et al., 2008; Johnson et al., 2008). Therefore, this
299 provides an explanation as to why males may be more confident in the use of technology, which
300 may be transferring into physical activity app based technology use.

301 Results within the current study suggest that technology may positively influence male
302 physical activity, due to males using a larger range of devices and having more reasons for using
303 technology in comparison to females. Females are motivated differently than males, in relation to
304 physical activity. Generally speaking, females are less ego and mastery-oriented than males,
305 therefore caring less about their performance in relation to others (Egli, Bland, Melton, & Czech,
306 2011; Su, McBride, & Xiang, 2015). Their goals in relation to physical activity are more aligned
307 to overall health, appearance and physical attractiveness (Chowdhury, 2012; Molanorouzi et al.,
308 2015; Morris, Clayton, Power, & Han, 1995). Therefore, as the majority of mobile technology is
309 predominantly geared towards incentivising participants through demonstrating individual

310 standing in relation to peers, vis-a-vie enhancement of performance, females may be less likely
311 than males to be motivated by this function. Subsequently, there is a need for technology
312 designers to further personalise and provide incentives for individual progress, particularly for
313 females, irrespective of peer-performance.

314 Wider evidence suggests that early structured physical activity experiences for girls, such
315 as school-based Physical Education, fails to provide adequate levels of PA, or develop self-
316 regulatory skills and habits that would enable them to continue physical activity through their
317 transition into adulthood (Hobbs, Daly-Smith, Morley, & McKenna, 2014; Knuth & Hallal,
318 2009). When research has evidenced the link between intrinsic motivation and self-regulation in
319 physical activity in general (Teixeira, Carraça, Markland, Silva, & Ryan, 2012), and specifically
320 female physical activity (Lauderdale, Yli-Piipari, Irwin, & Layne, 2015), it is crucial that mobile
321 technology is tailored effectively to meet the gender-specific demands of its users. op den Akker,
322 Jones, and Hermens (2014) provide a series of tailoring concepts for designing physical activity
323 apps that could readily be used, as one such solution.

324 It is interesting that age predicted stage membership for physical activity, but
325 nevertheless failed to negate the direct or indirect contribution of gender (albeit noting that
326 gender did not directly predict stage membership in the context of perceived benefits). It follows
327 that although younger respondents were more likely to achieve the action/maintenance for
328 physical activity (Dumith, Gigante, & Domingues, 2007; Garber et al., 2008) female respondents
329 were nevertheless still less likely than males to have achieved such stage membership, which
330 may be due to the underlying technology-related mediating factors (e.g., females used fewer
331 devices). In other words, the role of mobile technology in explaining gender differences in
332 physical activity isn't necessarily diminished by age; older adults, who presumably are less
333 active, may still potentially achieve action/maintenance for physical activity if they perceive

334 sufficient reasons for using mobile technology. If so, this may have significant implications for
335 the use of mobile technology to boost activity levels in (otherwise less active) older adults;
336 particularly males.

337 It is important to acknowledge the limitations within this study. Firstly, the sample
338 consisted of a small number of participants in the pre-contemplation, contemplation and
339 preparation stages of change. Over 70% of respondents had achieved Action/Maintenance,
340 suggesting, as a sample, an existing motivation to the use of technology to facilitate an active
341 lifestyle. A problem with survey research design is the possible non-response bias, which may
342 have occurred within this study, where there are different rates of responses between study
343 participants and some of those who were invited to complete the survey but did not respond
344 (Drivsholm et al., 2006; Grotzinger, Stuart, & Ahern, 1994; Holle et al., 2006). More
345 specifically, those who may have completed the survey may have an interest in physical activity,
346 which could result in bias. Non-response bias within physical activity research should be
347 acknowledged as a limitation, reducing the final sample size and generalisability of a population
348 through potential under-reporting of a specific group (Berry & Spence, 2006; Lahaut, Jansen,
349 Van de Mheen, & Garretsen, 2002). Furthermore, the study did not control for previous history
350 of technology use or other variables such as current BMI, health status or body image and it is
351 plausible to suggest that these factors had an influence on the use of health and sport apps. It is
352 therefore suggested that future research takes into account these variables, to provide a wider
353 understanding of the motives behind health and sport technology engagement.

