

A protocol to encourage accelerometer wear in children and young people

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10

11 **Abstract**

12 **Background:** Improving compliance to physical activity monitoring is critical for obtaining
13 valid, comparable data free from inconsistencies that occur during data reduction. The first
14 aim of this study was to investigate children (8-11 years) and young people's (12-15 years)
15 views on strategies to promote habitual wear of hip (ActiGraph) and wrist-worn (GENEActiv)
16 accelerometers. The second aim was to subsequently develop a protocol to reduce participant
17 and researcher burden and maximise accelerometer wear time data.

18 **Methods:** An interpretivist methodology was used with semi-structured, mixed-gender focus
19 groups in 7 elementary ($n=10$; 47 children) and 5 high schools ($n =10$; 49 young people).
20 Focus groups were transcribed verbatim and outcomes from deductive and inductive analysis
21 were represented via pen profiles.

22 **Results:** Deductive content analysis revealed four general dimensions: 1) participant driven
23 compliance strategies; 2) reasons for non-compliance to wear time; 3) strategies to improve
24 accelerometer care; 4) reasons for non-compliance to study conditions. Children perceived
25 popular wear time compliance strategies to be: 1) sticky note reminders; 2) mobile phone
26 reminders; 3) social conformity, whereas young people's perceptions were: 1) social
27 conformity; 2) mobile phone reminders; 3) monetary compensation.

28 **Conclusions:** Where possible, compliance strategies should accommodate the varying
29 preferences of children and young people. It is recommended that future accelerometry based
30 research adopts a formative phase. In the absence of a formative research phase, future
31 research should consider the use of this informed protocol to improve compliance to physical
32 activity monitoring in children and young people.

33

34 **Keywords:** Accelerometry, compliance, youth, physical activity, measurement, protocol

35

36 **Background**

37 Valid assessment of habitual physical activity (PA) in children (8-11 years) and young people
38 (12-15 years) is fundamental to reliable descriptive and experimental research. Hip or wrist
39 worn accelerometers are widely used objective PA measurement devices for use with
40 children and young people (CYP). Participants are often instructed to wear the device during
41 waking hours but not during water based activities such as bathing and swimming
42 (Fairclough *et al.* 2012, Philips *et al.* 2013, Brooke *et al.* 2014). Such monitoring protocols
43 that discourage 24-hour wear are increasingly susceptible to low accelerometer wear time and
44 monitor loss, which have time and cost implications for research.

45 Non accelerometer wear time has led to inconsistencies in how to classify a non-wear period.
46 A review by Masse *et al.* (2005) found non-wear periods ranged from 10 to 30 minutes of
47 consecutive zero counts. This lack of standardization further extends to the minimum wear
48 time required for inclusion in data analysis, namely the number of hours per day and total
49 number of days that characterize usual activity (Mattocks *et al.* 2008, Sirard and Slater 2009,
50 Belton *et al.* 2013). Criteria have ranged from 8-10 hours wear per day and ≥ 2 to ≥ 4 days,
51 with inconsistencies in the requirement for a valid weekend day (Wells *et al.* 2013). Mattocks
52 *et al.* (2008) examined various hour-day combinations and concluded the variation of non-
53 wear periods and inclusion criteria limits comparability across studies, reduces the validity of
54 accelerometer data, and ultimately impacts upon conclusions drawn from descriptive and
55 experimental research (Masse *et al.* 2005). Promoting compliance to habitual PA monitoring
56 is therefore critical for obtaining valid, comparable data free from inconsistencies that can
57 occur during the data reduction process (Trost *et al.* 2005, Sirard and Slater 2009). However,
58 surprisingly little is known about effective recruitment and retention of CYP in accelerometer
59 based studies (Van Sluijs and Kriemler, 2016).

60 Various researcher derived compliance strategies have been implemented to promote
61 accelerometer wear in young people. Sirard and Slater (2009) conducted a study with 89
62 young people (mean age 17 years). Participants were assigned to one of three compliance
63 strategies to encourage hip-mounted ActiGraph (model 7164) wear for 4 days at ≥ 10 hours
64 per day. Monetary compensation contingent on the number of complete days (≥ 10 hours)
65 was deemed most effective ($n = 26$; 96%), followed by daily journal completion ($n = 20$; 85%)
66 and receiving three phone calls throughout the monitoring period ($n = 21$; 72%). Conversely,
67 Belton *et al.* (2013) conducted a study with 117 participants ((mean age 12.4 years (43 male))
68 and found that young people receiving an SMS message were significantly more likely to
69 wear hip mounted ActiGraph (GT1M; GT3X) accelerometers in the morning than those who
70 did not, but this did not improve overall compliance to accelerometer wear time. Whilst some
71 researcher driven strategies have reportedly been effective in promoting accelerometer
72 compliance (Trost *et al.* 2005, Sirard and Slater 2009) few studies have gained the
73 participants perspectives on accelerometer wear. Kirby *et al.* (2012) conducted a qualitative
74 study with 35 young people (aged 7-18 years) to investigate their views on ActiGraph
75 (GT1M) accelerometer use. Participants offered advice on how to improve wear time
76 compliance suggesting the use of a clip instead of a belt, personalising the device, and having
77 feedback on activity levels. Furthermore, Audrey *et al.* (2012) gained the perspectives of 61
78 young people (12-13 years (29 females)) on wearing ActiGraph (GT1M) accelerometers to
79 measure PA and concluded that a two part reward system (part one for returns and part two
80 for compliance), personal activity graphs and less obtrusive monitors may improve
81 compliance to accelerometer wear.

82 To the authors knowledge no previous study has used a formative phase to investigate the
83 views of CYP on compliance strategies to improve accelerometer wear with two varying
84 types of monitor; the hip-mounted (ActiGraph wGT3X-BT) and wrist-worn (GENEActiv)

85 devices. This research is deemed important as compliance to wrist-worn accelerometers is
86 often greater than hip-worn accelerometers (Trost *et al.* 2014) and thus location specific
87 strategies may be warranted. Furthermore, no previous study has used a formative phase to
88 subsequently develop a protocol from the views of those expected to participate. This active
89 engagement ensures the protocol is acceptable to the target population, thus increasing the
90 likelihood of reducing participant burden and maximising accelerometer wear time in CYP
91 (Van Sluijs and Kriemler, 2016).

92 This first aim of this study was to explore the views of CYP on strategies they perceive to
93 encourage free-living accelerometer wear time compliance with hip mounted ActiGraph
94 wGT3X-BT and wrist worn GENEActiv accelerometers. The second aim was to create a
95 study protocol from the suggestions of CYP to maximise accelerometer wear time data and
96 reduce participant and researcher burden in future accelerometer based studies.

97

98 **Methods**

99

100 ***Study population***

101 The study population was from Wigan, a large borough in the North West of England with a
102 population of 320,000 (Wigan Borough CCG, 2014). Fifty seven elementary and high
103 schools in the borough were asked to participate. Seven elementary (18% response rate) and
104 five high schools (28% response rate) consented to participate. School-level socioeconomic
105 status (SES) was determined by the percentage of pupils eligible to receive free school meals,
106 and defined as high or low SES in comparison to the 2014 England national average
107 (Gov.UK, 2014). After receiving gatekeeper consent, in-class presentations and small group
108 discussions were held at consenting schools to introduce the study to pupils. Forty seven
109 children (25 female) and forty nine young people (28 female) from these schools provided

110 written informed assent and parental/guardian consent to participate. This study builds on
111 previous collaborations between Liverpool John Moores University (LJMU) and Wigan
112 Council (Mackintosh *et al.*: 2011; Boddy *et al.*: 2012; Gobbi *et al.*: 2012; Fairclough *et al.*:
113 2013), and was granted ethical approval by LJMU Research Ethics Committee (reference
114 number 14/SPS/018).

