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**Comparability and feasibility of wrist- and hip-worn accelerometers in free-living adolescents**

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**Abstract**

*Objective:* To determine the comparability and feasibility of wrist- and hip-worn accelerometers among free-living adolescents.

*Design:* 89 adolescents (age = 13-14y old) from eight secondary schools in New South Wales (NSW), Australia wore wrist-worn GENEActiv and hip-worn ActiGraph (GT3X+) accelerometers simultaneously for seven days and completed an accelerometry behavior questionnaire.

*Methods:* Bivariate correlations between the wrist- and hip-worn out-put were used to determine concurrent validity. Paired samples t-test were used to compare minutes per day in moderate-to-vigorous physical activity (MVPA). Group means and paired sample t-tests were used to analyse participants' perceptions of the wrist- and hip-worn monitoring protocols to assist with determining the feasibility.

*Results:* Wrist-worn accelerometry compared favorably with the hip-worn in average activity ($r = 0.88$, $p < .001$) and MVPA ($r = 0.84$ $p < .001$, mean difference = 3.54 mins/day, SD = 12.37). The wrist-worn accelerometer had 50% fewer non-valid days (75 days, 12%) than the hip-worn accelerometer ($n = 152$, 24.4%). Participants reported they liked to wear the device on the wrist ($p < 0.01$), and that it was less uncomfortable (p =0.02) and less embarrassing to wear on the wrist (p <0.01). Furthermore, that they would be more willing to wear the device again on the wrist over the hip (p <0.01).

Conclusions: Our findings reveal there is a strong linear relationship between wrist- and hip-worn accelerometer out-put among adolescents in free-living conditions. Adolescent compliance was significantly higher with wrist placement, with participants reporting that it was more comfortable and less embarrassing to wear on the wrist.

**Key words:** ActiGraph, GENEActiv, Physical Activity, Compliance, Perceptions, Youth.

## 1. Introduction

Poor adherence to accelerometer monitoring protocols and subsequent missing data are major issues for researchers [1-3]. Low compliance reduces the sample size and subsequent statistical power, while high compliance is desirable because it provides a more accurate representation of habitual activity patterns [4]. Adolescents, in particular, have been a challenging population to measure with accelerometers [5, 6]. Reasons for poor compliance among adolescents include: dissatisfaction with the size and comfort of devices [6]; unwanted attention and increased risk of being bullied [1]; and feelings of embarrassment [6, 7]. Various strategies have been employed by researchers to increase compliance to accelerometer monitoring protocols, including: i) increasing the amount of researcher contact [8], ii) calls and SMS reminders [9], iii) activity logs [10], iv) gifts and cash incentives [1]. However, even with these strategies, compliance to accelerometer monitoring protocols among adolescents is poor, especially in longitudinal and experimental studies that require individuals to wear devices on multiple occasions [11, 12].

There is clearly an urgent need to reconsider accelerometer-monitoring protocols with adolescent populations. While the ActiGraph accelerometer is the most commonly used validated accelerometer in physical activity research [2], it is typically worn on the hip rather than the wrist and removed whilst sleeping, resulting in non-wear time prior to sleep time and after waking [13]. ActiGraph recently released the GT9X accelerometer which is designed to be worn at the wrist, which reflects a recent shift toward wrist-worn activity monitoring. Emerging research suggests that participants consider wrist worn devices to be less burdensome, resulting in higher levels of compliance [14, 15]. Notably, the National Health and Nutrition Examination Survey (NHANES) 2011–2012 revealed wear time was 100% greater for wrist-worn accelerometers in comparison to the previous years, when monitors were worn on the hip [16]. Such findings highlight the potential for using wrist-worn accelerometry increase participant's compliance to protocols.

