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ORIGINAL ARTICLE

Exploring the challenges in obtaining physical activity data from women using hip-worn accelerometers

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Abstract
Quality objective physical activity data are required to inform physical activity-based health improvement initiatives, however, various challenges undermine acquisition of such data. We examined the efficacy and challenges of a hip-worn accelerometry protocol in women. Specific objectives included determining accelerometer-wear-compliance rates and understanding the barriers and acceptability of wearing accelerometers. Healthy New Zealand women ($n = 406$) of three ethnicities (Māori (indigenous New Zealander), Pacific, European) aged 16–45 years (30.9 ± 8.7 y) wore hip-mounted Actigraph wGT3X+ accelerometers for 7 consecutive days under a 24-h wear protocol. *Post hoc*, a sub-sample ($n = 45$; age: 29.4 ± 9.0 y) was interviewed to investigate comfort/convenience and burdens of accelerometer-wear. Wear-compliance (≥10 h/day, ≥4 day) was 86%. European women returned more valid data (92.7%, $p < .04$) than Pacific (73.0%) or Māori women (82.1%). Twenty-two participants (5.4%) had completely missing data; 13 due to lost accelerometers. Burden of accelerometer-wear was greatest during sleeping (66.7%) due to discomfort. Embarrassment of accelerometer visibility through clothing and consequent restricted clothing choices caused high burden in social settings (45.2%). Discomfort during sleeping, embarrassment due to perceived appearance in social settings and ethnicity are key factors affecting the efficacy of collecting physical activity data from women using hip-worn accelerometers. Refining accelerometer design to reduce size and subsequently participant burden should improve acceptability and wear-compliance. Increasing overall participant compliance by reducing burden and ensuring appropriate understanding of study aims and relevance should reduce attrition and improve wear-compliance and data quality when collecting accelerometry data from women of different ethnicities.

Keywords: *Ethnicity, exercise, health, obesity, measurement*

Highlights
- Sleeping discomfort and accelerometer visibility are key factors for women that affect accelerometer wear compliance.
- Ethnicity is a major factor influencing women's adherence to accelerometry protocols.
- Accelerometer size and placement (hip) cause embarrassment and restrict clothing choices for women wearing accelerometers in social settings.

Introduction

Physical activity (PA) is an important and modifiable risk factor for many chronic diseases (e.g. cardiovascular disease, type 2 diabetes, some cancers) (Lee et al., 2012; Warburton, Nicol, & Bredin, 2006). Conversely, the negative health consequences of inactivity are equivalent in impact to the health risks of smoking and obesity (Lee et al., 2012). However, despite overwhelming evidence for the benefits of PA, participation rates are declining worldwide, and are below recommendations for health in substantial portions of the population (Ng & Popkin, 2012).

Good-quality objectively measured PA data are vital to informing decisions by national health bodies on PA-based health initiatives. Historically, population-level assessment of PA behaviour has been characterised using self-report questionnaires

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(Health and Social Care Information Centre, 2015; Ministry of Health, 2015). However, the increasing practicality and economic viability of accelerometers for population-based studies have led to their utilisation in numerous national surveys (e.g. National Health and Nutrition Examination Survey (Centers for Disease Control and Prevention, 2014), British Whitehall Study (Bell et al., 2015)). Using accelerometers to objectively assess PA under free-living conditions provide activity intensity, duration, timing and frequency, eliminating the need for participant recall, as relied upon with self-report methods (Troiano, McClain, Brychta, & Chen, 2014).