115

116 *Study design*

117 From May to July 2014 the first author facilitated twenty semi-structured, mixed-gender,
118 focus groups throughout seven elementary schools ($n = 10$; 47 children (25 female)) and five
119 high schools ($n = 10$; 49 young people (28 female)). Focus groups took place in a familiar
120 school setting, during school time and within a space where participants could be overlooked
121 but not overheard to comply with safeguarding procedures (Porcellanto *et al.* 2002). Nineteen
122 focus groups involved the recommended group size of four to six CYP participants (Morgan
123 *et al.* 2002, Gibson *et al.* 2007, Mackintosh *et al.* 2011) and one involved three participants
124 due to circumstances linked to unforeseen absenteeism. To allow for variations in
125 comprehension of CYP, the maximum age range of participants was two years (Gibson *et al.*
126 2007). During the focus groups all participants were given approximately 10 minutes to look
127 at, hold and explore both types of accelerometer (one at a time) alongside their accompanying
128 wear time diary and instruction leaflet. The equipment was then removed and discussions
129 focused on participants' first impressions. All participants then wore each accelerometer (one
130 at a time) for approximately 10 minutes, again equipment was removed and further
131 discussions were encouraged (Porcellanto *et al.* 2002). Focus group questions were reviewed
132 by a Chartered sport and exercise psychologist for age appropriateness with ordering and
133 flow designed to maximise the interaction between CYP. Questions focused on recruitment
134 and retention strategies (Van Sluijs and Kriemler, 2016). They followed the social diagnostic

135 phase of the PRECEDE-PROCEED Model (PPM) (Crosby and Noar, 2011), addressing
136 perceived attitudes and barriers towards compliance to accelerometer wear including: 1)
137 participant driven compliance strategies for improved accelerometer wear; 2) participants'
138 reasons for non-compliance to accelerometer wear; 3) their views on non-compliance to study
139 conditions; 4) participant driven strategies to reduce time and cost burden to researchers,
140 caused by broken or damaged accelerometers. Questions therefore demonstrated aspects of
141 face validity as they were transparent and relevant to the topic (Crosby and Noar, 2011,
142 Boddy *et al.* 2012). Sample focus group questions are presented in Table 1. [Table 1 near
143 here]

144

145 ***Data analysis***

146 Focus groups lasted an average time of 41 minutes (38-73 minutes elementary schools (25-
147 42.25 minutes high schools)), were audio and video recorded and later transcribed verbatim.
148 410 pages (260 for elementary schools) of Arial size 12 font, double spaced raw transcription
149 data was produced. Verbatim transcripts were read and re-read to allow familiarisation of the
150 data and then imported into the QSR NVivo 10 software package. The authors then followed
151 the pen profiling protocol which is detailed in previous studies (Mackintosh *et al.* 2011,
152 Boddy *et al.* 2012, Ridgers *et al.* 2012, Downs *et al.* 2014). In summary, using the focus
153 group questions as a guide, themes were created using deductive analysis. Inductive analysis
154 then allowed for emerging themes to be created beyond the pre-defined categories. To assist
155 with the interpretation of general dimensions, higher order and raw data theme outcomes
156 were then represented as pen profiles. Characterising traits of this protocol include detail of
157 frequency count and extracts of verbatim quotes to provide context to the themes, which are
158 presented in a format deemed appropriate for researchers from qualitative and quantitative
159 backgrounds (Mackintosh *et al.* 2011; Shinke *et al.* 2013). Triangular consensus between the

160 authors and an independent researcher who was not involved in the study nor from the same
161 Institution is characteristic of the pen profiling technique (Knowles *et al.* 2001; Shinke *et al.*
162 2013). This offers transparency to the study, as data was critically reviewed by all authors
163 using a reverse tracking process from pen profiles to verbatim transcripts, providing
164 alternative interpretations of the data (Smith and Caddick, 2012). The process was repeated
165 until satisfactory agreement on data themes in relation to verbatim extracts was reached with
166 all authors and the external researcher (Mackintosh *et al.* 2011, Boddy *et al.* 2012, Ridgers *et*
167 *al.* 2012).

168 Pen profiles can be found in the supplementary files (Figures 1-4). Frequency count refers to
169 the total number of focus groups (C=children, YP=young people, (H= high SES, L=low SES))
170 in agreement to each theme, example verbatim quotes (with participant numbers) are
171 included to provide context for each theme. Consensus refers to an equal number of focus
172 groups from each group (children and young people) in agreement to each theme.

173

174 **Results**

175

176 Deductive content analysis revealed four general dimensions on strategies deemed to be
177 effective in encouraging accelerometer wear by CYP: 1) participant driven compliance
178 strategies for improved accelerometer wear; 2) participants provide reasons for non-
179 compliance to accelerometer wear; 3) participants offer their views on non-compliance to
180 study conditions; 4) participants provide strategies to reduce time and cost burden to
181 researchers, caused by broken or damaged accelerometers. During inductive analysis,
182 consensus and differences in higher order and raw data themes emerged between participants.
183 Pen profiles were categorized by age and SES and both were analysed throughout.

184

185 ***General dimension: participant driven compliance strategies for improved accelerometer***
186 ***wear (Figure 1).***

187 Figure 1 represents seven higher order themes for perceived useful or effective strategies to
188 encourage compliance to habitual accelerometer wear, in hierarchical order these are: 1)
189 participants to be offered rewards for wear time compliance; 2) daily participant wear time
190 reminders; 3) social conformity to improve accelerometer wear; 4) participants shown their 7
191 day wear time result; 5) advanced accelerometer technology; 6) viewing participation as a
192 privileged selection; 7) accelerometer to be provided with a storage box.

193 During inductive analysis, social conformity was reported to be of particular importance to
194 young people ($n = 18$), with all focus groups offering views (YP=10). For example, one young
195 person stated: 'Just doing it (wearing an accelerometer) with your friends, like, and you're
196 talking about it, and discussing it, you'd always remember' (BB2). Mobile phone reminders
197 were identified as a popular compliance strategy by participants ($n = 17$, YP=9, C=8), and
198 whilst there was consensus on receiving food such as chocolate and sweets as a reward for
199 compliance ($n = 10$, YP=5, C=5), differences in higher order and raw data themes emerged
200 between the two groups. Children preferred reminders such as sticky note reminders (C=10)
201 and electronic app reminders (C=7), whereas young people preferred rewards for compliance
202 to habitual accelerometry wear, including monetary compensation (YP=8), and trips (YP=6).

203 [Figure 1 near here]

204

205 ***General dimension: participants provide perceived reasons for non-compliance to***
206 ***accelerometer wear (Figure 2).***

207 Figure 2 represents four higher order themes: 1) social conformity; 2) negative comments
208 related to accelerometers; 3); inappropriate or inconvenient times of the day to wear an
209 accelerometer 4) general participant concerns.