In recent years, there has been a proliferation in the number of commercially available accelerometers designed for both hip and wrist placement (e.g. Fitbit, Smartband, iFit Active, Archos Activity Tracker, Atlas, Vivofit etc.). While this has helped to reduce the cost of accelerometers and increase their use in large-scale research, it has introduced new challenges in the interpretation and comparability of accelerometer outputs [17]. The GENEActiv is a relatively new accelerometer, and laboratory studies using calibration with oxygen consumption, have shown that this wrist-worn device can accurately assess children's and adults' physical activity intensity [18, 19]. Moreover, a recent field-based study [3] compared the wrist-worn GENEActiv and the hip-worn Actigraph GT3X+ monitors in children and found higher compliance for the wrist-worn device, regardless of the wear-time criteria applied. In terms of concurrent validity, the authors reported a strong positive association between output from the two accelerometers (MVPA, $r$ =0.83, $p$ <0.001).

To the authors' knowledge, no previous study has examined the acceptability and comparability of hip- and wrist-worn accelerometers among adolescents in free-living conditions. Therefore, the primary aim of this study was to test the comparability and feasibility of wrist- and hip-worn accelerometers in a sample of free-living adolescents. A secondary aim was to compare wear-time, missing data and participant perceptions of the wrist and hip device placement in this population. Improving our understanding of adolescents' perceptions of the monitoring process is vitally important, and will help guide researchers to improve the accuracy of assessment in a sub-population who have been largely neglected in physical activity research.

## 2. Methods

Data for the current study were collected during baseline assessments as part of the existing Switch-off 4 Healthy Minds' (S4HM) cluster randomised controlled trial [20]. S4HM was a recreational screen-time reduction intervention targeting male and female adolescents in Grade 7 (first year of secondary school) in eight independent schools in NSW, Australia (2014). Ethics approval for the study was obtained from the Human Research Ethics Committees of the University of Newcastle, Newcastle-Maitland Catholic Schools Office and the Diocese of Broken Bay. All students in grade 7 were invited to be involved in the study and were considered eligible to participate in the S4HM study if they self-reported ≥2 hrs/day of recreational screen time per day. Students who satisfied the eligibility criteria and provided signed written informed parental consent, were invited to participate in the study. Of the 322 eligible participants, every third student from each school (n=113) was randomly selected and invited to participant in this study component. Data were collected in New South Wales (NSW), Australia in April/May 2014 (Term 2 of the school year). Participants were asked to wear both wrist- and hip-worn accelerometers simultaneously for seven full days and complete an accelerometry behaviour questionnaire that was designed for the purpose of this study.

Participants wore the Gravity Estimator of Normal Everyday Activity (GENEActiv), seismic acceleration sensor, dynamic range +/- 8g, ActivInsights, Cambridgeshire, UK) on their non-dominant wrist. Using the GENEA software (version 2.2), the devices were initialized to collect tri-axial acceleration data at a sample rate of 100 Hz. Participants also wore the ActiGraph GT3X+ (monolithic differential capacitance sensor, dynamic range +/- 6g, ActiGraph LLC, Pensacola, FL, USA) on the non-dominant hip. Using the Actilife5 (version 6.5.3) software the ActiGraph GT3X+ devices were initialized to collect tri-axial acceleration data at a sample rate of 80 Hz. This study used different sampling frequencies for each monitoring device, however due to the nature of the signal processing (summarising output over 15 s epochs) this difference in sampling frequency would not have impacted on the output [21]. The accelerometry behavior questionnaire was based on a previous pedometer questionnaire designed to examine participants' perceptions of the objective monitoring process [6]. The questionnaire consisted of eight questions, each scored on a 5-point Likert- scale. The questions explored students' perceptions of wearing accelerometers with responses ranging from 1 = *strongly disagree* to 5 = *strongly agree*. The wording of the items was derived from a previous pedometer questionnaires designed for adolescents. They were then reviewed by academics that have an expertise in physical activity interventions for input and feedback. The questionnaire was administered on the last day of the monitoring phase. Responses from the accelerometry behavior questionnaire were used to provide insights into participants' perceptions of the monitoring process and to compare feasibility of the wrist- and the hip-worn devices among adolescents in free-living conditions.

