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Patterns of Noncompliance in Adolescent Field-Based Accelerometer Research

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***Background*:** The primary purpose of this study was to investigate patterns of noncompliance in an adolescent field based accelerometer study. A further purpose was to investigate the effect of a cost efficient strategy (SMS reminder message) on the compliance of adolescents ***Method*:** The research carried out in 2010 involved 117 second level students (12.41 ± .53 yrs) from 4 schools in a rural Irish town. The Actigraph accelerometer data were processed over 7 days to determine compliance level. ***Results*:** Students were more likely to remove their monitor in the evening period than at any other time, however if students removed their monitor after school it remained unworn for a significantly longer duration than in any other time period. Students who received a SMS message were significantly more likely (P = .008) to wear their monitor in the morning than those that did not. ***Conclusions*:** Sending an SMS message each morning is effective for improving the number of students wearing monitors to school. The after school period is a critical period for nonwear time and should be targeted in future studies wishing to improve compliance.

***Keywords*:** physical activity, day period, compliance, strategies

One of the greatest difficulties in using accelerometers to measure levels of free living physical activity is getting participants to comply with research conditions. Generally in field based accelerometer research, participants are asked to wear the monitor during all waking hours (except while bathing or swimming) across several days.[1] Compliance difficulties arise when participants forget to put the monitor on first thing in the morning, or when they forget to put the monitor on after certain activities. When an accelerometer is not being worn the output will show consecutive zero counts for each epoch for the duration of non wear time. Sirard and Slater[2] reported on the difficulties inherent in the accelerometer data reduction process when the monitor has not been worn for a certain period. Masse et al[1] highlighted the range of criteria researchers have employed when trying to ascertain nonwear periods from 10 minutes of consecutive zeros to 30 minutes. Though 10-minute[3–6] and 20-minute criterions[7–10] are more prevalent in youth accelerometer studies, durations as long as 60 minutes have also been employed in some studies.[11–13] The choice of criterion in a given study will have implications for deciding on whether a participant has met the criteria for minimal wear time, and thereby inclusion of their data set in analysis.

Trost et al[14] discussed several strategies to improve monitor wearing compliance: activity monitoring log, reminder phone call or flyer, information sheets for participants on wearing accelerometers, notifying teachers/parents of the protocol, showing participants non wear output, or providing incentives contingent on compliance (eg, money, gift cards); however, the effectiveness of these strategies in field-based work is unclear, specifically among youth.[15] Among high school aged students (15–18 years), Sirard and Slater[2] examined the effect of different strategies on compliance with wearing accelerometers. Three compliance strategies—1) receiving 3 phone calls over the data collection period, 2) completing a daily journal, and 3) monetary compensation contingent on number of complete days—were compared with a control condition. The authors reported that the monetary compensation strategy resulted in significantly greater compliance than the other conditions examined.

There is a definite need for standardization of criteria for deciding upon nonwear time, and minimal wear time,[1] however as highlighted by Sirard and Slater[2] if researchers can reduce the amount of missing data then less burden will be placed on these factors in the data reduction process. This point was also highlighted by Rowlands et al,[15] who noted that if participants do not wear the monitors consistently during the measurement period then questions relating to epoch length, data reduction processes or intensity cut points are of little consequence. The purpose of this research was to investigate whether there were patterns of noncompliance within the data, and to build upon the work of Sirard and Slater[2] by carrying out an investigation into the effect of a cost efficient SMS strategy on the compliance of adolescents in field based accelerometer research.

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Methods

Participants

A convenience sample of 134 first year students from all 4 second level schools in a rural Irish town were invited to participate in this study. Students were invited to participate in the study by way of an information leaflet and an informed consent form which was distributed to parents/guardians through the school PE teacher. A total of 117 students assented (with parents consent) to participate in the study. This compliance study was part of a larger study measuring the physical activity levels of students in these schools. As such the purpose of the overall study was communicated to the students (measuring physical activity levels of youth), but we did not risk influencing students' compliance by telling them the further purpose of the study which is being presented in this paper. This study was approved by the Dublin City University Research Ethics Committee.

