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Abstract

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

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

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

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

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

Background

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

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

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

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

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

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

Methods

Study population

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

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

Study design

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

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

Data analysis

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

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

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

Results

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

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

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

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

[Figure 1 near here]

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

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

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

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

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

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

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

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

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

Discussion

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

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

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

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

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

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

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

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

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

Contrasting findings in children and young people support the use of different compliance strategies across age groups. In support of this, the Youth Physical Activity Promotion Model (YPAM) implies that there may be developmental differences in PA correlates with age (Welk 1999), and whilst previous research has largely focused on young people (12-17 years), compliance determinants may be considerably different in children, a consideration which 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).

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

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

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

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

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

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

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

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

Strengths and limitations

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

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

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

Conclusion

CYP perceived social conformity, sticky note reminders, mobile phone reminders and monetary compensation to be effective compliance strategies. Where possible, compliance strategies should accommodate the varying preferences of CYP. Focus groups revealed consistent themes between socioeconomic groups, the only apparent difference being that children from high SES would feel restricted by accelerometer wear when attending sports 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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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.

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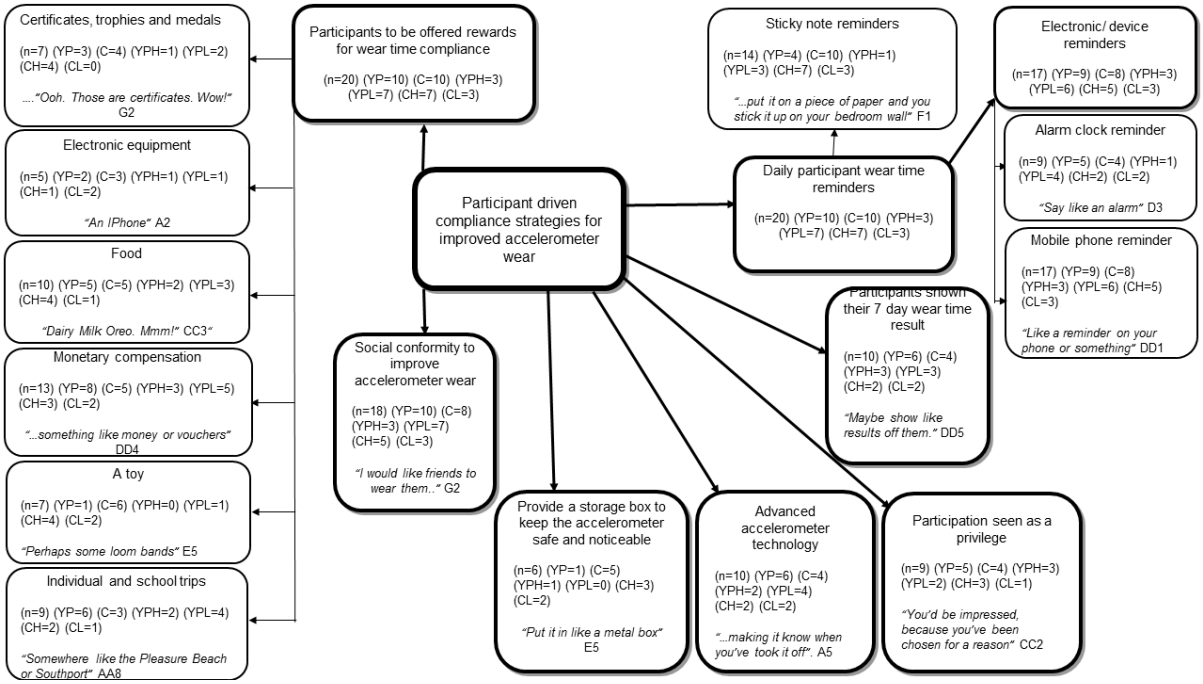

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628 ***Figure 1. Participant driven compliance strategies for improved accelerometer wear.***