The monitoring process was a total of nine days from dispersal to collection of the monitors, the first and last day were excluded from the analysis as they were only partial monitoring days, leaving 7-days. This study used a 24hour/day wear-time accelerometer protocol, compliance has been shown to be higher with 24 h/day protocols for both wrist-worn [22] and hip-worn monitors [23]. Both accelerometers were time and date synchronised using the same clock to start recording at 00:01am on Day 1 and finish recording at 11:59pm on Day 9. On completion of the monitoring period, participants returned both accelerometers and completed the accelerometry behavior questionnaire. The GENEActiv data were downloaded with GENEActiv software (version 2.2). R-package GGIR version 1.2-2 (http://cran.r-project.org) and was used to process and analyse GENEActiv .bin files (This includes auto-calibration using local gravity as a reference) [24, 25]. The software was used to detect abnormally high values and non-wear time, and to calculate the average magnitude of dynamic acceleration (Euclidean Norm minus 1 g, ENMO) over 15-seconds epochs, with negative values rounded up to zero.

$$\text{ENMO} = \sum \sqrt{x^2 + y^2 + z^2} - g$$

The cut-points applied to calculate MVPA based on ENMO values were taken from a recent study by Phillips et al[18] and adjusted for the 100 Hz sampling frequency and 15-second epochs. The adjusted ENMO value used in the current study was ≥20gs. Individual days were classed as invalid and excluded if wear-time was less than 10h. The detection of non-wear followed the procedures of Van Hees and colleagues [26]. Non-wear was estimated using the standard deviation (SD) and value range of each axis, calculated for 60 minute windows with 15 minute moving increments. If the SD on two of the three axes was less than 13mg or the value range was less than 50mg, the time window was classified as non-wear. In this study, there was no reclassification activity or imputation of missing data for the GENEActiv data, nor the GT3X+ data. Mean daily activity (ENMO, m*g*) and MVPA were the output variables used in the analysis.

The hip-worn Actigraph GT3X+ data were downloaded with the Actilife5 (version 6.5.3) software. The GT3X files were converted to 15s epoch AGD files for analysis of count data. The data were cleaned and scored using Actilife5 software (version 6.5.3). Non-wear was defined as ≥20 minutes of consecutive zero counts [27]. To remain consistent with previous studies, the wear-time criteria for both monitoring devices was ≥10hours/day on ≥3 days/week. Any participants that did not meet the minimum wear-time criteria were excluded from the analysis [2]. MVPA was estimated by applying the commonly used adolescent Evenson cut-points to the vertical count data (i.e. ≥2296 CPM)[28]. Mean daily activity (average daily vector magnitude counts (VM, cpm) and daily MVPA (mins/day) were the output measures used in analysis.

The mean daily activity and MVPA (mins/day) data, along with responses to the accelerometry behavior questionnaire were imported and analyzed using IBM Statistics (SPSS 12 Inc. Chicago, IL) software and alpha levels set at $p < 0.05$. The data for the GT3X+ and GENEActiv were matched on concurrent valid whole days where participants were wearing both devices at the same time (at least three valid week days of wear-time at ≥10hrs/day on both wrist- and hip-worn accelerometer). A more sensitive approach such as epoch matching may have allowed a more accurate assessment of concurrent validity, however this approach may lack ecological validity. Pearson bivariate correlations between the wrist- and hip- (daily mean physical activity and daily MVPA) accelerometer output were calculated to examine the relationship of the wrist- and hip-worn accelerometer data over the monitoring period. Paired samples t-tests were used to explore individual difference in MVPA mins/day for week and weekend days. Frequency analysis was used to reveal the amount of days that participants did not wear either device; or wore one device and not the other. Responses to the accelerometry behavior questionnaire were coded and imported into SPSS to be analyzed quantitatively. Analysis of group means and paired sample t-tests were used to analyze the differences in participants' perceptions of the monitoring process.

## 3. Results

A total of 113 participants were involved in the monitoring process, of which 89 (41 boys, 48 females) met the inclusion criteria (at least three valid week days of wear-time at ≥10hrs/day on both wrist- and hip-worn accelerometer) and were included in the concurrent validity analysis. If the participant wore only once device and not the other, this day was removed and excluded from the analysis and treated as missing data (n = 132 days removed, 21.18%). Only 57 participants provided both wrist and hip accelerometry data for weekend days. Due to one participant being absent at the time of questionnaire completion, 112 participants completed the accelerometry behavior questionnaire. The questionnaire responses were only included in the analysis if the participant had met the accelerometry inclusion criteria, the remaining (n=23) were excluded.