354 Another limitation that should be acknowledged is the terminology for those participants
355 in the action and maintenance stage. When answering this question participants were guided by
356 the sentence which specified that they are to select the action stage if they engage in physical
357 activity for 30 or more minutes a day on 5 or more days per week for less than six months and

358 the maintenance stage if they engage in physical activity for 30 or more minutes a day on 5 or
359 more days per week and have done so for the last six months or more. This definition was taken
360 from NHS (2015) guidelines, however it is important to state that there are alternative guidelines
361 provided by both the NHS (NHS, 2015) and the American physical activity guidelines advisory
362 committee report (US Department of Health and Human Services, 2008). These guidelines also
363 offer more detail and different alternatives to the recommended physical activity guidelines
364 based around individuals participating in 150 minutes of physical activity per week but in
365 different forms (e.g. different levels of intensity, strength exercises and a mix of moderate and
366 vigorous aerobic activity). For simplicity, this study chose to use 30 minutes, five times per
367 week; future research should take these guidelines and the implications of asking these questions
368 in a certain manner into consideration. Finally, the measure of perceived benefits of technology
369 use was arguably perfunctory. It focused on generic concepts, notably ‘enhancing performance’,
370 ‘providing useful feedback’, and ‘motivating me’. These domains may exclude other
371 perceived advantages of technology use, such as goal setting.

372 The fact that the majority of participants in the present study were physically activity
373 seems to support the premise that new technologies may facilitate physical activity behaviours in
374 a variety of settings and environments. However, gender differences are clearly evident in
375 behaviours associated with technology use and physical activity. Males see more reasons or
376 motivations for using this type of technology, which may explain why they use more types of
377 devices and are more physically active. Females use fewer technological devices and see fewer
378 reasons or incentives in technology use than their male counterparts. This study is the first step in
379 probing the use of technology to facilitate physical activity behaviour and gender differences
380 associated with this. Further research, therefore, needs to develop this work by understanding the
381 mechanisms and the sociocultural factors that cause these gender differences. Understanding this

382 could support technology manufacturers and national initiatives to improve physical activity
383 levels and, in turn, create a healthier population.

384

385 **References**

386 Azzarito, L., & Hill, J. (2013). Girls looking for a ‘second home’: bodies, difference and places
387 of inclusion. *Physical Education and Sport Pedagogy*, 18(4), 351-375.

388 doi:10.1080/17408989.2012.666792

389 Baron, N. S., & Campbell, E. M. (2012). Gender and mobile phones in cross-national context.
390 *Language Sciences*, 34(1), 13-27. doi:10.1016/j.langsci.2011.06.018

391 Berry, T. R., & Spence, J. C. (2006). *Understanding Reported Rates of Physical Activity:*
392 *Comparing the Results of the Alberta Survey on Physical Activity and Canadian*

393 *Community Health Survey*. Retrieved from

394 https://era.library.ualberta.ca/files/9s1616385/Full_PASurvReport_Final.pdf

395 Booth, M. L., Owen, N., Bauman, A., Clavisi, O., & Leslie, E. (2000). Social–cognitive and
396 perceived environment influences associated with physical activity in older Australians.

397 *Preventive medicine*, 31(1), 15-22. doi:10.1006/pmed.2000.0661

398 Brand, S., Kalak, N., Gerber, M., Clough, P. J., Lemola, S., Sadeghi Bahmani, D., Puhse, U., &

399 Holsboer-Trachsler, E. (2016). During early to mid adolescence, moderate to vigorous
400 physical activity is associated with restoring sleep, psychological functioning, mental
401 toughness and male gender. *Journal of Sport Sciences*, 35(5).