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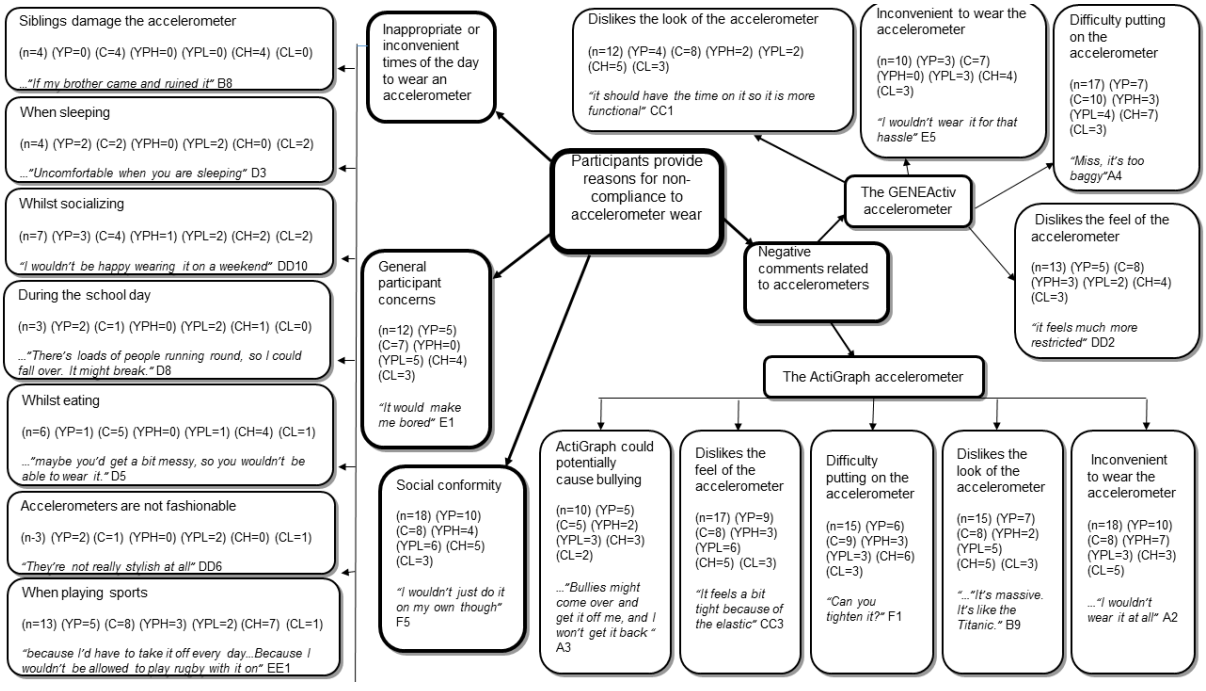

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631 ***Figure 2. Participants provide reasons for non-compliance to accelerometer wear.***

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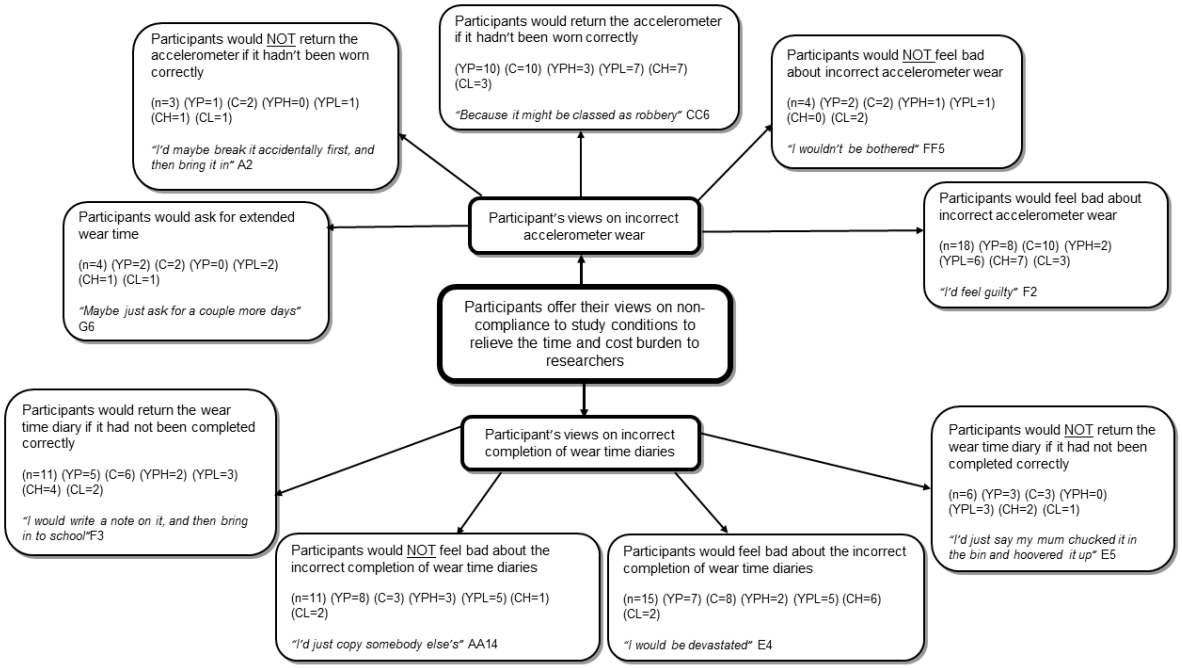

633

634 ***Figure 3. Participants views on non-compliance to study conditions to relieve researcher's***