Despite their recognised value, quality objective PA data are difficult to obtain. Various challenges undermine their acquisition in scientific research, leading to reduced compliance and data quality. High rates of non-compliance, resulting in insufficient wear-time and data (32%) (Troiano et al., 2008) and lost accelerometers (7%) (Hagströmer, Oja, & Sjöström, 2007) are not uncommon. Notwithstanding these known limitations with data collection, little is published regarding the drivers of non-compliance in accelerometer-based studies (Trost, McIver, & Pate, 2005). One of the few studies to document accelerometer-wear acceptability among women, reported that appearance, comfort and convenience were major barriers to compliance (Huberty, Ehlers, Kurka, Ainsworth, & Buman, 2015). However, perceptions of acceptability vary among different groups of women (Pollard & Guell, 2012). American women preferred accelerometers worn on the upper arm rather than on the hip (Huberty et al., 2015), whereas South Asian Muslim women rated hip-worn devices more favourably than those on the upper arm (Pollard & Guell, 2012). Among these women, their typical clothing influenced preference for accelerometer placement, highlighting the contrasting perceptions of acceptability in different populations (Huberty et al., 2015; Pollard & Guell, 2012). Therefore, if factors contributing to non-compliance in specific populations can be identified and understood in context, improved study protocols might be designed to increase participant engagement and maximise compliance to accelerometry protocols. This could lead to more reliable and representative data on which to base PA recommendations for population-specific health improvement initiatives.

The aim of this investigation was to examine the experiences of women wearing hip-worn accelerometers over a 7-day period. Specifically, these data were used to identify possible contributors to accelerometer-wear non-compliance. These findings will contribute to overcoming the challenges and improving the efficacy of objective PA assessments in women.

Methods

This study reports data obtained from objectively measured PA within the Women's EXPLORE (EXamining Predictors Linking Obesity Related Elements) study (Kruger et al., 2015). A semi-structured telephone interview was conducted *post hoc* with a sub-sample to investigate the acceptability of the accelerometry protocol. The full methodology of the EXPLORE study is described elsewhere (Kruger et al., 2015). The study was approved by the Massey University Human Ethics Committee (Southern A, Reference No.13/13) and conducted in accordance with the Declaration of Helsinki. Prior to data collection, written informed consent was obtained from participants.

Participants

Healthy, pre-menopausal women ($n = 406$), aged 16–45 years were recruited from Auckland, New Zealand (NZ). The women were of Māori (indigenous New Zealander), Pacific or NZ European ethnicities. Inclusion criteria consisted of being post-menarcheal but pre-menopausal and not pregnant, breastfeeding or diagnosed with any metabolic condition.

PA measurements

Tri-axial accelerometers (Actigraph wGT3X+, Pensacola, FL) were used to assess PA over seven consecutive days. Accelerometers attached to an elastic belt were fitted on participants' right hip by an experienced researcher. During fitting, researchers explained the correct positioning and orientation of the accelerometer, and the importance of collecting objectively measured PA data. Participants were instructed to wear the accelerometer at all times (excluding water-based activities) during a typical week. Instructions were reinforced on an information sheet given to each participant, along with pictures showing correct wear. On Day 6, participants were reminded to stop wearing the accelerometer on Day 7, and to immediately return it in the pre-paid envelope provided. To be considered as having valid data, participants must have worn the accelerometer during waking hours for ≥10 h/day (Matthews, Hagströmer, Pober, & Bowles, 2012) for ≥4 (week and/or weekend) days (Tudor-Locke, Camhi, & Troiano, 2012).

Accelerometry experience interview

A sub-sample ($n = 88$) of the main study was selected for a short (3–4 min) semi-structured telephone interview to explore the barriers to and acceptability of the accelerometry protocol. The sub-sample consisted of all participants with insufficient accelerometer data ($n = 49$), plus a random sample of participants with valid data ($n = 39$). A minimum of three attempts were made to contact participants by telephone. During the telephone interview, participants were asked if they had worn the accelerometer for the full seven days as directed, and to rate their experience of accelerometer-wear. These ratings covered overall comfort and the convenience of wearing the accelerometer in each of four lifestyle domains: day to day (e.g. work, home, university), social, sport/exercise and sleep. For each domain, participants were asked "How convenient was it to wear the accelerometer for [domain name]?", followed by "Can you explain why you gave that score for [domain name]?". If necessary, participants were asked open-ended questions to encourage elaboration of their answers; participants received no prompts based upon any specific themes.

Anthropometry

Anthropometric assessment was conducted using the International Society for the Advancement of Kinanthropometry protocol (Marfell-Jones, Olds, Stewart, & Carter, 2006) described by Kruger et al. (2015). Briefly, height (cm) and weight (kg) were measured to calculate body mass index (BMI; kg/m^2). Body fat percentage (BF%) was assessed via air displacement plethysmography (BodPod, 2007A, Life Measurement Inc, Concord, CA) using manufacturer-supplied software (V4.2+) and the thoracic gas volume method and Siri equation (Siri, 1961).