402 doi:10.1080/02640414.2016.1167936

403 Bronikowski, M., Laudanska-Krzeminska, I., Tomaczak, M., & Morina, B. (2016). Sense of
404 coherence, physical activity and its associations with gender and age among Kosovar

- 405 adolescents: a cross-sectional study. *Journal of Sports Medicine Physical Fitness*.
- 406 Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/27074438>
- 407 Brooks, F., & Magnusson, J. (2007). Physical activity as leisure: the meaning of physical activity
408 for the health and well-being of adolescent women. *Health care for women international*,
409 28(1), 69-87. doi:10.1080/07399330601003499
- 410 Caperchione, C. M., Chau, S., Walker, G. J., Mummery, W. K., & Jennings, C. (2015). Gender-
411 Associated Perceptions of Barriers and Motivators to Physical Activity Participation in
412 South Asian Punjabis Living in Western Canada. *Journal of physical activity & health*,
413 12(5), 686-693. doi:10.1123/jpah.2013-0208
- 414 Chiu, M., Maclagan, L. C., Tu, J. V., & Shah, B. R. (2015). Temporal trends in cardiovascular
415 disease risk factors among white, South Asian, Chinese and black groups in Ontario,
416 Canada, 2001 to 2012: a population-based study. *Bmj Open*, 5(8). doi:10.1136/bmjopen-
417 2014-007232
- 418 Chowdhury, D. (2012). *Examining reasons for participation in sport and exercise using the*
419 *physical activity and leisure motivation scale (PALMS)*. (Doctoral Dissertation), Victoria
420 University.
- 421 DiClemente, C. C., & Prochaska, J. O. (1998). Toward a comprehensive, transtheoretical model
422 of change: Stages of change and addictive behaviors. In W. R. Miller & N. Heather (Eds.),
423 *Treating addictive behaviours* (2nd ed ed., pp. 3-24). New York: Plenum Press.
- 424 Direito, A., Dale, L. P., Shields, E., Dobson, R., Whittaker, R., & Maddison, R. (2014). Do
425 physical activity and dietary smartphone applications incorporate evidence-based
426 behaviour change techniques? *BMC public health*, 14(1). doi:10.1186/1471-2458-14-646
- 427 Drivsholm, T., Eplov, L. F., Davidsen, M., Jørgensen, T., Ibsen, H., Hollnagel, H., & Borch-
428 Johnsen, K. (2006). Representativeness in population-based studies: a detailed description

429 of non-response in a Danish cohort study. *Scandinavian journal of public health*, 34(6),
430 623-631. doi:10.1080/14034940600607616

431 Du, T. T., Sun, X. X., Yin, P., Yuan, G., Zhang, M. X., Zhou, X. R., & Yu, X. F. (2014). Secular
432 trends in the prevalence of low risk factor burden for cardiovascular disease according to
433 obesity status among Chinese adults, 1993-2009. *BMC public health*, 14(1).
434 doi:10.1186/1471-2458-14-961

435 Dumith, S. C., Gigante, D. P., & Domingues, M. R. (2007). Stages of change for physical
436 activity in adults from Southern Brazil: a population-based survey. *International Journal of*
437 *Behavioral Nutrition and Physical Activity*, 4(1), 25. doi:10.1186/1479-5868-4-25

438 Egli, T., Bland, H. W., Melton, B. F., & Czech, D. R. (2011). Influence of age, sex, and race on
439 college students' exercise motivation of physical activity. *Journal of American college*
440 *health*, 59(5), 399-406. doi:10.1080/07448481.2010.513074

441 Etnier, J. L. (2011). Considerations in coaching girls and women in sport and physical activity
442 settings. *Women in Sport and Physical Activity Journal*, 20(1), 98-100.
443 doi:10.1123/wspaj.20.1.98

444 Garber, C. E., Allsworth, J. E., Marcus, B. H., Hesser, J., & Lapane, K. L. (2008). Correlates of
445 the stages of change for physical activity in a population survey. *American journal of*
446 *public health*, 98(5), 897-904. doi:10.2105/AJPH.2007.123075

447 Grotzinger, K. M., Stuart, B. C., & Ahern, F. (1994). Assessment and control of nonresponse
448 bias in a survey of medicine use by the elderly. *Medical care*, 32(10), 989-1003.