210 The most frequently cited reason for perceived non-compliance to accelerometer wear
211 amongst participants was a lack of social conformity ($n = 18$, YP=10, C=8). Accelerometers
212 were also described as inconvenient to sleep in ($n = 4$, YP=2, C=2), and participants
213 anticipated forgetting to wear or not wanting to wear the accelerometer ($n = 12$, YP=5, C=7).
214 For instance, one child stated: 'it would annoy you wearing it (accelerometer) all week' (E5).
215 All participants preferred wearing the wrist-worn GENEActiv to the hip-mounted ActiGraph
216 accelerometer ($n=20$, YP=10, C=10), for example, one child stated: 'It (GENEActiv) just
217 feels like an everyday watch, whereas that (ActiGraph), it feels like you shouldn't be wearing
218 it' (A2). All young people perceived the ActiGraph to be inconvenient to wear (YP=10), and
219 half of all participants perceived that wearing the hip-worn ActiGraph could potentially cause
220 them to be bullied ($n = 10$, YP=5, C=5). One child stated: 'Bullies might come over and get it
221 (ActiGraph) off me, and I won't get it back' (A3). Children experienced difficulty when
222 putting on both accelerometers (ActiGraph C=9), in particular GENEActiv (C=10), as they
223 did not wear watches on a regular basis. Children from high SES attended more sports clubs
224 than children from low SES but anticipated feeling inconvenienced if asked to wear an
225 accelerometer when playing sports (CH=7). For example, one child declared: 'I wouldn't
226 wear it because all the sport I play is like, sometimes it can get really rough' (A2). [Figure 2
227 near here]

228

229 *General dimension: participants offer their views on non-compliance to study conditions*
230 *(Figure 3).*

231 Figure 3 is constructed from two higher order themes: 1) participants anticipate consequences
232 of incorrect accelerometer wear which has five raw data themes, and; 2) participants
233 anticipate consequences of incorrect completion of wear time diaries and has four raw data
234 themes. Conflicting themes emerged from discussions on incorrect accelerometer wear.

235 Participants perceived that they would ‘feel bad’ for not wearing the accelerometer correctly
236 ($n=18$, YP=8, C=10) and suggested asking for extended wear time to correct their behaviour
237 ($n=4$, YP=2, C=2). However participants suggested that they would not return their wear
238 time diary if they hadn’t completed it correctly ($n=6$, YP=3, C=3), and young people were
239 unconcerned about the incorrect completion of wear time diaries (YP=8). For example, one
240 young person concluded that the research team could access all the data required from the
241 accelerometer, therefore completion of a diary was considered unimportant: ‘it’d be all right,
242 because you could get the information off that (the accelerometer)’ (CC3). [Figure 3 near
243 here]

244

245 *General dimension: participants provide strategies to reduce time and cost burden to*
246 *researchers, caused by broken or damaged accelerometers (Figure 4).*

247 Two higher order themes emerged from this general dimension (Figure 4): The first and most
248 frequently cited theme was participant driven strategies to improve the care of accelerometers,
249 with seven raw data themes. Participants suggested being made aware of the consequences
250 for broken or damaged accelerometers would encourage CYP to take better care of the
251 equipment ($n=14$, YP=8, C=6). For example, one child stated: ‘they would take more care of
252 it because they know how much it cost’ (F1). In the second higher order theme participants
253 feelings about broken or damaged accelerometers were discussed and all participants
254 perceived that they would feel upset if they had broken or damaged their accelerometer (n
255 $=20$, YP=10, C=10). Further, the group identified as most likely to return a broken or
256 damaged accelerometer was children from a high SES (CH=5). [Figure 4 near here]

257 Based on the results above, the protocol in figure 5 was created. [Figure 5 near here]

258

259 **Discussion**

260

261 This is the first study to explore formatively the perceptions and attitudes of CYP on
262 strategies they perceive to encourage free-living accelerometer wear time compliance with
263 hip-mounted ActiGraph wGT3X-BT and wrist-worn GENEActiv accelerometers.
264 Furthermore, based upon the PRECEDE stage of the PPM model (Crosby and Noar, 2011),
265 this is the first study to propose a protocol based upon these results to capture the experiences,
266 priorities and perspectives of CYP (figure 5). This protocol provides a practical solution to
267 recruitment and compliance issues that previous research has reported, to maximise
268 accelerometer wear time data and reduce participant and researcher burden in future studies
269 (Van Sluijs and Kriemler, 2016).

270

271 ***Participant driven compliance strategies for improved accelerometer wear (Figure 1).***

272 This study aimed to enhance previous research by identifying ways to maximise
273 accelerometer wear time in CYP (Van Coevering *et al.* 2005, Sirard and Slater, 2009, Belton
274 *et al.* 2013, Pfitzner *et al.* 2013). In contrast to figure 2, wherein social conformity appears to
275 negatively impact upon compliance, figure 1 details how social conformity, particularly in the
276 form of peer support, could play a critical role in positive compliance to free-living
277 accelerometer wear in CYP. The anticipated importance of friendship groups was highlighted
278 in this study, for example one young person stated ‘I’d just prefer it (wearing accelerometers)
279 if it was just us (CYP friendship group)’ (CC2). This concurs with previous research
280 reporting that friends’ PA level had a significant influence on participants PA level, with
281 children who shared similar PA habits clustering in friendship groups (Jargo *et al.* 2011,
282 MacDonald-Wallis *et al.* 2011, Gesell *et al.* 2012, Sawka *et al.* 2013). Within the present
283 study protocol (figure 5) the authors have afforded opportunity to the perceived impact of
284 friendship networks, which may lead to greater success in increasing compliance to free-

285 living accelerometer wear in CYP (Figure 5) (MacDonald-Wallis *et al.* 2011, Gesell *et al.*
286 2012, Sawka *et al.* 2013).

287 Previous studies have implemented various researcher derived compliance strategies in young
288 people which are comparable to the results of this study (Sirard and Slater 2009, Belton *et al.*
289 2013, Pfitzner *et al.* 2013). Mobile phone reminders were used in a study by Belton *et al.*
290 (2013) which found that although they significantly improved the likelihood of young people
291 wearing their accelerometer in the morning, overall compliance was not significantly
292 influenced. Sirard and Slater (2009) concluded that participants receiving three phone call
293 reminders was their least successful compliance strategy (72%). However our data suggests
294 the potential for alternative individual communication via mobile technology rather than
295 phone calls, suggesting that mobile phone apps or reminders could be a preferred compliance
296 strategy in both CYP ($n=17$, YP=9, C=8).

297 Furthermore, sticky note reminders, when applied to prominent surfaces/places within the
298 home environment were anticipated to improve compliance to accelerometer wear amongst
299 children (C=10), a notion suggested by Trost *et al.* (2005) for example, one child stated:
300 ‘...I’d have to stick it (sticker reminder) on my door so when I was going out of my room or
301 into my room I’d see it and remember’ (A2).

302 Monetary compensation was used as an incentive in previous research (Van Coevering *et al.*
303 2005, Sirard and Slater 2009). Sirard and Slater (2009) concluded that monetary
304 compensation (\$5.00) contingent on the number of complete days (≥ 10 hours) plus an
305 additional \$10.00 for the return of accelerometers achieved the greatest impact on compliance.
306 For other studies, lack of funds and cited ethical restrictions have prevented the use of
307 monetary compensation as a compliance strategy (Belton *et al.* 2013). In support of this,
308 monetary compensation was frequently cited by young people in this study as a strategy they
309 believed would improve compliance to accelerometer wear (YP=8). However, to concur with

310 previous research (Audrey *et al.* 2012), CYP in our study indicated that a lesser amount of
311 £10.00 as a one-off payment in the form of shopping vouchers may improve compliance to
312 accelerometry wear.