Statistical analysis

All statistical analyses were carried out using SPSS Statistics 22 for Windows (SPSS, Inc., Chicago, IL). All data were checked for normality using Kolmogorov–Smirnov tests. Descriptive data are presented as mean (s). Independent t-tests and Chi-square analysis were used to compare data against physical and demographic characteristics. One-way ANOVA was used to compare wear data between ethnic groups. The level of significance was set at $p < .05$ for all analyses.

Interview responses were recorded, and raw data were reviewed using an inductive approach allowing for formation of core categories based on the study aims and objectives. Findings are presented as two core categories with underlying themes, supported by direct quotes of participants' experiences.

Results

In total, 406 women participated in the study, 350 (86%) of whom provided valid accelerometer data (≥10 h/day for ≥4 days). Participant characteristics are presented in Table I.

Women with valid data were older ($t(404) = -4.7$, $p < .001$) and more likely to be in fulltime employment ($x^2(2) = 8.94$, $p = .011$) than those with insufficient data. Average daily waking wear-time for participants with insufficient data was 9.1 ±1.1 h; for participants with valid data, daily waking wear-time was 13.7 ±0.3 h. More valid data were returned from NZ European (92.7%,) than Pacific (73.0%) or Māori (82.1%) women ($F(2, 405) = 11.8$, $p < .001$). No significant differences in body composition measures were found between the total population, and those with and without valid data.

Table I. Demographic and body composition characteristics.

			Insufficient data obtained		
	Total[a]	Valid data[b]	Total[a]	Insufficient wear-time	No data[a]
n	406 (100%)	350 (86%)	56 (13.8%)	34 (8.4%)	22 (5.4%)
Age (y)	30.9 (8.7)	31.6 (8.5)	26.3 (8.1)*	24.1 (7.1)*	29.7 (8.5)
BMI (kg/m^2)	27.4 (6.4)	27.1 (5.9)	29.3 (8.9)	28.8 (8.4)	30.2 (9.7)
BF% (%)	34.3 (8.3)	34.0 (8.1)	36.0 (9.4)	35.4 (9.3)	36.9 (9.8)
Wear-time (h/day)		13.7 (0.3)			
Employed	187	170	17*	4*	13
Ethnicity					
Māori	84 (100%)	69 (82.1%)	15 (17.9%)	10 (11.9%)	5 (6.0%)
Pacific	89 (100%)	65 (73.0%)	24 (27.0%)	16 (18.0%)	8 (9.0%)
NZE	233 (100%)	216 (92.7%)	17 (7.3%)	8 (3.4%)	9 (3.9%)

Note: Mean value (s); NZE: New Zealand European.
[a]Includes two participants whose data were lost due to hardware failure;
[b]Valid accelerometer data defined as ≥10 h/day for ≥4 day;
*Significantly different from participants with valid data $p < .05$.

Missing accelerometer data

Twenty-two participants (5.4%) had completely missing accelerometer data (Table II), including 13 participants (3.2%) whose accelerometers were lost. Pacific women were more likely to lose accelerometers than NZ European women ($x^2(2) = 11.07$, $p = .004$). No common themes were identified to explain lost accelerometers (Table II).

Qualitative results from interviews

Of the 88 participants in the interview sample, 46 (52.3%) were successfully contacted, with one declining to participate. Of the 45 interviewed participants (age: 29.4 ± 9.0 year; BMI: 30.1 ± 9.0 kg/m^2; BF% 36.0 ± 10.0%), 25 returned insufficient data and 20 returned valid data.

Responses regarding wear-compliance revealed that 23 participants (51%) failed to wear the accelerometer for the full seven days. Wear non-compliance responses were categorised into "Discomfort/inconvenience" ($n = 16$) and "Forgetfulness" ($n = 13$). Some participants' responses were categorised in both.

The general comfort of wearing the accelerometer was investigated using a rating scale of 1 (worst) to 4 (best), followed by comments explaining the particular rating. The average comfort rating was 2.8. Comments were categorised as "Comfort" or "Discomfort". Examples of comments include:

- "It was uncomfortable at first but was OK once I got used to it",
- "It was fine most of the time except sleeping",
- "I didn't really notice it",
- "It was uncomfortable to sleep and it moved around too much when I was walking".