Pearson bivariate correlations (shown in Table 1) revealed strong associations between the wrist- and hip-worn output in both daily mean activity ($r = 0.88$, $p < .001$, 95% CI =0.82-0.93) and MVPA ($r = 0.84$, $p < .001$, 95% CI =0.77-0.89) over the 7 days. When analyzing the weekdays only, the correlations were strong but slightly lower in both daily mean activity ($r = 0.84$, $p < .001$, 95% CI =0.76-0.89) and MVPA ($r = 0.79$, $p < .001$, 95% CI =0.72-0.85). Furthermore, weekend days only, whilst lower again, there was moderate association for daily mean activity ($r = 0.71$, $p < .001$, 95% CI =0.56-0.82) and MVPA ($r = 0.53$, $p < .001$, 95% CI =0.37-0.71). Paired samples t-tests (shown in Table 2) revealed a low mean MVPA difference between the wrist and hip output on both weekdays (mean difference =3.54 mins/day, $p = 0.01$) and weekend days (mean difference =1.57 mins/day, $p = 0.63$). Tests for proportional bias indicated that there was a correlation between mean physical activity and the difference in estimates for acceleration ($r = 0.18$, $p > 0.05$) and MPVA ($r = 0.46$, $p < 0.05$).

Participant compliance to the monitoring protocols ranged from 3-7 days and is presented in Table 3. Overall the hip-worn accelerometer (152 days, 24.4%) had twice as many non-valid (missing) days than the wrist-worn accelerometer (75 days, 12%). In boys, there was minor difference in compliance between wrist and hip (wrist =43 days, hip =56 days), whereas for girls; there were three times as many non-valid days for the hip-worn accelerometer (n =96), compared to the wrist-worn accelerometer (n =32). Paired samples t-tests of non-valid (missing) days revealed that the mean difference between wrist- and hip-worn data was 11days (SD =10.6, p =0.03), for weekdays only (mean difference =5.4, SD =4.5, p >0.05) and weekend days only (mean difference =25, SD =7.1, p >0.05). Analysis of the excluded data due to participants only wearing one device revealed that participants were three times more likely to wear the wrist-worn accelerometer (n =33 missing days) than only wear the hip-worn accelerometer (n =99 missing days).

Participants reported a preference for the wrist-worn accelerometer (mean= 3.18, SD= 0.10), compared to the hip-worn accelerometer (mean= 2.51, SD= 1.01). Participants reported wearing the device on the wrist to be less uncomfortable and less embarrassing (mean= 1.93, SD= 0.10) to wear, compared to the hip-worn accelerometer (mean= 3.35, SD= 1.06; mean= 2.42, SD= 1.20, respectively). Participants reported they would be more willing to wear the wrist-worn accelerometer (mean= 3.65, SD= 1.06) than the hip-worn accelerometer (mean= 2.74, SD= 1.33) in future assessments. Participants, particularly adolescent females, reported the wrist-worn accelerometer to be more comfortable (p =0.03), and less embarrassing (p <0.01), to wear than the waist-worn accelerometer, but there were no other statistical differences between the wear sites based on mean scores for both sexes.

## 4. Discussion

This study investigated the concurrent validity and feasibility of wrist- and hip-worn accelerometers in a free-living adolescent population. We found that the wrist-worn accelerometer output compared favourably with the hip-worn accelerometer output in both mean daily activity and MVPA. In addition, the participants reported that they liked wearing the wrist-worn accelerometer more than the hip-worn accelerometer and would be more willing to wear it again on the wrist over the hip. Furthermore, there was three times as much missing data for the hip-worn accelerometer than that of the wrist-worn accelerometer.