449 Hayes, A. F. (2009). Beyond Baron and Kenny: Statistical mediation analysis in the new
450 millennium. *Communication monographs*, 76(4), 408-420.
451 doi:10.1080/03637750903310360

- 452 Hayes, A. F. (2013). *Introduction to Mediation, Moderation, and Conditional Process Analysis:*
453 *A Regression-based Approach*. New York, NY: The Guilford Press.
- 454 Hobbs, M., Daly-Smith, A., Morley, D., & McKenna, J. (2014). A case study objectively
455 assessing female physical activity levels within the National Curriculum for Physical
456 Education. *European Physical Education Review*, 21(2). doi:10.1177/1356336X14555296
- 457 Holle, R., Hochadel, M., Reitmeir, P., Meisinger, C., Wichmann, H.-E., & Group, K. (2006).
458 Prolonged recruitment efforts in health surveys: effects on response, costs, and potential
459 bias. *Epidemiology*, 17(6), 639-643. doi:10.1097/01.ede.0000239731.86975.7f
- 460 Ivory, J. D. (2006). Still a Man's Game: Gender Representation in Online Reviews of Video
461 Games. *Mass Communication & Society*, 9(1), 103-114.
462 doi:10.1207/s15327825mcs0901_6
- 463 Johnson, S. S., Paiva, A. L., Cummins, C. O., Johnson, J. L., Dymont, S. J., Wright, J. A.,
464 Prochaska, J. O., Prochaska, J. M., & Sherman, K. (2008). Transtheoretical model-based
465 multiple behavior intervention for weight management: effectiveness on a population basis.
466 *Preventive medicine*, 46(3), 238-246. doi:10.1016/j.ypmed.2007.09.010
- 467 Kanter, R., & Caballero, B. (2012). Global Gender Disparities in Obesity: A Review. *Advances*
468 *in Nutrition*, 3(4), 491-498. doi:10.3945/an.112.002063
- 469 Kelly, J., Edney, K., Moran, C., Srikanth, V., & Callisaya, M. (2016). Gender Differences in
470 Physical Activity Levels of Older People With Type 2 Diabetes Mellitus. *Journal of*
471 *physical activity & health*, 13(4), 409-415. doi:10.1123/jpah.2015-0147
- 472 Knuth, A. G., & Hallal, P. C. (2009). Temporal trends in physical activity: a systematic review.
473 *Journal of physical activity & health*, 6(5), 548. doi:10.1123/jpah.6.5.548

- 474 Lahaut, V. M., Jansen, H. A., Van de Mheen, D., & Garretsen, H. F. (2002). Non-response bias
475 in a sample survey on alcohol consumption. *Alcohol and Alcoholism*, 37(3), 256-260.
476 doi:10.1093/alcalc/37.3.256
- 477 Lauderdale, M. E., Yli-Piipari, S., Irwin, C. C., & Layne, T. E. (2015). Gender differences
478 regarding motivation for physical activity among college students: A self-determination
479 s approach. *Physical Educator*, 72(1). doi:10.18666/TPE-2015-V72-I5-4682
- 480 Lepp, A., Barkley, J. E., Sanders, G. J., Rebold, M., & Gates, P. (2013). The relationship
481 between cell phone use, physical and sedentary activity, and cardiorespiratory fitness in a
482 sample of U.S. college students. *International Journal of Behavioral Nutrition and*
483 *Physical Activity*, 10(1). doi:10.1186/1479-5868-10-79
- 484 Magoc, D., Tomaka, J., Shamaley, A. G., & Bridges, A. (2016). Gender Differences in Physical
485 Activity and Related Beliefs Among Hispanic College Students. *Hispanic Journal of*
486 *Behavioral Sciences*, 38(2), 279-290. doi:10.1177/0739986316637355
- 487 Martins, J., Marques, A., Sarmiento, H., & da Costa, F. C. (2015). Adolescents' perspectives on
488 the barriers and facilitators of physical activity: a systematic review of qualitative studies.
489 *Health Education Research*. doi:10.1093/her/cyv042
- 490 McLaughlin, S. J., Connell, C. M., & Janevic, M. R. (2016). Gender Differences in Trajectories
491 of Physical Activity Among Older Americans With Diabetes. *Journal of Aging and Health*,
492 28(3), 460-480. doi:10.1177/0898264315594136
- 493 Molanorouzi, K., Khoo, S., & Morris, T. (2015). Motives for adult participation in physical
494 activity: type of activity, age, and gender. *BMC public health*, 15(1), 66.
495 doi:10.1186/s12889-015-1429-7
- 496 Morris, T., Clayton, H., Power, H., & Han, J. (1995). Activity type differences in participation
497 motives. *Australian Journal of Psychology*, 47, 101-102.