313 Furthermore, our findings suggest that CYP believed individual or school trips, varying from
314 a day out at a theme park or to sporting events, when used as a reward for accelerometer wear
315 would be an effective compliance strategy in studies with young people (YP=6). Such
316 strategies may be effective when used in social networks to further enhance compliance.
317 Finally, providing individual feedback to participants has been trialled in a study by Pfitzner
318 *et al.* (2013) which concluded that visual graphs of participants PA data when provided as an
319 incentive for compliance to accelerometer wear in young people, was inadequate in
320 encouraging participation. Conversely, in support of previous studies (Audrey *et al.* 2012,
321 Kirby *et al.* 2012) this data suggests that CYP ($n= 10$, YP=6, C=4) would like to be shown
322 and have explained to them their 7 day wear time PA result. A frequently cited concern of
323 CYP in the present study was the lack of tangible results available to them, for example one
324 young person asked: ‘where does it (the accelerometer) show how active you are?’ (G2). This
325 concurs previous research, alluding to the ‘black box’ nature of accelerometers (Lee *et al.*
326 2013), whereby participants not having access to their immediate data, influences motivation
327 to wear time continuance. This could be exacerbated by the promotion and availability of
328 wearable PA monitors and apps that provide instant feedback to participants

329 Contrasting findings in children and young people support the use of different compliance
330 strategies across age groups. In support of this, the Youth Physical Activity Promotion Model
331 (YPAM) implies that there may be developmental differences in PA correlates with age
332 (Welk 1999), and whilst previous research has largely focused on young people (12-17 years),
333 compliance determinants may be considerably different in children, a consideration which
334 has been highlighted previously (Sirard and Slater 2009, Belton *et al.* 2013, Pfitzner *et al.*

2013). The authors therefore suggest formative research should explore age specific strategies to improve compliance to free-living accelerometer wear in CYP, in the absence of a formative phase, future accelerometry research should consider the informed strategies identified in the study protocol (figure 5).

339

Participants provide perceived reasons non-compliance to accelerometer wear (Figure 2).

Accelerometry is the most common objective method used to measure PA in CYP (Wells *et al.* 2013), however consistent with previous research the findings of this study suggests that accelerometer wear could cause participant burden amongst this population. As shown in Figure 2, participants disliked the look, feel and wear of both accelerometers, in particular the ActiGraph which they would prefer to hide under clothing and, in agreement with previous research, raised concerns of provoked bullying (Kirby *et al.* 2012). In the present study CYP alluded to the ActiGraph being conspicuous therefore attracting unwanted attention, for example one young person stated: ‘They’d (bullies) be like “oh what’s that red belt on here? What are you wearing?” They might look at you. Stare you out’ (CC3). To concur with previous research, this study suggests that social conformity in the form of peer influence, teacher, and parental support has the potential to negatively affect behaviour and therefore accelerometer wear time in CYP (Jargo *et al.* 2011, Gesell *et al.* 2012, Sawka *et al.* 2013). For example, one child stated: ‘I wouldn’t just do it (wear an accelerometer) on my own, though’ (F5).

Furthermore, despite the wrist worn GENEActiv being waterproof and suited to water based PA, one young person who was a competitive swimmer described how she would not wear the GENEActiv accelerometer during swim training: ‘Not in the water, because it’d irritate me (the accelerometer). I wouldn’t be able to swim’ (AA12). Although this may be less of a concern for those CYP who use swimming as a recreational or fun form of PA, active

360 participants considering accelerometry a hindrance is well reported amongst researchers
361 (Audrey *et al.* 2012, Kirby *et al.* 2012).

362 Although accelerometry is frequently viewed as a more precise measure of PA when
363 compared to self-report measures, it is often limited by accrued missing data caused by
364 participant non wear time and legitimate reasons such as compliance to mandatory sports
365 clubs' safety regulations (Welk 1999, Trost *et al.* 2005, Sirard and Slater 2009, Belton *et al.*
366 2013, Pfitzner *et al.* 2013). Such issues emphasise the importance of a formative phase within
367 future accelerometry research to pro-actively explore and address wear time barriers and
368 increase the likelihood of a successful trial (Van Sluijs and Kriemler, 2016), as highlighted in
369 the study protocol (Figure 5).

370

371 ***Participants offer their views on non-compliance to study conditions (Figure 3).***

372 Previous research has recommended diaries to collect data on wear time and to promote
373 compliance to monitor wear. A study by Pfitzner *et al.* (2013) suggested that the diary is vital
374 for identification of invalid data and non-compliant participants. Furthermore, Sirard *et al.*
375 (2009) reported that when used as a strategy to encourage wear time, this resulted in 85%
376 compliance on ≥ 10 hours per day for ≥ 4 days per week. In contrast, the findings from this
377 study suggested that CYP would not want to complete the diary. Further, despite typical
378 instructions conveyed at the stage of initiating a wear time study, CYP would be unconcerned
379 if they had not completed the wear time diary correctly and perceived that they would not
380 return incomplete diaries. Further, for those who would, completion was not viewed as
381 important, so much so that providing false information was viewed as acceptable. To
382 counteract this, participants provided suggestions on improving the diary such as simplifying
383 it, decreasing the size of the diary and making it electronic, as detailed in the study protocol

384 (figure 5). In contrast CYP anticipated that they would ‘feel bad’ ($n = 18$) about incorrect
385 wear of accelerometers and to rectify this, offered suggestions of extended wear periods.

386

387 ***Participant driven strategies to improve the care of accelerometers (Figure 4).***

388 The time and cost burden caused by non-wear and loss of accelerometers remains an issue for
389 researchers (Cattelier *et al.* 2005, Sharpe *et al.* 2011, Wells *et al.* 2013). Findings from this
390 study (figure 4) suggest that making participants aware of the cost of accelerometers plus
391 acknowledgement that accelerometers remain the property of the research team could prevent
392 broken or damaged accelerometers by instilling a sense of trust in CYP as detailed in the
393 study protocol (figure 5).

394

395 **Strengths and limitations**

396

397 A number of strengths are apparent across this study which contributes to the currently
398 limited research within this area. Firstly, the use of comprehensive formative research and the
399 methodological rigour employed to ensure credibility and transferability of the findings (Van
400 Sluijs and Kriemler, 2016). Secondly, the inclusion of both children and young people
401 acknowledged developmental differences in their views on free-living accelerometer wear
402 time compliance, and generated perceived strategies that can be applied across the two age
403 groups (Welk 1999). Thirdly, the inclusion of participants from high and low SES adds to the
404 limited available literature on school based characteristics such as SES and school
405 involvement with health-promoting activities that are associated with compliance to
406 accelerometer wear, therefore further enhances the generalizability of the study findings
407 (Wells *et al.* 2013). Finally, providing the views of CYP on two commercially different types
408 of accelerometers: the hip-mounted ActiGraph wGT3X-BT and wrist-worn GENEActiv

409 ensures that the application of results from this study can be used within various
410 accelerometry based research.

411 In terms of study limitations, participation bias may have impacted upon results, as despite an
412 equal representation of CYP from areas of high (n=10) and low SES (n=10), the percentage
413 varied between children (high=70%, low=30%) and young people (high=30%, low=70%).
414 The sample size was a convenience sample based on level of interest and selected by the
415 school teacher, using a random number generator is recommended for future research to
416 provide a representative sample of the population. The study was conducted in one borough
417 in the North West of England in which the population is largely White British, therefore
418 findings may not be generalizable to children and young people in other locations. Focus
419 group questions were anticipatory although every effort was made to offer CYP the same
420 information as in a typical in a wear time study. These findings are based upon the
421 perceptions of CYP on strategies to encourage free-living accelerometer wear, although
422 participants interacted with, tried on and wore the accelerometers for a given time they did
423 not wear them for a 7 day period, it is therefore recommended that future studies follow a
424 similar formative phase post data collection.