Design

As part of the study protocol, an investigator checked in school each morning between 9:00 AM and 10:00 AM to ensure participants were wearing monitors correctly. In the event that a child forgot to wear his/her device, their parents/guardians were contacted to drop in the device within the first 2 hours of school. The compliance strategy employed was to send an SMS reminder message before 8 AM each weekday morning (9.30 AM on weekend days). Due to ethical restrictions students self selected whether to provide their mobile number to receive the reminder SMS strategy. Subsequently, 67.5% participants consented to provide their mobile number leaving 32.5% participants acting as a control group.

Measures

Actigraph GT1M and GT3X accelerometers were used to determine periods of the day when the monitor was worn and when it was not. Both devices have similar dimensions (3.8cm × 3.7cm × 1.8cm) and are capable of producing comparable activity counts for the vertical axis.[16] As such, only activity counts from the vertical axis were used in the study. Detailed specifications of the hardware and a full description of how the monitor acquires and filters data are available from the manufacturers website (www.theactigraph.com).

Procedures

All data were collected during a 4-week period from September to October 2010. Accelerometers were distributed to students in their PE classes following a strict overview and protocol. In line with other studies,[17,18] students were instructed to wear the monitors above the iliac crest of the right hip with an elastic belt and adjustable buckle. The same research investigator led the distribution and explanation process throughout the 4 schools, 5 research assistants were also present at each school to assist in showing students how to attach the monitor and adjust the elastic waist band to ensure a snug fit. Monitors were collected from the students on the morning of the final day of monitoring.

Data Reduction

Data in relation to accelerometer compliance was available for all 117 participants. Due to a malfunction with Actigraph software (Version 4.4.1), data from 52 of the 117 participants failed to download correctly resulting in a remaining sample size of 65 participants with valid accelerometer recorded data. Actigraph data were reduced using a custom software program developed for this study. The first and last days of monitoring were excluded from analysis to allow provision for subject reactivity.[19] The processing was then conducted on participants with data from 7 days.

Consistent with previous studies a valid day was determined as having greater than 600 minutes of wear time.[1,2,12] Strings of 20 consecutive minutes of zero counts were considered to be times when the monitor was not being worn.[19] The Troiano et al[13] model of allowing for short (1 min max) interruptions of small values between 0–100 was employed in the processing of nonwear time. Waking hours in this study were considered to be between 8 AM and 10 PM (ie, a string of zero counts was only categorized as noncompliance if it occurred during this period). Nonwear time each day was calculated as the number of minutes of nonwear events recorded between 8 AM and 10 PM. Once data had been processed through the inclusion criteria detailed above, the number of 'valid' days of data each participant had recorded was calculated.

Statistical Analysis

Preliminary statistics were conducted between the 4 schools to identify if potential differences in age and nonwear time occurred. A chi-square test for independence identified if percentage differences in the number of days meeting the minimum wear requirement existed across schools. A one-way between-groups ANOVA was conducted to explore the impact of both age and non wear time in the morning across the 4 schools. An independent sample t test was conducted to compare differences in overall non wear time per day between those who wore their device in the morning and those who forgot.[1]

Time of day was broken down into 4-day periods: morning (8 AM to noon), afternoon (noon to 4 PM), after school (4 PM to 6 PM), and evening (6 PM to 10 PM). Because 3 of the day periods were 4 hours in duration with the after school period being just 2 hours, data were standardized by computing a new variable to illustrate average nonwear time per hour for each of the 4 time periods. Descriptive statistics were calculated from the data. Based on the receipt of SMS or nonreceipt of SMS, independent sample t tests were used to investigate 1) differences in percentage of days wearing monitor to school,

Table 1 School and Participant Characteristics of Irish Adolescents in 2010 Including Compliance Strategies (n = 117)

n	Age [mean (SD)]	No SMS	SMS
Full cohort 117 (64 male)	12.41 (.51)	38 (32%)	79 (68%)
Reduced cohort 65 (43 male)	12.41 (.53)	20 (31%)	45 (69%)

and 2) minutes of nonwear time overall, on weekdays/weekend days, and in each of the 4-day periods. A 2 (gender) × 4 (day period) ANOVA was used to investigate the effect of gender and day period on hourly minutes of non wear time. A two-way between groups ANOVA was conducted to explore the impact of gender and removal of monitor during a particular day period on non wear time per hour. The alpha level for analysis was set at $P < .05$.