Responses to the convenience of wearing accelerometers in the four lifestyle domains were categorised as "Burden" or "Acceptable". Convenience data are presented in Table III, with participant comments in Table IV.

Sleeping was the domain of greatest burden (66.7%). Sleep burden responses were 100% due to discomfort. Day to day was the domain of lowest burden (31.1%), whilst social settings were burdensome for 45.2% of participants. Participants who reported burden in social and day to day had lower BMI and BF% than those with acceptable responses for these domains (Table III). In the social domain, all burden responses referenced clothing and related to the accelerometer protruding or showing through clothing, causing discomfort or embarrassment

Table II. Breakdown of missing accelerometer data ($n = 22$).

Reason for missing data	n
Participant non-compliance (did not wear accelerometer at all)	7
Accelerometer hardware failure	2
Accelerometer lost	13
Posted but not received	3 (Pacific = 1, NZE = 2)
Given to someone else to return	2 (Māori = 1, Pacific = 1)
Simply lost	8 (Māori = 2, Pacific = 5, NZE = 1)

Note: NZE: New Zealand European.

Table III. Interview convenience responses.

Domain	Response categories	n	Valid data[a] (%)	Rating[b]	Age (y)	BMI (kg/m^2)	BF% (%)
Day to day ($n = 45$)	Burden	14	21.4%	3.1	24.7 (5.7)*	26.1 (7.9)*	32.3 (9.5)*
	Acceptable	31	58.1%	3.5	31.8 (9.5)	32.1 (9.0)	37.9 (9.8)
Social ($n = 42$)	Burden	19	47.4%	3.0	27.3 (9.4)	27.1 (6.5)*	32.0 (7.6)*
	Acceptable	23	52.2%	3.7	31.6 (9.0)	32.7 (9.6)	39.6 (9.1)
Sport ($n = 40$)	Burden	15	53.3%	3.0	31.2 (7.5)	32.8 (9.9)	38.6 (10.2)
	Acceptable	25	52.0%	3.5	29.6 (10.2)	29.3 (7.8)	35.4 (8.5)
Sleep ($n = 45$)	Burden	30	36.7%	2.2	28.1 (8.8)	29.8 (9.1)	36.0 (10.2)
	Acceptable	15	66.7%	3.5	32.7 (9.0)	31.0 (9.3)	36.4 (9.7)

Notes: Variance in number of responses in each domain occurred as some participants did not engage in the domain during the 7 days. Mean value (s).

[a]Valid data indicate the percentage of participants within each Burden and Acceptable category who returned valid data (≥10 h/day for ≥4 days).

[b]Rating column is the mean rating for each domain and is on a scale of 1 (worst) – 4 (best).

*Significantly different to Acceptable within domain $p < .05$.

Table IV. Participant comments regarding convenience of accelerometer-wear in each lifestyle domain.

Domain	Participant comments
Day to day	"OK because there was a good reason for it. There was a meaning to it."
	"Fine, other than being uncomfortable."
	"Remembering was a pain at first but no big deal otherwise."
Social	"Didn't sit well with nice clothes. It was best with jeans."
	"It was fine but I had to think about what clothes to wear cos it stuck out and showed with some."
	"Was uncomfortable and showed through clothes. Going out was worst."
	"Couldn't wear some clothes cos lots of them it showed and looked dumb."
Sport	"It moved a lot when I did exercise and was uncomfortable cos of my tummy shape."
	"Felt less weird, kind of like it felt more sporty."
	"OK but it rode up sometimes."
Sleep	"I mostly sleep on that side so was really uncomfortable and annoying."
	"Sleeping was the most uncomfortable. It dug in and got in the way."
	"Terrible! I stopped wearing it to bed in the end."
	"Sleeping was really bad, it was really annoying and uncomfortable."

(Table IV). Some participants found wearing the accelerometer acceptable in almost all domains; common responses were:

- "It was fine",
- "It was no worries".