- 498 NHS. (2015, July 11). Physical activity guidelines for adults. Retrieved from
499 <http://www.nhs.uk/Livewell/fitness/Pages/physical-activity-guidelines-for-adults.aspx>
- 500 op den Akker, H., Jones, V. M., & Hermens, H. J. (2014). Tailoring real-time physical activity
501 coaching systems: a literature survey and model. *User modeling and user-adapted*
502 *interaction, 24*(5), 351-392. doi:10.1007/s11257-014-9146-y
- 503 Pawlowski, C. S., Tjornhoj-Thomsen, T., Schipperijn, J., & Troelsen, J. (2014). Barriers for
504 recess physical activity: a gender specific qualitative focus group exploration. *BMC public*
505 *health, 14*(639). doi:10.1186/1471-2458-14-639
- 506 Prochaska, J. O., & Velicer, W. F. (1997). The transtheoretical model of health behavior change.
507 *American journal of health promotion, 12*(1), 38-48. doi:10.4278/0890-1171-12.1.38
- 508 Prochaska, J. O., Velicer, W. F., Redding, C., Rossi, J. S., Goldstein, M., DePue, J., Greene, G.
509 W., Rossi, S. R., Sun, X., & Fava, J. L. (2005). Stage-based expert systems to guide a
510 population of primary care patients to quit smoking, eat healthier, prevent skin cancer, and
511 receive regular mammograms. *Preventive medicine, 41*(2), 406-416.
512 doi:10.1016/j.ypmed.2004.09.050
- 513 Rehbein, F., Kliem, S., Baier, D., Mößle, T., & Petry, N. M. (2015). Prevalence of internet
514 gaming disorder in German adolescents: diagnostic contribution of the nine DSM-5 criteria
515 in a state-wide representative sample. *Addiction, 110*(5), 842-851. doi:10.1111/add.12849
- 516 Samaranyaka, S., & Gulliford, M. C. (2013). Trends in cardiovascular risk factors among
517 people with diabetes in a population based study, Health Survey for England 1994-2009.
518 *Primary Care Diabetes, 7*(3), 193-198. doi:10.1016/j.pcd.2013.04.010
- 519 Saydah, S., Bullard, K. M., Cheng, Y. L., Ali, M. K., Gregg, E. W., Geiss, L., & Imperatore, G.
520 (2014). Trends in Cardiovascular Disease Risk Factors by Obesity Level in Adults in the
521 United States, NHANES 1999-2010. *Obesity, 22*(8), 1888-1895. doi:10.1002/oby.20761