Results

The mean age of the participants was 12.41 (±.51) years with no significant differences across the 4 schools [$F(3, 113) = 1.144$, $P > .05$]. Using a Chi-square test for independence, no significant association was found between school attended and the number of days meeting minimum wear requirement ($\chi^2 = 19.745$, $P > .05$). There was no statistically significant difference in morning non wear time for the 4 schools [$F(3, 41) = 0.143$, $P > .05$]. On average 9% of participants forgot to wear their monitor to school in the morning. An independent *t* test confirmed that there was no significant differences [$t(43) = -0.679$, $P > .05$] in overall nonwear time per day between those who wore and forgot their devices (see footnote 1). The remaining analysis was carried out with data collapsed across the 4 schools. Participant characteristics are presented in Table 1.

Patterns of Noncompliance

Overall 15.4% of participants met the minimum wear requirement (>600 minutes) on all 7 days, 50.8% met the requirement on 6 days, with 63.1% meeting it on 5 days. While 80% of the sample met the minimum wear requirement on at least 4 days, if 3 weekdays and 1 weekend day was to be taken as a minimum requirement for inclusion in analysis of physical activity levels of this group,[12,13] 70% would meet the requirement. 84.6% of the sample met the minimum requirement of 600 minutes on at least 3 days.

On average participants recorded 240.6 (±225.1) minutes of non wear time per day; 225.3 (±262.4) minutes on a weekday and 285.3 (±368.1) minutes on a weekend day. The difference in nonwear duration on a weekday versus a weekend day was not significant. All participants recorded at least 1 nonwear event (period during waking hours with 20 consecutive minutes of zero counts); on average participants removed their device 9.05 times over 7 days of monitoring (1.29 times per day). Figure 1 displays the percentage of participants with frequency of nonwear events over the 7-day period. The number of times participants removed their monitors within each day period over the 7 days are shown in Table 2, the percentage of participants that removed their monitors during these periods are also shown. Students were twice as likely to remove their monitor in the evening period than at any other time.

Further analysis investigated the average duration of nonwear events per hour during each of the 4-day periods. Results of this analysis are also shown in Table 2. Results of a two-way between groups ANOVA (exploring the impact of gender and removal during a particular day period on non wear time per hour) showed that the interaction effect between day period and gender was not significant. There was a statistically significant main effect for day period [$F(2, 184) = 5.643$, $P = .001$], with a medium effect size (partial eta squared = .084). There was no significant main effect for gender. Post hoc comparisons using the Tukey HSD indicated that the mean hourly minutes for the after school period was significantly higher than the other 3-day periods. If students removed their monitor during the after school time period it would remain removed for 44.1 minutes per hour, compared with 12.7, 11.2, and 14.4 minutes for the morning, afternoon, and evening periods, respectively.

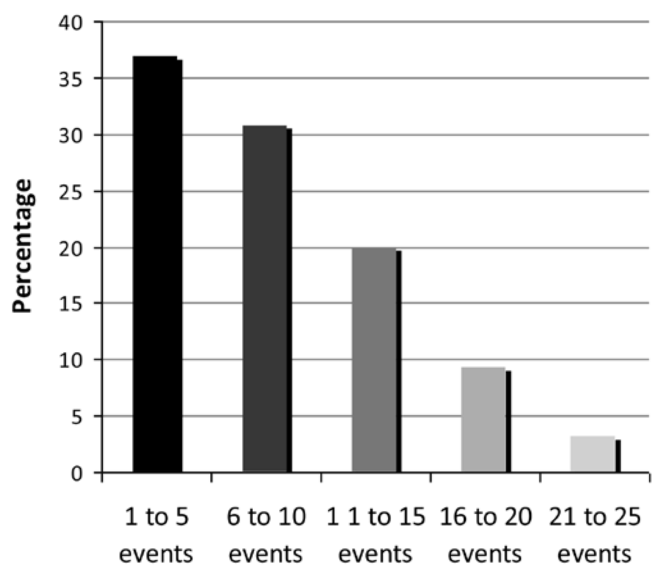

Figure 1 — Percentage of Irish adolescents in 2010 with frequency of nonwear events over 7 days (n = 65).