Discussion

Women's experiences of wearing hip-worn accelerometers were examined to identify possible barriers to compliance and acceptability of their use in PA research. Few data were available regarding factors influencing the acceptability of hip-worn accelerometers over extended periods. A number of issues were identified that might influence accelerometer-wear-compliance and acceptability, and may have contributed to accelerometer losses or non-wear. Comfort, convenience and demographic differences (particularly ethnicity) were identified as the most likely contributors to participant burden and non-compliance in this study.

Rates of compliance in accelerometer-based studies are often reported, but less data are published on attrition (i.e. unreturned accelerometers due to loss during data collection, uncontactable participants, loss to follow-up). Attrition in the current study (3.2%) was substantially lower than was reported in Swedish adults (6.9%) (Hagströmer et al., 2007), although higher than in a large ongoing study of older American women (2.1%) (Lee & Shiroma, 2014). Overall, no consistent patterns were identified as to how or why accelerometers were lost in the present study. Whether or not losses would have been reduced with face-to-face collection rather than postal return of devices is debatable. Well-structured postal returns are recommended as an effective alternative to face-to-face collection (Trost et al., 2005) and is the method employed in many large-scale studies (Hagströmer et al., 2007; Lee & Shiroma, 2014; Troiano et al., 2008). Even when collection of outstanding devices was arranged, some were never recovered despite numerous attempts to do so. Following failed collection, some participants became unresponsive (unanswered phone calls, emails, messages) whilst others subsequently admitted losing the device. Replacement cost of lost devices, although a large financial burden on projects, is secondary to the unrecoverable data lost along with devices. Therefore, minimising attrition is important in maximising data collection.

Wear-compliance in the present study resulted in valid data (86%) being relatively high compared to some large studies (40–94%) (Hagströmer et al., 2007; Roth & Mindell, 2013; Troiano et al., 2008). The observed level of valid data may be attributable to the 24-h wear protocol employed in the present study, designed to capture both PA data and some aspects of sleep. Daily waking wear-time (13.7 ± 0.3 h) was comparable to that reported in other NZ adults (14.1 ± 1.2 h) (Cerin et al., 2014) and young American women (14.6 ± 1.0 h) (Green et al., 2014) when devices were worn only during waking hours. Wearing the accelerometer at all times, rather than during waking hours only, may have reduced incidents of participants forgetting to replace the device each morning. Indeed, in protocols instructing removal for sleeping, participants reported difficulty remembering to replace devices each morning (Pollard & Guell, 2012; Troiano et al., 2014). Huberty et al. (2015) also concluded that 24-h wear protocols likely reduced reliance on participant memory to replace devices after sleeping. Furthermore, in a waking wear protocol, discrepancies between participants' documented sleep/wake times and wear-times evident from accelerometry indicated accelerometers were not always replaced immediately upon waking (Pollard & Guell, 2012). Overcoming reliance on participants' memory to replace devices each morning meant waking wear data collection commenced immediately after participants woke each morning. However, the burden of discomfort during sleeping was highlighted by many participants and must be considered (discussed further below). Arguably, greater wear-time may have occurred if devices were not removed for water activities. Almost half of participants in the present study reported sometimes forgetting to replace the device after showering and some removed the device for prolonged periods while at the beach. Others (Huberty et al., 2015; Perry et al., 2010) have similarly reported that forgetting to replace accelerometers after removal for water activities may have affected wear-time. Although the wGT3X + is waterproof (Actigraph LLC, 2016), if worn during water activities, the elastic belt would become wet and need replacing with a dry belt or risk greater discomfort, thereby increasing participant burden and likely reducing compliance. Despite high ratings of discomfort and inconvenience in the present study, wear-time was comparable to previous reports (Cerin et al., 2014; Green et al., 2014). Similarly, when accelerometers were trialled at different body locations, variations in location preference and levels of acceptability did not significantly affect compliance (Berendsen et al., 2014).