By comparing the wrist-worn (GENEActiv) accelerometer output to the previously validated hip-worn (ActiGraph GT3X+) output under free-living conditions, this study provides an important contribution. Our findings revealed that the physical activity outcomes from the wrist-worn accelerometer were strongly associated with hip-worn accelerometer output for both physical activity patterning (r =0.88, p <.001) and ranking of activity level (r =0.84, p <.001) within the sample, however absolute values differed. In MVPA minutes, there was also a low mean difference (3.54 mins/day weekdays, 1.57 mins/day weekend days) between the devices with the hip-worn accelerometer estimating slightly higher activity on both weekdays and weekend days. A strength of this study was that it reported the mean difference (minutes) between the wrist- and hip-worn accelerometers, which has not previously been done in previous adult and child GENEActiv validation. These findings may have relevance for researchers interested in evaluating physical activity intervention effects, but it is important to note that the results are dependent on the selected cut-points, population group and monitor used. Our results support previous findings reported in children and adults, where the wrist-worn GENEActiv compared well to the hip-worn Actigraph GT3X+ in both acceleration and MVPA [3]. Moreover, the small mean difference between the monitors provides a unique contribution to the literature.

However, our findings differ to the previous findings of GENEActiv studies that concluded that the wrist worn GENEAcitv had higher physical activity estimates than the hip worn Actigraph [3, 21]. Further equivalency studies are required to determine the interchangeability of the devices, application of cut-points and site placement of the accelerometer. To remain consistent with the literature, the application of cut-points was based on previous studies in adolescents that have used Actigraph and GENEActiv accelerometers to quantify activity [28-30]. For the GENEActiv monitor, this study used the Phillips et al [18] left wrist cut-points. Evenson cut-points were applied to the ActiGraph GT3X+ data. As cut-points are developed specifically for each accelerometer monitoring device and are both protocol- and population-specific, direct comparison of devices is very difficult, and further research into the application of different cut-points and the influence on estimates of sedentary, light, moderate and vigorous physical activity is clearly warranted.

A recent study in free-living adult women compared physical activity estimates for both hip and wrist site placements and concluded that there was only moderate correlation between the two sites [31]. A further study in an older adult population compared physical activity estimates for different wear-time protocols and hip and wrist placement with GT3X+ accelerometers. Findings revealed that wear-time adherence for the hip and wrist only varied by 2.7%, however, activity estimates for hip and wrist were statistically different and varied by as much as 41% [32]. These results differed to a study that compared GT3X+ accelerometer activity estimates at both the hip and wrist in pre-school aged children, which found a strong correlation between hip and wrist ($r = 0.81$, $p < 0.01$) accelerometer output. However, but large systematic bias with wide limits of agreement were observed [33]. Differences in accelerometer protocol and data reduction techniques for both hip and wrist accelerometers may explain the current inconsistencies found in the literature. Standardisation of hip and wrist accelerometer protocols are clearly warranted.

A recent study concluded that the GENEActiv can accurately assess physical activity intensities in children when worn at the hip or wrist [18]. Although previous research has also highlighted decoupling differences in hip and wrist accelerations depending on the type of activity and level of intensity in children [34]. This becomes more complex in a free-living conditions when hip and wrist accelerations can be more disproportionate [16]. As the research is currently limited on preference for site placement in adolescents [3, 35], our study compared the wrist and hip placement site in a free-living adolescent population. It was expected that the hip and wrist accelerometer would be subjected to slightly different movements, which would account for some minor degree of error. Of note, correlations were lower on weekend days in comparison to weekdays. This finding may reflect the way that young people spend their weekends. For example, emerging research suggests that children are more active during weekdays, while on weekends they spend large amounts of time sedentary engaged in seated screen-based recreation [3, 16]. It has also been reported in the literature that activity in free-living adolescents is different on weekend days in comparison to weekdays where activity is commonly more routinized and structured [36]. These differences of daily activity patterns may also influence the accuracy of both hip and wrist activity estimates.