425

426 **Conclusion**

427

428 CYP perceived social conformity, sticky note reminders, mobile phone reminders and
429 monetary compensation to be effective compliance strategies. Where possible, compliance
430 strategies should accommodate the varying preferences of CYP. Focus groups revealed
431 consistent themes between socioeconomic groups, the only apparent difference being that
432 children from high SES would feel restricted by accelerometer wear when attending sports
433 clubs. It is recommended that future research adopts a similar formative phase. In the absence

434 of a formative research phase, future accelerometry based research should consider the use of
435 this informed protocol (figure 5) to improve compliance to habitual physical activity
436 monitoring in CYP.

437

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439

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444 **References**

- 445 Audrey, S., Bell, S., Hughes, R., Campbell, R., 2012. Adolescent perspectives on wearing
446 accelerometers to measure physical activity in population-based trials. *Eur J Pub Health*
447 [online], 23(3): 475-80 Available from: PubMed doi:10.1093/eurpub/cks081 [Accessed
448 26 May 2015].
- 449 Belton, S., O'Brien, W., Wickel, E.E., Issartel, J., 2013. Patterns of noncompliance in
450 adolescent field-based accelerometer research. *J Phys Act Health*, 10 suppl 8:1181-5.
- 451 Boddy, L.M., Knowles, Z.R., Davies, I.G., Warburton, G.L., Houghton, L., Fairclough,
452 S.J., 2012. Using formative research to develop the healthy eating component of the
453 CHANGE! School-based curriculum intervention. *BMC Public Health* [online], 12:710
454 Available from: PubMed doi: 10.1186/1471-2458-12-710 [Accessed 11 January 2015].
- 455 Brooke, H.L., Atkin, A.J., Corder, K., Ekelund, U., Sluijs, E.M.F., 2014. Changes in
456 time-segment specific physical activity between ages 10 and 14 years: a longitudinal
457 observational study. *J Sci Med Sport* [online], Available from: PubMed
458 doi:10.1016/j.jsams.2014.10.003 [Accessed 26 May 2015].
- 459 Cattelier, D.J., Hannan, P.J., Murray, D.M., Addy, C.L., Conway, T.L., Yang, S., Rice,
460 J.C., 2005. Imputation of missing data when measuring physical activity by
461 accelerometry. *Med Sci Sports Exerc*, 37 suppl 11:555-5562.
- 462 Crosby, R., Noar, S.M., 2011. What is a planning model? An introduction to PRECEDE-
463 PROCEED. *J Public Health Dent*, 71 suppl 1:7-15.
- 464 Downs, S.J., Knowles, Z.R., Fairclough, S.J., Heffernan, N., Whitehead, S., Halliwell, S.,
465 Boddy, L.M., 2014. Exploring teachers' perceptions on physical activity engagement for
466 children and young people with intellectual disabilities. *European Journal of Special*
467 *Needs Education*, 3-29.

468 Fairclough, S.J., Hackett, A.F., Davies, I.G., Gobbi, R., Mackintosh, K.A; Warburton,
469 G.L., Stratton, G., Van Sluijs, E.M.F., Boddy, L.M., 2013. Promoting healthy weight in
470 primary school children through physical activity and nutrition education: a pragmatic
471 evaluation of the CHANGE! randomised intervention study. *BMC Public Health* [online],
472 13:626. Available from: PubMed doi: 10.1186/1471-2458-13-626 [Accessed 10 February
473 2016].

474 Fairclough, S.J., Beighle, A., Erwin, H., Ridgers, N., 2012. School day segmented
475 physical activity patterns of low and high active children. *BMC Public Health* [online],
476 12:406. Available from: PubMed doi: 10.1186/1471-2458-12-406 [Accessed 17 January
477 2014].

478 Gesell, S.B., Tesdahl, E., Ruchman, E., 2012. The distribution of physical activity in an
479 after-school friendship network. *Paediatrics* [online], Available from: PubMed doi:
480 10.1542/peds.2011-2567 [Accessed 14 January 2015].

481 Gibson, F., 2007. Conducting focus groups with children and young people: strategies for
482 success. *Journal of Research in Nursing* [online], 12(5):473-483 Available from: PubMed
483 doi: 10.1177/17449871079791 [Accessed 16 December 2014].

484 Gobbi, R.M., Davies, I.G., Fairclough, S.J., Mackintosh, K.A., Warburton, G.L., Stratton,
485 G., George, K.P., Hackett, A.F., Boddy, L.M., 2012. Clustered cardiometabolic risk,
486 cardiorespiratory fitness and physical activity in 10-11 year old children. The CHANGE!
487 project baseline. *Archives of Exercise in Health and Disease*, 3 suppl 3: 207-2013.

488 Jargo, R., MacDonald-Wallis, K., Thompson, J.L., Page, A.S., Brockman, R., Fox, K.R.,
489 2011. Better with a buddy: Influence of best friends on children's physical activity. *Med*
490 *Sci Sports Exerc* [online], 43(2): 259-65 Available from: PubMed
491 doi:10.1249/MSS.0b013e3181edefaa [Accessed 26 May 2015].

- 492 Kirby, J., Tibbins, C., Callens, C., Lang, B., Thorogood, M., Tigbe, W., Robertson, W.,
493 2012. Young people's views on accelerometer use in physical activity research: Findings
494 from a user involvement investigation. *ISRN Obesity* [online], Available from: PubMed
495 doi:10.5402/2012/948504 [Accessed 26 May 2015].
- 496 Knowles, Z., Gilbourne, D., Borrie, A., Neville, A., 2001. Developing the reflective
497 sports coach: a study exploring the process of reflective practice with a higher education
498 sports programme. *Reflective practice*, 2 suppl 2: 924-935.
- 499 Lee, P.H., Macfarlane, D.J., Lam, T.H., 2013. Factors associated with participant
500 compliance in studies using accelerometers. *Gait Posture* [online], 38(4): 912-7 Available
501 from: PubMed doi:10.1016/j.gaitpost.2013.04.018 [Accessed 22 January 2014].
- 502 MacDonald-Wallis, K., Jargo, R., Page, A.S., Brockman, R., Thompson, J.L., 2011.
503 School-based friendship networks and children's physical activity: A spatial analytical
504 approach. *Soc Sci Med* [online], 73(1):6-12 Available from: PubMed
505 doi:10.1016/j.socscimed.2011.04.018 [Accessed 14 January 2015].
- 506 Mackintosh, K.A., Knowles, Z.R., Ridgers, N.D., Fairclough, S.J., 2011. Using formative
507 research to develop CHANGE: A curriculum- based physical activity promoting
508 intervention. *BMC Public Health* [online], 11:831 Available from: PubMed doi:
509 10.1186/1471-2458-11-831 [Accessed 17 January 2014].
- 510 Masse, L.C., Fuemmeler, B.F., Anderson, C.B., Matthews, C.E., Trost, S.G., Cattellier,
511 D.J., Treuth,, M., 2005. Accelerometer data reduction: A comparison of four reduction
512 algorithms on select outcome variables. *Med Sci Sports Exerc* [online], 37 suppl 11:544-
513 54 Available from: PubMed doi:10.1249/01.mss0000185674.09066.8a [Accessed 17
514 January 2014].