Differences in demographic and lifestyle characteristics have been reported between participants with and without valid data (Loprinzi et al., 2013; Roth & Mindell, 2013). Lifestyle data were not collected in the current study; however, some demographic differences were identified. Accelerometer losses were substantially higher among Pacific women than others. Furthermore, women with valid data were older and more likely to be NZ European than those with insufficient data. Māori and NZ European compliance could not be compared with previous research due to a paucity of existing data, however, Pacific women's compliance (73%) was higher than in another NZ Pacific women's study (68%) (Oliver, Schluter, Paterson, Kolt, & Schofield, 2009). Cultural lifestyles and values reportedly influence how Pacific peoples view health care and status (Ministry of Health, 2012). The social and cultural contexts of health and Pacific peoples' sometimes limited understanding of the benefits of a physically active lifestyle (Ministry of Health, 2012) may have contributed to higher attrition and non-compliance among Pacific women. Similar limitations in health literacy and lifestyle understanding have also been reported in migrant and indigenous populations. Although no differences in comfort and convenience were evident between the ethnic groups, different preferences for accelerometer placement have been reported according to ethnic and/or cultural background. South Asian Muslim women living in the United Kingdom rated hip-worn Actigraph GT3X accelerometers more favourably than the upper arm placement of Sensewear Armbands (Pollard & Guell, 2012). Conversely, American Caucasian women preferred Armbands over the GT3X (Huberty et al., 2015). In both studies, clothing influenced placement preference, although interestingly, the specific issues differed between the groups (Huberty et al., 2015; Pollard & Guell, 2012). Whereas the Muslim women were embarrassed by the upper arm placement of the Armband, finding it uncomfortable under traditional tight-sleeved tops (Pollard & Guell, 2012), American women were satisfied by the Armband's easy concealment under clothing (Huberty et al., 2015). In agreement with the present study, the American women regarded the hip placement of the GT3X as annoying, embarrassing and uncomfortable (Huberty et al., 2015). Such distinct cultural preferences highlight the need for population-specific investigations to better understand the PA habits of different groups, along with the cultural and lifestyle factors contributing to participant non-compliance.

Sleep was clearly the most burdensome domain in the present study due to the discomfort of accelerometer-wear during sleep. Over three-quarters of respondents reported some degree of discomfort wearing the accelerometer whilst sleeping. Participants' comments ranged from the accelerometer being "a bit of a nuisance at first" to "so bad I couldn't sleep with it". In contrast, American women assessing accelerometer acceptability during sleep, rated devices acceptably and similarly whether worn on the wrist or upper arm (Huberty et al., 2015). Importantly though, no other known studies have assessed hip-worn accelerometers for acceptability during sleep. It is difficult to determine to what extent dissatisfaction from wearing the accelerometer whilst sleeping influenced compliance, since compliance was higher in the current study than in some other studies (Cerin et al., 2014; Hagströmer et al., 2007). In another 24-h wear protocol using Actigraph GT3X's, the devices were worn on the hip during waking hours and then transferred to a wrist strap for sleeping (Huberty et al., 2015). This protocol also had low participant acceptability, however, dissatisfaction related to the additional burden of swapping straps, rather than overall discomfort, as in the present study.

Previous research in women examining accelerometer-wear acceptability at different body locations identified comfort, convenience and appearance as barriers to compliance (Berendsen et al., 2014; Huberty et al., 2015). In the present study, all burden from accelerometer-wear in social settings related to clothing, as participants were embarrassed by the visibility of accelerometers through clothing. Consequently, devices were either not worn or clothing choices became restricted, requiring careful consideration in order to minimise embarrassment. Interestingly, women regarding social and day to day accelerometer-wear as burdensome had lower BMI and BF% than those regarding these domains as acceptable. Although no supporting evidence could be found, it could be speculated that the burden for these women in day to day and social settings might result from hip-worn accelerometers being more apparent on their slimmer body, especially if tight-fitting clothing was worn. Women wearing devices at other body locations (e.g. thigh, upper arm, wrist) also reported concerns over clothing, appearance and embarrassment (Berendsen et al., 2014; Huberty et al., 2015; Pollard & Guell, 2012). In line with current findings, these women also reported high levels of burden and unacceptability, largely due to discomfort and visibility of devices through clothing. An alternative to hip-wear is wrist-worn accelerometers. Traditionally used for sleep assessment, more recent devices and newly developed algorithms have enabled the use of wrist-worn accelerometers for assessing PA. In an investigation of accelerometers worn at different body locations, wrist-worn GENEActiv devices were rated with low acceptability due to appearance and difficulty in hiding the device (Huberty et al., 2015). However, the US National Health and Nutrition Examination Survey adopted wrist placement of devices in 2011–2012, with improved compliance over previously used hip-worn devices (Troiano et al., 2014). Although accelerometer size has reduced markedly in recent years (Chen & Bassett, 2005), most research-quality devices are likely visible and unacceptable to some extent, regardless of wear location. Until research-quality movement-sensing devices are slimlined and/or stylish, compliance or at least wearer acceptability will likely remain suboptimal for free-living individuals. Since compliance is critical to accurate quantification of PA behaviours (Trost et al., 2005), minimising participant burden regarding comfort, convenience and acceptability is vital to obtaining good-quality objective PA data.