Previous research has identified the challenges of assessing physical activity using objective measures in adolescent populations [5, 37, 38]. Studies in children have revealed that compliance is higher when devices are worn on the wrist, in comparison to hip placement [3]. This study was designed to confirm this finding among adolescents in free-living conditions and assess participants' perceptions of the two placement sites. To determine feasibility, adolescents self-reported their perceptions of the two placements sites and the research team compared accelerometer protocol compliance. Compliance to the monitoring protocol was operationalized as whole days that the monitor was worn, rather than periodic removal. Our results revealed twice as much non-valid (full days) for the hip-worn accelerometer (n =152, 24.4%), compared to the wrist-worn accelerometer (75 days, 12%). The boys (wrist =43, hip =56) had fewer total missing days for the wrist-worn accelerometer. In girls, there was three times more missing days on the hip-worn accelerometer than the wrist-worn accelerometer (wrist =32, hip =96). Hence, in both sexes there was less missing data for the wrist-worn accelerometer indicating higher compliance to the 7-day protocol. The results also revealed that participants were three times more likely to wear only the wrist-worn accelerometer.

This study is novel as it used a self-reported questionnaire, to not only investigate participants' preferred accelerometer site placement, but also investigated some of the potential reasons why. Our findings showed that adolescents found the wrist-worn device to be more comfortable and less embarrassing to wear. Interestingly, there were sex differences; girls reported that they found the hip-worn accelerometer more embarrassing to wear than the boys. Previous research has shown that girls have higher dissatisfaction with body image and concerns with body changes than boys [39], which could be a reason for preferring to wear the device on the wrist rather than around their waist. This may be an important finding as adolescent girls are a target population for physical activity interventions due to low activity levels [1, 40].

Both the hip-worn GT3X+ and the wrist-worn GENEActiv devices are robust, waterproof, lightweight and have long battery life. An additional advantage of the GENEActiv is its watch-like appearance. Indeed, the design and appearance of the accelerometer may be a key determinant in increasing adolescent compliance, especially in girls who have previously shown poor adherence to physical activity intervention protocols and reported a dislike to the physical appearance of accelerometers [7, 10]. Wrist-worn GENEActiv accelerometer data correlated with the previously validated hip-worn GT3X+data (mean activity: r =0.88, p <.001; MVPA: r =0.84, p <.001), and also daily compliance was far higher. The participants reported they liked wearing the accelerometer on the wrist more than the hip, and reported a higher willingness to wear it again on the wrist over the hip. This may be an important finding, as previous physical activity intervention research in adolescents have found poorer compliance to accelerometer protocols in post-test and follow-up assessments [10, 12]. As non-compliance to accelerometer protocols is such a complex issue in the adolescent population [1, 2], further investigation into reasons why participants choose to wear one device over the other or simply not comply with protocol is warranted.

To our knowledge, this the first study to examine the concurrent validity and feasibility of wrist- and hip worn accelerometers among adolescents in free-living conditions. Despite the importance of our study findings, some limitations should be noted. First, the sample was relatively small and findings may not be generalizable to the entire adolescent domain. Second, for MVPA, the cut-points used for each device may have affected the classification of intensity of activity. Third, Other than sex, no other participant characteristics were analysed for association with wear time. Forth, this study primarily focused on comparability of hip and wrist accelerometer placement rather than the equivalency of the Actigraph GT3X+ and the GENEActiv; further research using raw accelerometer data is warranted to determine the interchangeability of the two monitoring devices. Finally, the accelerometry behavior questionnaire was not piloted with a group of adolescents prior to data collection and has not been fully validated in adolescents.

## 5. Conclusion

The wrist-worn accelerometer (GENEActiv) showed good concurrent validity when compared to the previously validated hip-worn accelerometer (ActiGraph GT3X+) in both daily mean activity and MVPA. Our findings reveal there is a strong linear relationship between the wrist- and hip-worn accelerometer output and that daily wear-time compliance was far higher for the wrist-worn accelerometer. Overall, adolescents reported a preference for the wrist-worn accelerometer. More specifically, adolescents considered the wrist-worn accelerometer to be more comfortable and less embarrassing to wear and importantly, that they would be more willing to wear it again on the wrist rather than the hip. The use of wrist-worn accelerometry may assist researchers to increase participant compliance to accelerometer protocols in free-living adolescents. The authors recommend further adolescent physical activity studies utilise wrist-worn accelerometry to increase the probability of higher compliance to protocol, as greater wear time will provide a more accurate assessment of habitual physical activity.