- 522 Spencer, R. A., Rehman, L., & Kirk, S. F. L. (2015). Understanding gender norms, nutrition, and
523 physical activity in adolescent girls: a scoping review. *International Journal of Behavioral*
524 *Nutrition and Physical Activity*, 12. doi:10.1186/s12966-015-0166-8
- 525 sports coach UK. (2016). Technology, Participation and Coaching. Retrieved from
526 [http://www.sportscoachuk.org/sites/default/files/Coaching%20and%20New%20Technolog](http://www.sportscoachuk.org/sites/default/files/Coaching%20and%20New%20Technology.pdf)
527 [y.pdf](http://www.sportscoachuk.org/sites/default/files/Coaching%20and%20New%20Technology.pdf)
- 528 Su, X., McBride, R. E., & Xiang, P. (2015). College students' achievement goal orientation and
529 motivational regulations in physical activity classes: A test of gender invariance. *Journal of*
530 *Teaching in Physical Education*, 34, 2-17. doi:10.1123/jtpe.2013-0151
- 531 Teixeira, P. J., Carraça, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise,
532 physical activity, and self-determination theory: a systematic review. *International Journal*
533 *of Behavioral Nutrition and Physical Activity*, 9(1), 1. doi:10.1186/1479-5868-9-78
- 534 US Department of Health and Human Services. (2008). Physical Activity Guidelines Advisory
535 Committee Report. Retrieved from
536 <https://health.gov/paguidelines/report/pdf/CommitteeReport.pdf>
- 537 Viciano, J., Mayorga-Vega, D., & Martinez-Baena, A. (2016). Moderate-to-Vigorous Physical
538 Activity Levels in Physical Education, School Recess and After-School Time. Influence of
539 Gender, Age, and Weight Status. *Journal of Physical Activity and Health*.
540 doi:10.1123/jpah.2015-0537
- 541 Vilhjalmsón, R., & Kristjansdóttir, G. (2003). Gender differences in physical activity in older
542 children and adolescents: the central role of organized sport. *Social science & medicine*,
543 56(2), 363-374. doi:10.1016/S0277-9536(02)00042-4

- 544 Walshaw, M. (2015). Confirmations and contradictions: Investigating the part that digital
545 technologies play in students' everyday and school lives. *Waikato Journal of Education*,
546 20(3).
- 547 Wang, D., Xiang, Z., & Fesenmaier, D. R. (2016). Smartphone use in everyday life and travel.
548 *Journal of Travel Research*, 55(1), 52-63.
- 549 Yau, H. K., & Cheng, A. L. F. (2012). Gender difference of confidence in using technology for
550 learning. doi:10.21061/jots.v38i2.a.2
- 551 Yungblut, H. E., Schinke, R. J., & McGannon, K. R. (2012). Views of adolescent female youth
552 on physical activity during early adolescence. *Journal of Sports Science and Medicine*,
553 11(1), 39-50.
- 554

Table 1 – *Mediating effect of cumulative device types on gender differences in stages of change for physical activity, before and after adjusting for selected covariates.*

Variables	Path a (Gender → Cumulative device types)	Path b (Cumulative device types → A/M Stages for Physical Activity)	Path c (Gender → A/M Stages for Physical Activity)	Path a*b or Indirect effect (Gender → Cumulative device types → A/M Stages for Physical Activity)
Unadjusted	-0.36 (-0.63, -0.09) ^a	0.43 (0.17, 0.68) ^a	0.06 (-0.59, 0.72)	-0.15 (-0.39, -0.042) ^a
Adjusted for age range	-0.36 (-0.64, -0.09) ^a	0.43 (0.17, 0.70) ^a	-0.03 (-0.70, 0.63)	-0.16 (-0.39, -0.03) ^a
Adjusted for Age range, and Coaching (<i>Yes/No</i>)	-0.38 (-0.66, -0.09) ^a	-0.05 (-0.57, 0.45)	-1.05 (-2.79, 0.69)	0.02 (-0.43, 0.37)
Adjusted for Age range, and Coaching (<i>Yes/No</i>), Organising index score (<i>Organising Myself + With my friends + Club + Gym</i>)	-0.36 (-0.64, -0.07) ^a	-0.07 (-0.58, 0.44)	-1.07 (-2.84, 0.68)	0.02 (-0.42, 0.56)
Adjusted for Age range, and Coaching (<i>Yes/No</i>), Organising index score (<i>Organising Myself + With my friends + Club + Gym</i>), Perceived benefits (<i>Enhance performance + Provides useful feedback + Motivates me</i>)	-0.20 (-0.47, 0.05)	-0.14 (-0.72, 0.44)	-1.05 (-2.83, 0.71)	0.03 (-0.16, 0.53)

^a $p < 0.05$ or CI range excludes '0'. The table does not include the *direct* effect of variable X (gender) on variable Y (stages of change for physical activity), unadjusted for variance attributable to the mediator variable (cumulative device types).