- 515 Mattocks, C., Ness, A.R., Leary, S.D., Tilling, K., Blair, S.N., 2008. Use of
516 accelerometers in a large field-based study of children: Protocols, design issues, and
517 effects on precision. *J Phys Act Health*, 5 suppl 1:98-111.
- 518 Morgan, M., Gibbs, S., Maxwell, K., Britten, N., 2002. Hearing children's voices:
519 methodological issues in conducting focus groups with children aged 7-11 years. *Qual*
520 *Res*, 2:15-20.
- 521 Pfitzner, R., Gorzelniak, L., Heinrich, J., Von Berg, A., Klumper, C., Bauer, CP.,
522 Koletzko, S., Berdel, D., Horsch, A., Schulz, H., 2013. Physical activity in German
523 adolescents measured by accelerometry and activity diary: Introducing a comprehensive
524 approach for data management and preliminary results. *PLoS One* [online] 8(6) Available
525 from: PubMed doi:10.1371/journal.pone.0065192 [Accessed 17 January 2014].
- 526 Phillips, L.R.S., Parfitt, G., Rowlands, AV., 2013. Calibration of the GENE
527 accelerometer for the assessment of physical activity in children. *J Sci Med Sport* [online],
528 16(2): 124-8 Available from: PubMed doi:10.1016/j.jsams.2012.05.013 [Accessed 27
529 January 2014].
- 530 Porcellanto, L., Dugdill, L., Springett., 2002. Using focus groups to explore children's
531 perceptions of smoking: reflections on practice. *Health Education*, 102 suppl 6:310-320.
- 532 Ridgers, N.D., Knowles, Z.R., Sayers, J., 2012. Encouraging play in the natural
533 environment: a child- focused case study of forest school. *Children's Geographies*, 10
534 suppl 1: 49-65.
- 535 Rowlands, A.V., Pilgrim, E.L., Eston, R.G., 2007. Patterns of habitual activity across
536 weekdays and weekend days in 9-11 year-old children. *Prev Med*, 46 suppl 4:317-24.
- 537 Sawka, S.J., McCormack, G.R., Nettel-Aguirre, A., Hawe, P., Doyle-Barker, P., 2013.
538 Friendship networks and physical activity and sedentary behaviour among youth: a

539 systemized review. *Int J Behav Nutr Phys Act* [online], 10:130 Available from: PubMed
540 doi: 10.1186/1479-5868-10-130 [Accessed 26 May 2015].

541 Sharpe, P.A., Wilcox, S., Rooney, L.J., Strong, D., Hopkins-Campbell, R., Butel, J.,
542 Ainsworth, B., Parra-Medina, D., 2011. Adherence to accelerometer protocols among
543 women from economically disadvantages neighbourhoods. *J Phys Act Health*. 8 suppl
544 5:699-706.

545 Schinke, R.J., Smith, B., McGannon, K.R., 2013. Pathways for community research in
546 sport and physical activity: criteria for consideration. *Qualitative Research in Sport,*
547 *Exercise and Health*. 5 suppl 3:460-468.

548 Sirard, J.R., Slater, M.E., 2009. Compliance with wearing physical activity
549 accelerometers in high school students. *J Phys Act Health*, 6 suppl 1:148-55.

550 Smith, B., Caddick, N., 2012. Qualitative methods in sport: A concise overview for
551 guiding social scientific research. *Asia Pacific Journal of Sport and Social Science*,
552 1suppl 1:60-73.

553 Statistics-National statistics. Schools, pupils and their characteristics: January 2014.
554 Gov.UK. [online]. Gov. UK 2014. Available from:
555 [https://www.gov.uk/government/statistics/schools-pupils-and-their-characteristics-](https://www.gov.uk/government/statistics/schools-pupils-and-their-characteristics-january-2014)
556 [january-2014](https://www.gov.uk/government/statistics/schools-pupils-and-their-characteristics-january-2014). [Accessed 21 Sept 2014].

557 Trost, S.G., McIver, K.L., Pate, R.R., 2005. Conducting accelerometer-based activity
558 assessments in field based research. *Med Sci Sports Exerc*, 37 suppl 11:531-43.

559 Trost, S.G., Zheng. Y., Wong, W.K., 2014. Machine learning for activity recognition: hip
560 versus wrist data. *Physiol. Meas* [online], 35(11): 2183-9 Available from: PubMed
561 doi:10.1088/0967-3334/35/11/2183 [Accessed 26 May 2015].

562 Welk, G.J., 1999. The youth physical activity promotion model: A conceptual bridge
563 between theory and practice. *Quest* [online], 51(1):5-23 Available from: PubMed doi:
564 10.1080/00336297.1999.10484297 [Accessed 21 February 2015].

565 Wells, S.L., Kipling, R.R., Jargo, R., Brown, J., Hucker, D., Blacklett, A., Lawlor, D.A.,
566 2013. Characteristics associated with requested and required accelerometer wear in
567 children. *BMJ Open* [online], 3:8 Available from: PubMed doi:10.1136/bmjopen-2013-
568 003402 [Accessed 21 February 2015].

569 Wigan Borough Clinical Commissioning Group., 2014. *Wigan Borough Clinical*
570 *Commissioning Group* [online]. Wigan Borough CCG. Available from:
571 <http://www.wiganboroughccg.nhs.uk>. [Accessed 21 Sept 2014].

572 Van Coevering, P., Harnack, L., Schmitz, K., Fulton, J.E., Galuska, D.A., Goa, S., 2005.
573 Feasibility of using accelerometers to measure physical activity in young adolescents.
574 *Med Sci Sports Exerc*, 37 suppl 5: 867-71.

575 Van Sluijs, E.M.F., Kriemler, S., 2016. Reflections on physical activity intervention
576 research in young people-dos, don'ts, and critical thoughts. *Int J Behav Nutr Phys Act*
577 13(1):25 Available from: PubMed doi: 10.1186/s 12966-016-0348-z [Accessed 21
578 February 2016].

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583 **Tables**

584 *Table 1. Example of focus group questions.*

Orienting statement	Practical task	Questions	Prompt(s)
I would like to talk about how young people like you may feel when both an accelerometer and an instruction leaflet is handed to them.	I would like to show you how to wear both accelerometers, please watch carefully so that you can wear them too. Now it is your turn, let's try the ActiGraph accelerometer, pick one up, put it in and spend a few minutes wearing it.	“Can you talk me through how it felt to put on the ActiGraph accelerometer?” “Can you tell me how it felt to wear the ActiGraph accelerometer?”	“Would you wear this on top of your clothes or underneath them?” “Would it matter if other pupils could see them?”

585

586 **Figure captions.**

587 ***Figure 1. Participant driven compliance strategies for improved accelerometer wear.***

588 This pen profile represents seven higher order themes and a number of raw data themes for
589 perceived useful or effective strategies to encourage compliance to habitual accelerometer
590 wear. Frequency count refers to the total number of focus groups (C=children, YP=young
591 people, (H= high SES, L=low SES)) in agreement to each theme, and example verbatim
592 quotes (with participant numbers) are included to provide context for each theme. Consensus
593 refers to an equal frequency count between two variables.