With only 52% of the sub-sample contactable for the interview, participants' experiences of accelerometer-wear have limited generalisability. However, since very few published studies report accelerometer-wear comfort and acceptability, the current findings provide valuable insight and may lead to improved accelerometry protocols and wear-compliance in future studies. Importantly, all data regarding compliance and attrition relate to the entire study population ($n = 406$), providing strength to these findings. Although participants were reminded on Day 6 to return their accelerometer, additional communication may have encouraged compliance, especially in those who were compliant only initially (Matthews et al., 2012; Perry et al., 2010). Furthermore, compensation (supermarket and petrol vouchers) was given to participants at the time of fitting their accelerometer. Withholding vouchers until the accelerometer and sufficient data were returned might have encouraged compliance and accelerometer return. Such strategies are recommended by others to promote compliance (Sirard & Slater, 2009; Trost et al., 2005). The 24-h wear protocol may have affected compliance both positively and negatively. Although the burden of discomfort whilst sleeping seemed not to adversely affect compliance, wear-time may have been even higher if devices were more comfortable for sleep-wear. Dissatisfaction and non-wear caused by sleep-wear discomfort may have negated potential increases in wear-time gained when participant memory was not relied upon to replace devices after sleeping. Accordingly, the benefits and additional data gained from wear during sleeping should be carefully considered in future protocols.

Conclusions

Accelerometer-wear-compliance during a PA assessment in women of three different ethnicities was examined. Barriers to wearer acceptability and compliance to the hip-worn accelerometry protocol were identified through a semi-structured telephone interview. Although no single factor was identified as the sole determinant of compliance, a number of possible contributors emerged. Arguably the biggest contributors to non-compliance were discomfort (mainly during sleeping) and embarrassment (related to clothing in social settings) caused by accelerometer size and placement. Future protocols should consider the burden of discomfort whilst sleeping, maintaining a balance between participant burden and acquisition of the desired data, ensuring neither compliance nor data quality are unnecessarily compromised. Despite advancing technology, the GT3X+ and other research-quality accelerometers remain relatively large and conspicuous. If devices were more comfortable, and smaller and less conspicuous, or stylish and socially acceptable (e.g. Fitbit™), then wear-compliance in PA research might increase. Pacific women recorded higher attrition and lower compliance than other women; factors possibly attributable to the known limited understanding of health and healthy lifestyle factors (e.g. physical activity) of some Pacific women (Ministry of Health, 2003, 2012). Furthermore, the vital role of many women in the family is often prioritised ahead of their own health and well-being, and possibly also the priority given to a study of this nature (Koloto & Sharma, 2006; Schluter, Oliver, & Paterson, 2011). Increasing participants' understanding of the importance of both the study and the lifestyle factors being examined might improve engagement, and consequently encourage adherence to accelerometry protocols.

This study highlights key issues around the overall compliance of participants regarding accelerometer-wear. These issues must be appropriately addressed in order to improve wear-compliance and collection of high-quality accelerometry data, particularly from women of different ethnicities. With non-compliance largely focused on discomfort, embarrassment and device visibility, encouraging designers and engineers to improve these aspects in future accelerometer design may reduce participant burden and increase compliance. Careful considerations of the pitfalls regarding comfort and wearer acceptability, and ensuring appropriate understanding of study aims and relevance should encourage participant engagement even further, thereby improving compliance and subsequent data quality. Responding to the issues identified in this study may guide future protocols and study designs across all populations, improving the efficacy and participant acceptability of PA research using hip-worn accelerometers.

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