Table 2 – *Mediating effect of cumulative reasons for device use on gender differences in stages of change for physical activity, before and after adjusting for selected covariates.*

Variables	Path a (Gender → Cumulative perceived reasons for device use)	Path b (Cumulative perceived reasons for device use → A/M Stages for Physical Activity)	Path c (Gender → A/M Stages for Physical Activity)	Path a*b or Indirect effect (Gender → perceived reasons for device use → A/M Stages for Physical Activity)
Unadjusted	-0.27 (-0.54, 0.00)	0.57 (0.29, 0.84) ^a	0.07 (-0.59, 0.73)	-0.15 (-0.39, -0.02) ^a
Adjusted for age range	-0.28 (-0.55, -0.00) ^a	0.57 (0.29, 0.85) ^a	-0.02 (-0.69, 0.65)	-0.16 (-0.38, -0.01) ^a
Adjusted for Age range, and Coaching (<i>Yes/No</i>)	-0.33 (-0.62, -0.04) ^a	0.14 (-0.37, 0.66)	-0.97 (-2.71, 0.76)	-0.04 (-0.99, 0.05)
Adjusted for Age range, and Coaching (<i>Yes/No</i>), Organising index score (<i>Organising Myself + With my friends + Club + Gym</i>)	-0.30 (-0.59, -0.01) ^a	0.13 (-0.39, 0.66)	-0.99 (-2.74, 0.76)	-0.04 (-0.81, 0.06)
Adjusted for Age range, and Coaching (<i>Yes/No</i>), Organising index score (<i>Organising Myself + With my friends + Club + Gym</i>), Perceived benefits (<i>Enhance performance + Provides useful feedback + Motivates me</i>)	-0.16 (-0.44, 0.10)	0.11 (-0.44, 0.68)	-0.97 (-2.73, 0.78)	-0.02 (-0.79, 0.04)

^a $p < 0.05$ or CI range excludes '0'. The table does not include the *direct* effect of variable *X* (gender) on variable *Y* (stages of change for physical activity), unadjusted for variance attributable to the mediator variable (cumulative reasons for using technology).