**Practical implications**

- In free-living adolescents, the wrist-worn (GENEActiv) accelerometer output compares favourably to the previously validated hip-worn accelerometer output (Actigraph GT3X+) in both daily activity and MVPA.
- Adolescents in free-living conditions reported that they liked wearing accelerometers on the wrist more than the hip, finding it more comfortable and less embarrassing to wear.
- Daily wear-time compliance was far higher for the wrist-worn device with adolescents being twice as likely to wear the device on the wrist rather than the hip.
- Importantly for intervention studies, free-living adolescents reported they would be more willing to wear the accelerometer again on the wrist rather than the hip.

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**Table 1. Relationship between the wrist- and hip-worn accelerometer output**

| | | Wrist vs Hip | |
|---|---|---|---|
| | | Mean acceleration | MVPA |
| | | *(VM vs ENMO mgs)* | *(Minutes)* |
| All days | *r* | .88* | .84* |
| | *p-value* | < .001 | < .001 |
| | *n* | 89 | 89 |
| Weekdays only | *r* | .84* | .79* |
| | *p-value* | < .001 | < .001 |
| | *n* | 89 | 89 |
| Weekend days only | *r* | .71* | .53* |
| | *p-value* | < .001 | < .001 |
| | *n* | 58 | 58 |

**Significant at 0.05*

**Table 2. Paired sample t-tests to explore individual differences in MVPA**

| | Wrist | Hip | | |
|---|---|---|---|---|
| | Mean (SD) | Mean (SD) | Mean difference (SD) | *p*-value |
| Weekday MVPA mins/day (n= 89) | 31.1 (19.2) | 34.6 (19.1) | 3.5 (12.4) | <0.01 |
| Weekend days mins/day (n= 57) | 32.7 (21.5) | 34.3 (27.3) | 1.6 (24.2) | 0.63 |

**Table 3. Comparison of non-valid (missing) days**

| | | | Wrist | | Hip | | |
|---|---|---|---|---|---|---|---|
| | | All | Boys | Girls | All | Boys | Girls |
| | *n* | 89 | 41 | 48 | 89 | 41 | 48 |
| Monday | (Days missing) | 0 | 0 | 0 | 1 | 1 | 0 |
| | *(%)* | 0 | 0 | 0 | 1.12 | 2.4 | 0 |
| Tuesday | (Days missing) | 5 | 3 | 2 | 10 | 2 | 8 |
| | *(%)* | 5.6 | 7.3 | 4.2 | 11.2 | 4.9 | 16.7 |
| Wednesday | (Days missing) | 13 | 7 | 6 | 17 | 7 | 10 |
| | *(%)* | 14.6 | 17.1 | 12.5 | 19.1 | 17.1 | 20.8 |
| Thursday | (Days missing) | 10 | 7 | 3 | 23 | 8 | 15 |
| | *(%)* | 11.2 | 17.1 | 6.3 | 25.8 | 19.5 | 31.3 |
| Friday | (Days missing) | 24 | 12 | 12 | 28 | 11 | 17 |
| | *(%)* | 27.0 | 29.3 | 25.0 | 31.5 | 26.8 | 35.4 |
| Saturday | (Days missing) | 16 | 8 | 8 | 36 | 14 | 22 |
| | *(%)* | 18.0 | 19.5 | 16.6 | 40.4 | 34.2 | 45.8 |
| Sunday | (Days missing) | 7 | 6 | 1 | 37 | 13 | 24 |
| | *(%)* | 7.9 | 14.6 | 2.1 | 41.6 | 31.7 | 50.0 |
| | Total days missing/week | 75 | 43 | 32 | 152 | 56 | 96 |
| | Total missing/week (%) | 12.1 | 6.9 | 5.1 | 24.4 | 9.0 | 15.4 |