Table 2 Patterns of Compliance of Irish Adolescents in 2010 Across Day Periods (n = 65)

Day period	Morning	Afternoon	After school	Evening
Number of times monitor removed over 7 days	1.88	1.94	1.65	3.58
% of participants that removed monitor at least once over 7 days	67.7%	63.1%	67.7%	95.4%
Duration of nonwear (mins/hr) if monitor removed	12.7	11.2	44.1	14.4

Impact of Compliance Strategies

Overall, 69% of the participants wore their monitor into school every morning, 23% wore the monitor on 4 mornings, 7% on 3 mornings, and 1% on just 2 mornings. Results of an independent sample *t* test showed that students who received the reminder SMS were significantly more likely ($P = .008$) to wear their monitor in the morning than those that did not receive the SMS.

When the Actigraph data were considered (n = 65) it was found (using a one-way ANOVA) that the number of days students remembered to wear monitor to school in the morning did not significantly influence overall average nonwear time. An independent samples *t* test showed no significant differences in average duration of total nonwear, weekday nonwear, weekend day nonwear, morning nonwear, afternoon nonwear, after school nonwear or evening nonwear based on receipt of the different support strategies.

Discussion

Compliance of participants engaging within this study protocol are in some ways comparable to that reported in other studies carried out with similar age groups. Overall, 84.6% of the sample in the current study met the 600-minute minimum criterion on at least 3 days. This is in line with the findings of Ness at al,[20] who reported 85% compliance, but is slightly lower than that reported by Van Coevering et al,[21] who reported 92%. Troiano et al[13] reported that 71% of their sample provided 4 or more valid days of data—this compares to 80% in the current study. It must be noted however that only 15.4% of the sample in the current study met the minimum wear criterion on all 7 days monitored; this is in contrast to the figures of 50% and 45% reported by Van Coevering et al[21] and Sirard et al[22] respectively. These differences can possibly be explained by a much longer nonwear criteria time employed in the Van Coevering et al[21] study (180 minutes of consecutive zeros), and the older age group sampled in the Sirard et al[22] study (16.7 ± 1.34 years).

It was found in this study that participants were almost twice as likely to remove their monitor in the evening period (between 6 PM and 10 PM) than at any other time. On average, participants removed their monitors 3.58 times in the evening over the 7-day period, and just 1.65 times in the after-school period. The interesting thing however is that while the students removed their monitors less often in the after-school period, if they did remove it they left it removed for a significantly greater period of time (44.1 minutes for each hour) than if they removed it in any of the other 3-day periods. This identifies the after school period as a particularly critical period in terms of compliance reduction.

Sirard and Slater[2] found that providing a monetary incentive contingent on the number of valid days of data a participant recorded, significantly influenced compliance in their cohort of 15- to 18-year-old youth. In the current study, both ethical and monetary restrictions meant that this strategy was not an option. Results from the current study indicate that students who received an SMS reminder message were significantly more likely to remember to wear their monitor first thing in the morning than those that those who did not receive the compliance SMS strategy. Interestingly, however, this did not significantly influence overall compliance in terms of either valid days of data or minutes of nonwear. Having an investigator present each morning increased wear time compliance and thus increased the number of children adhering to the minimum wear time criteria (>600 minutes per day). Subsequently, having this investigator present each morning in schools supported accelerometer compliance providing a representative insight into the habitual physical activity behavior among rural adolescent youth.

Conclusion

Sending an SMS reminder message each morning appeared to influence the likelihood of students wearing the monitor to school each morning. Even allowing for the number of data sets lost due to software malfunction, the remaining sample used in this study means that important conclusions can be drawn. Based on our findings we would strongly recommend sending an SMS reminder message each morning to participants for future field based accelerometer studies. In addition findings in relation to patterns of noncompliance indicate that an additional SMS reminder each day during the period immediately after school may significantly improve minutes of wear time. While we would tentatively recommend this as an additional strategy to aid compliance in future studies, there is a need for further research to investigate the significance of any impact this strategy may have on overall minutes of nonwear.

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Notes

I The purpose of this independent t-test was to ensure that those participants who forgot their monitor in the morning compared to those who wore monitors were not statistically different in terms of overall non-wear time.

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