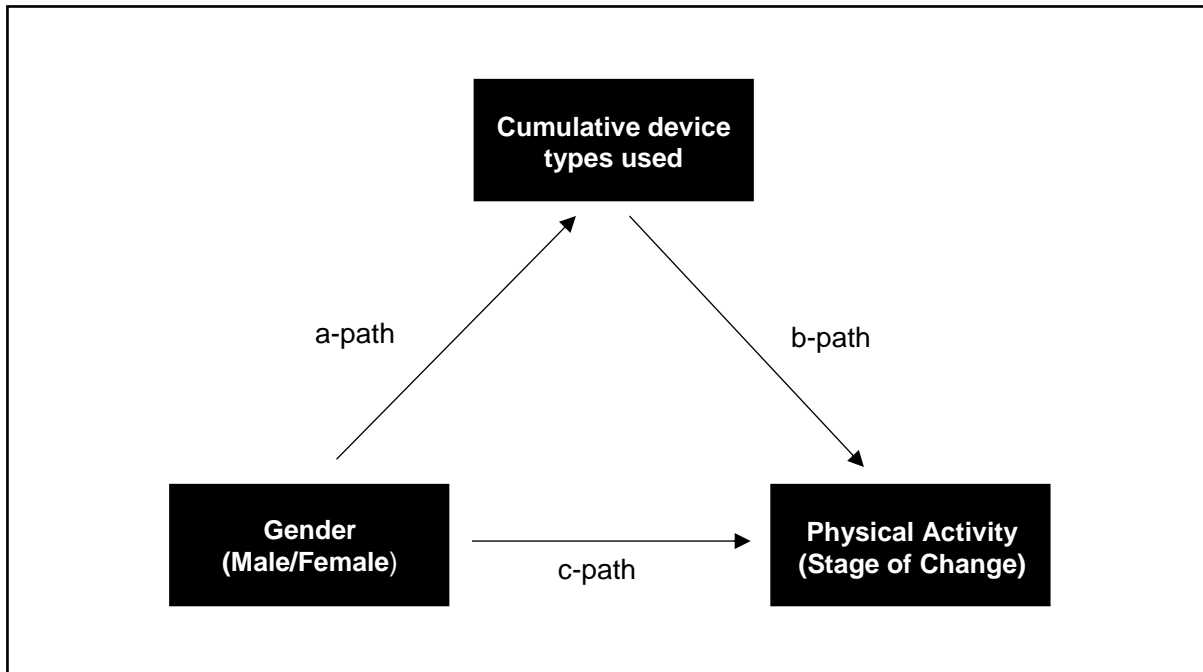


Figure 1: Mediating effect of cumulative device types on relations between gender and stages of change in physical activity (Pre/Post Action & Maintenance)

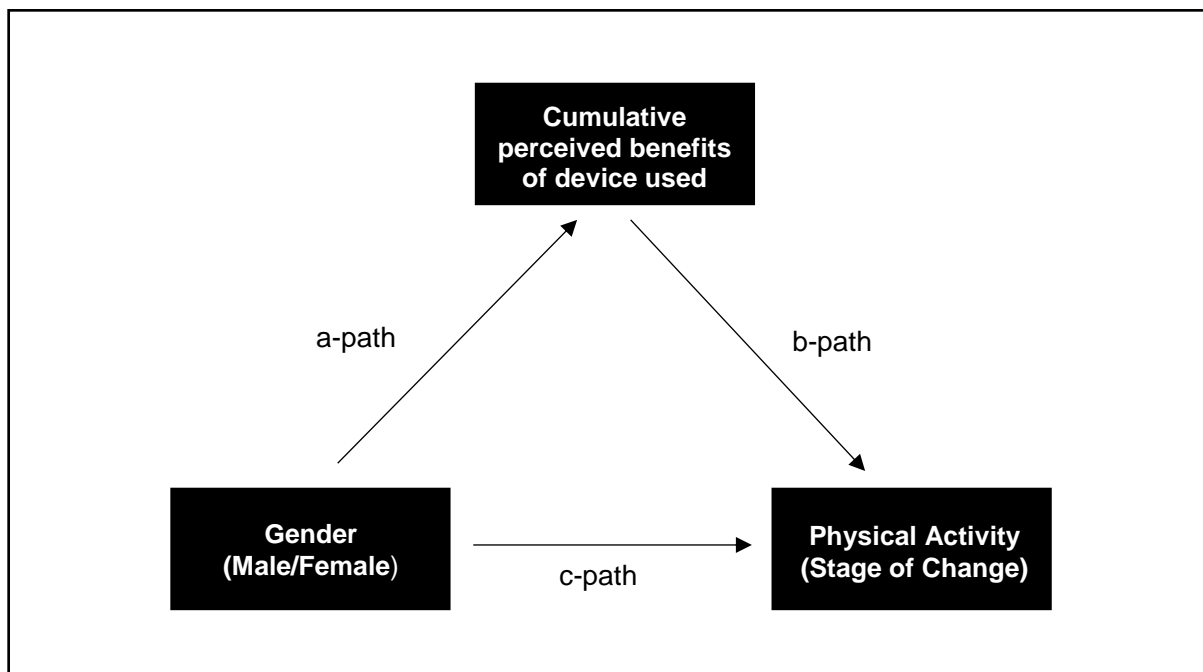


Figure 2 Mediating effect of cumulative perceived benefits for device use on relations between gender and stages of change in physical activity (Pre/Post Action & Maintenance)