635 ***time and cost burden.***

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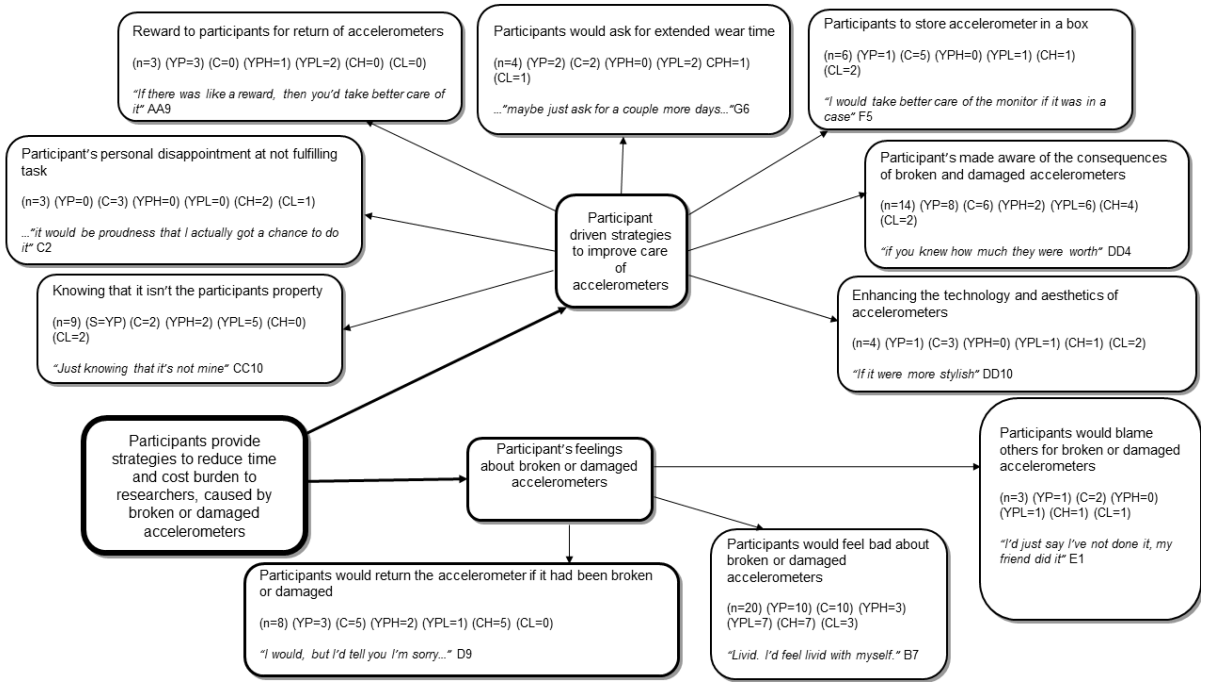

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638 ***Figure 4. Participant's strategies to reduce burden to researchers caused by broken or***

639 ***damaged accelerometers.***

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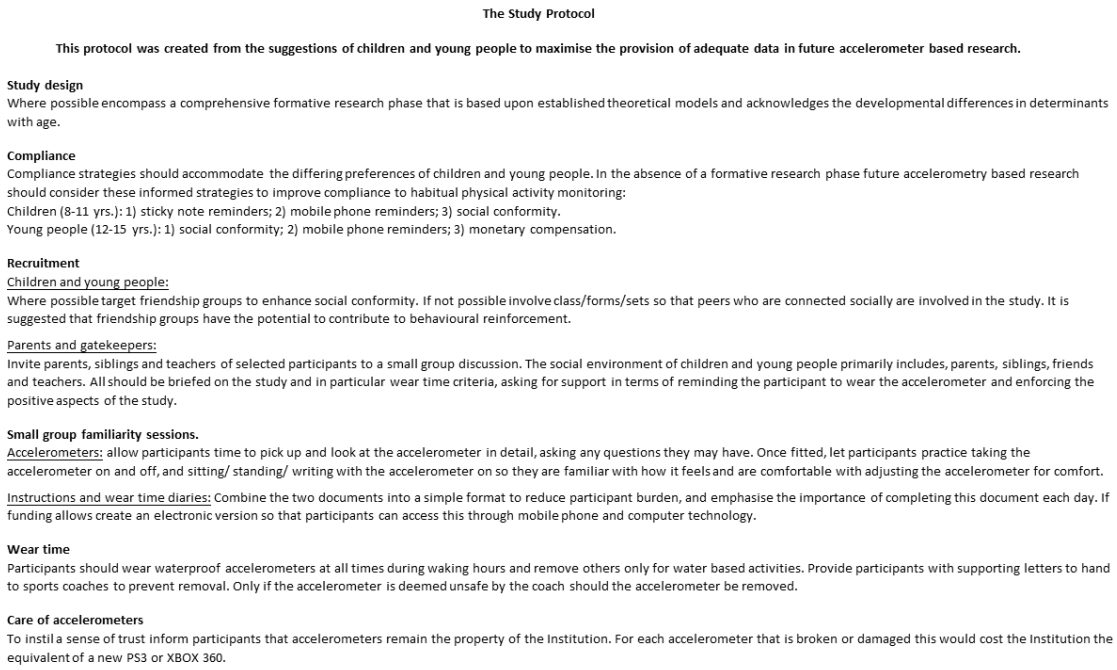

The Study Protocol

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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