594

595 ***Figure 2. Participants provide reasons for non-compliance to accelerometer wear.***

596 This pen profile represents four higher order themes and a number of raw data themes that
597 emerged from participant's perceptions of non-compliance to accelerometer wear. Frequency
598 count refers to the total number of focus groups (C=children, YP=young people, (H= high
599 SES, L=low SES)) in agreement to each theme, and example verbatim quotes (with
600 participant numbers) are included to provide context for each theme. Consensus refers to an
601 equal frequency count between two variables.

602

603 ***Figure 3. Participants views on non-compliance to study conditions to relieve researcher's***
604 ***time and cost burden.***

605 This pen profile is constructed from two higher order themes and nine raw data themes which
606 emerged from participant's views on non-compliance to study conditions. Frequency count
607 refers to the total number of focus groups (C=children, YP=young people, (H= high SES,
608 L=low SES)) in agreement to each theme, and example verbatim quotes (with participant

609 numbers) are included to provide context for each theme. Consensus refers to an equal
610 frequency count between two variables.

611

612 ***Figure 4. Participant's strategies to reduce burden to researchers caused by broken or***
613 ***damaged accelerometers.***

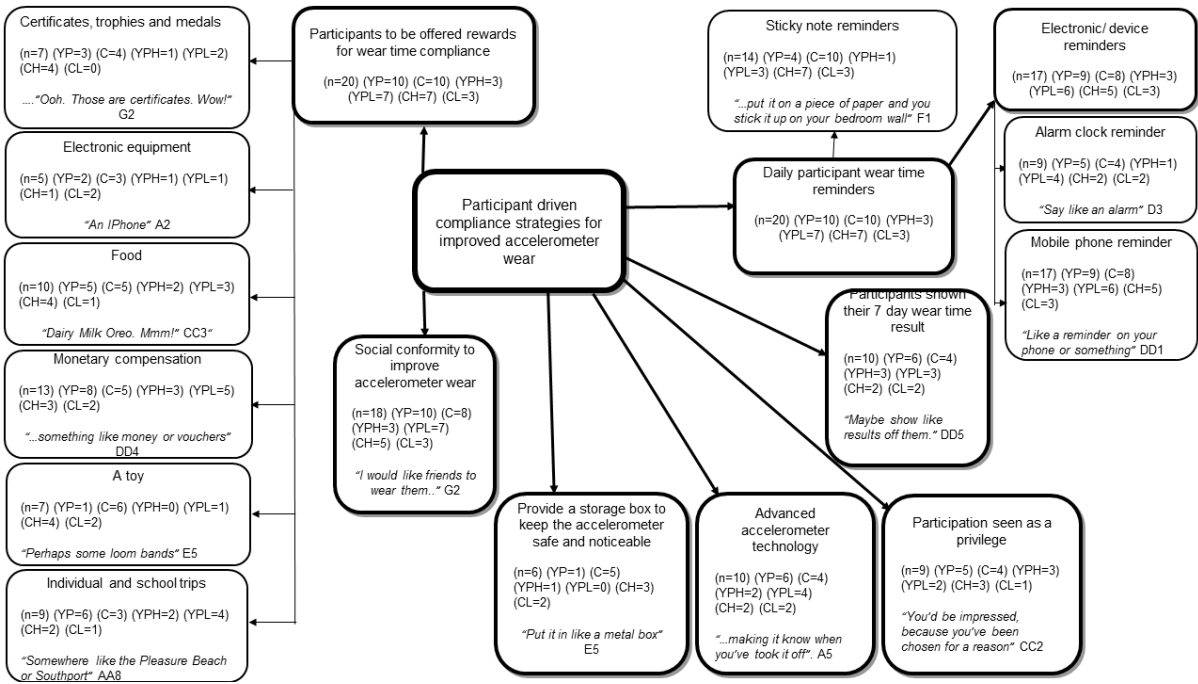
614 This pen profile represents two higher order themes and a number of raw data themes
615 suggested by participants to reduce the burden to researchers. Frequency count refers to the
616 total number of focus groups (C=children, YP=young people, (H= high SES, L=low SES)) in
617 agreement to each theme, and example verbatim quotes (with participant numbers) are
618 included to provide context for each theme. Consensus refers to an equal frequency count
619 between two variables.

620

621 ***Figure 5. A proposed protocol to maximise the provision of adequate data in future***
622 ***accelerometer based research.***

623 From the results displayed in figures 1-4 a study protocol was created, using the suggestions
624 of CYP to maximise accelerometer wear time data and reduce participant and researcher
625 burden.

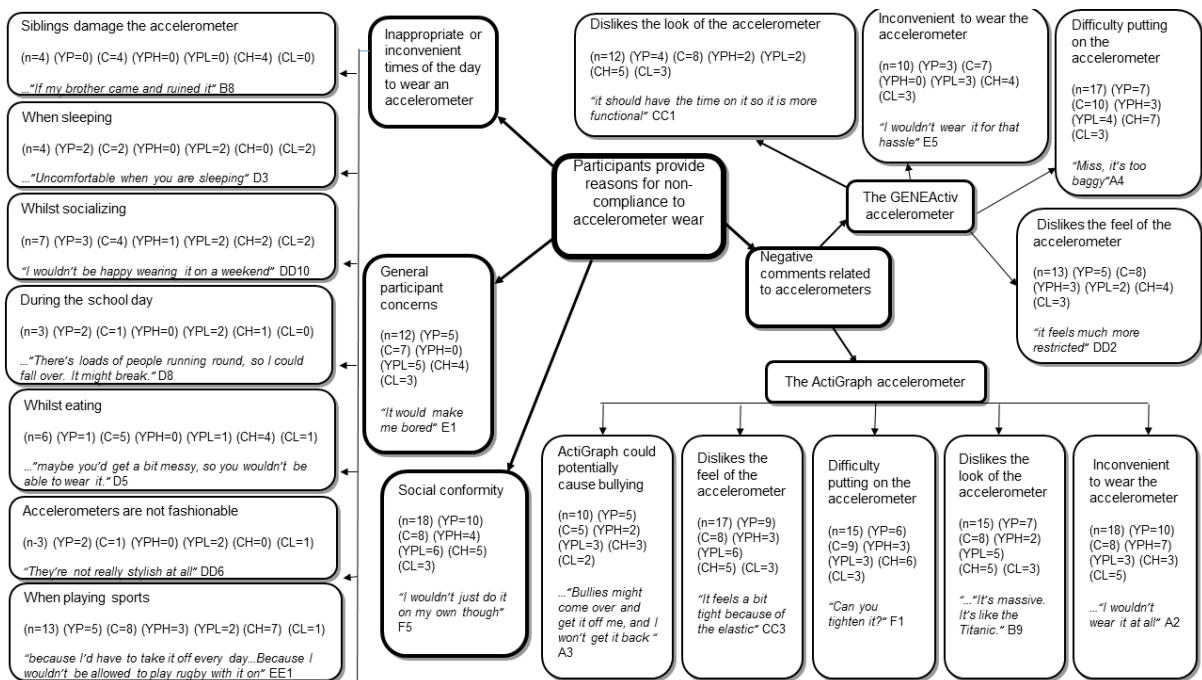
626



627

628 **Figure 1. Participant driven compliance strategies for improved accelerometer wear.**

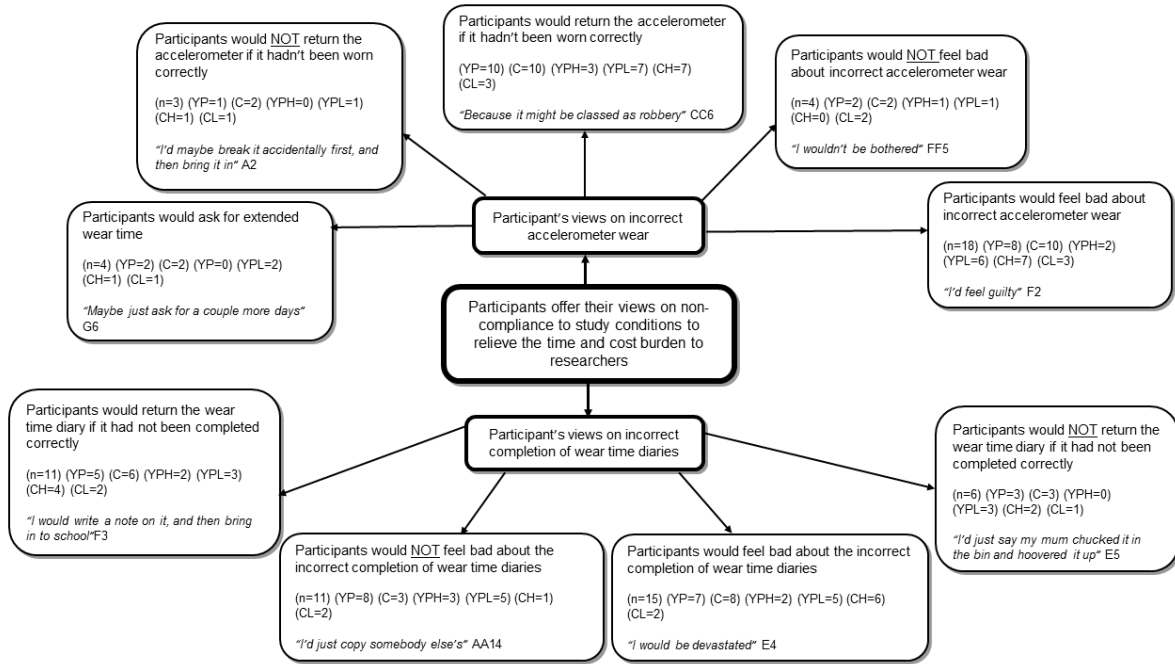
629



630

631 **Figure 2. Participants provide reasons for non-compliance to accelerometer wear.**

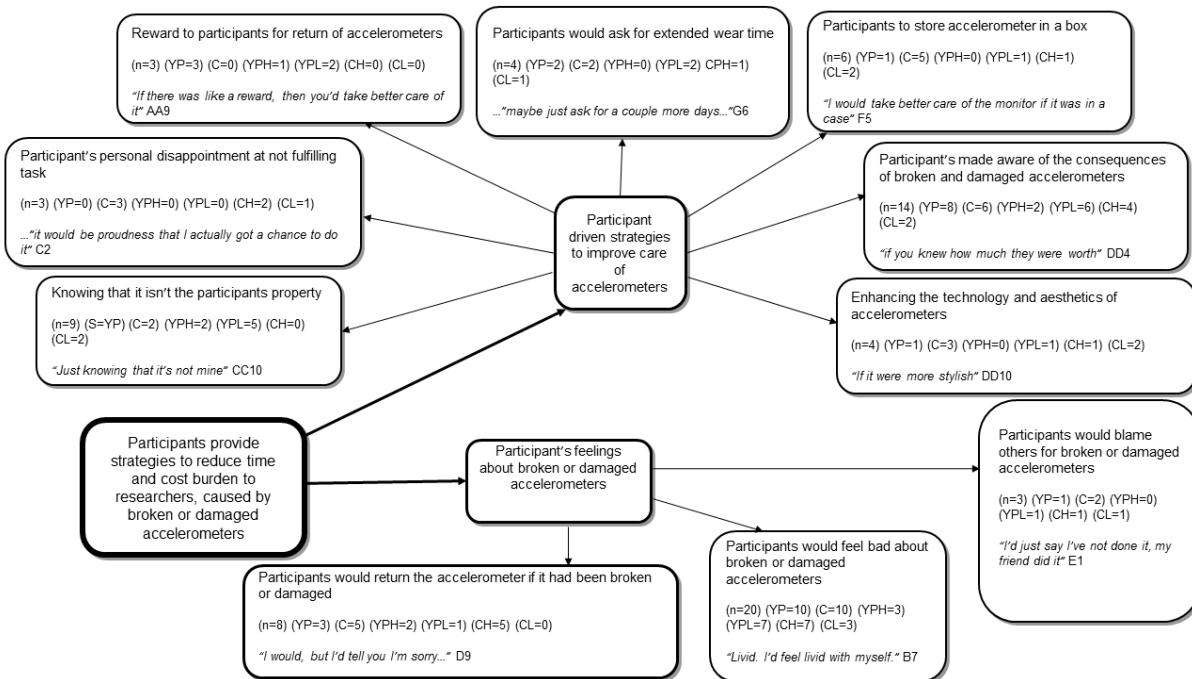
632



633

634 **Figure 3. Participants views on non-compliance to study conditions to relieve researcher's**
 635 **time and cost burden.**

636



637

638 **Figure 4. Participant's strategies to reduce burden to researchers caused by broken or**
 639 **damaged accelerometers.**

640

The Study Protocol

This protocol was created from the suggestions of children and young people to maximise the provision of adequate data in future accelerometer based research.

Study design

Where possible encompass a comprehensive formative research phase that is based upon established theoretical models and acknowledges the developmental differences in determinants with age.

Compliance

Compliance strategies should accommodate the differing preferences of children and young people. In the absence of a formative research phase future accelerometry based research should consider these informed strategies to improve compliance to habitual physical activity monitoring:

Children (8-11 yrs.): 1) sticky note reminders; 2) mobile phone reminders; 3) social conformity.

Young people (12-15 yrs.): 1) social conformity; 2) mobile phone reminders; 3) monetary compensation.

Recruitment

Children and young people:

Where possible target friendship groups to enhance social conformity. If not possible involve class/forms/sets so that peers who are connected socially are involved in the study. It is suggested that friendship groups have the potential to contribute to behavioural reinforcement.

Parents and gatekeepers:

Invite parents, siblings and teachers of selected participants to a small group discussion. The social environment of children and young people primarily includes, parents, siblings, friends and teachers. All should be briefed on the study and in particular wear time criteria, asking for support in terms of reminding the participant to wear the accelerometer and enforcing the positive aspects of the study.

Small group familiarity sessions.

Accelerometers: allow participants time to pick up and look at the accelerometer in detail, asking any questions they may have. Once fitted, let participants practice taking the accelerometer on and off, and sitting/ standing/ writing with the accelerometer on so they are familiar with how it feels and are comfortable with adjusting the accelerometer for comfort.

Instructions and wear time diaries: Combine the two documents into a simple format to reduce participant burden, and emphasise the importance of completing this document each day. If funding allows create an electronic version so that participants can access this through mobile phone and computer technology.

Wear time

Participants should wear waterproof accelerometers at all times during waking hours and remove others only for water based activities. Provide participants with supporting letters to hand to sports coaches to prevent removal. Only if the accelerometer is deemed unsafe by the coach should the accelerometer be removed.

Care of accelerometers

To instil a sense of trust inform participants that accelerometers remain the property of the Institution. For each accelerometer that is broken or damaged this would cost the Institution the equivalent of a new PS3 or XBOX 360.

641

642 *Figure 5. A proposed protocol to maximise the provision of adequate data in future*

643 *accelerometer based research.*

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