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Collecting accelerometry data among adolescents: Lessons learns from the field

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Abstract

Background: While physical inactivity remains a pervasive public health problem, issues surrounding measuring physical activity plague researchers. Accelerometers are the gold-standard tool to assess physical activity behavior. However, accelerometer wear compliance varies by population and is influenced by factors, such as comfort and product features, among others. While compliance and acceptability of wrist-worn accelerometers is superior to hip-worn accelerometers, issues with compliance remain and likely vary by demographics and subpopulations.

Objective: The purpose of this study is to compare the effects of three consumer-grade accelerometer protocols on wear compliance among adolescents.

Methods: Move More, Get More (MMGM) is a an after-school sports sampling program to increase physical activity and physical literacy urban middle schoolers. Study participants were provided a Garmin VivoFit4 accelerometer watch; participant steps and physical activity were measured during the study period. Three methods of data collection were used to assess physical activity: 1) Continuous wear, self-sync, 2) Continuous wear, researcher-sync, and 3) Intermittent wear, researcher-sync. A one-way analysis of variance was conducted to assess between-group differences.

Results: Mean valid days were significantly higher at baseline ($F=27.52$, $p<0.001$) and 6 months ($F=9.98$, $p<0.001$) of the intermittent wear, researcher-synced condition than for both the continuous wear conditions, and significantly higher at 3 months ($F=4.05$, $p<0.05$) for the continuous wear, research-synced condition.

Conclusions: Study findings suggest that intermittent wear, researcher-synced protocol significantly improve wear-time compliance and meets recommendations needed for reliable estimates of physical activity compared to continuous wear protocols as measured by mean valid days. To our knowledge, there are no studies comparing accelerometer protocols specifically for consumer-grade, wrist-worn accelerometers among adolescence, a population that has lower compliance rates compared to other age groups.

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Abstract
Background
While physical inactivity remains a pervasive public health problem, issues surrounding measuring physical activity plague researchers. Accelerometers are the gold-standard tool to assess physical activity behavior. However, accelerometer wear compliance varies by population and is influenced by factors, such as comfort and product features, among others. While compliance and acceptability of wrist-worn accelerometers is superior to hip-worn accelerometers, issues with compliance remain and likely vary by demographics and subpopulations. Therefore, the purpose of this study is to compare the effects of three consumer-grade accelerometer protocols on wear compliance among adolescents.
Methods

Move More, Get More (MMGM) is a an after-school sports sampling program to increase physical activity and physical literacy urban middle schoolers. Study participants were provided a Garmin VivoFit4 accelerometer watch; participant steps and physical activity were measured during the study period. Three methods of data collection were used to assess physical activity: 1) Continuous wear, self-sync, 2) Continuous wear, researcher-sync, and 3) Intermittent wear, researcher-sync. A one-way analysis of variance was conducted to assess between-group differences.

Results
Mean valid days were significantly higher at baseline ($F=27.52$, $p<0.001$) and 6 months ($F=9.98$, $p<0.001$) of the intermittent wear, researcher-synced condition than for both the continuous wear conditions, and significantly higher at 3 months ($F=4.05$, $p<0.05$) for the continuous wear, research-synced condition.
Discussion
Study findings suggest that intermittent wear, researcher-synced protocol significantly improve wear-time compliance and meets recommendations needed for reliable estimates of physical activity compared to continuous wear protocols as measured by mean valid days. To our knowledge, there are no studies comparing accelerometer protocols specifically for consumer-grade, wrist-worn accelerometers among adolescence, a population that has lower compliance rates compared to other age groups.

Introduction

The National Physical Activity Plan calls for all populations to be studied with accelerometry, especially those that are vulnerable and/or marginalized to accurately capture the prevention of disease and promotion of quality of life (Physical Activity Alliance, n.d.). Additionally, evidence suggests that accelerometer device presence significantly increased interest in self-monitoring physical activity (Strain et al., 2022). Accelerometry-based physical activity measurement may not only aid in reducing sedentary behavior among children, it also is an influential tool used in informing policy and practice interventions in public health (Reilly et al., 2022).

Previous research found that four days of valid accelerometer-measured physical activity is needed for reliable estimates (Antczak et al., 2021; Cain et al., 2013). However, accelerometer wear compliance varies by population and is influenced by factors such as comfort and product features among others (Strain et al., 2022). In a recent review of accelerometer compliance in children, in which type of accelerometer was not synthesized, non-compliance ranged from 2-70%, and was highest non-compliance among adolescents (Howie & Straker, 2016).

Recent research suggests the benefits of wrist worn devices may outweigh those of the hip-worn devices (Rowlands et al., 2018). Wrist worn devices significantly increase wear time compliance, especially in children (Fairclough et al., 2016; McAlister et al., 2019; Scott et al., 2017). Consumer wearable devices were found to have valid and reliable measures of step count and heart rate (Fuller et al., 2020), and have additional advantages over research-grade accelerometers. For example, consumer-grade accelerometers are ubiquitous, and therefore are more socially acceptable than research grade accelerometers (Fuller et al., 2020), are less burdensome to the research participants, and increase ease in personal monitoring (Fairclough et al., 2016).

Issues with compliance remain and vary by demographics. Studies of research-grade accelerometers have shown individual characteristics to be correlates of compliance. For example, overweight, non-white, and children from lower socioeconomic backgrounds were more likely to show non-compliance in a large study using research grade accelerometers (Rich et al, 2013). As a result, certain populations are not well-represented in the literature.

Given the increased popularity of consumer grade accelerometers (Fuller et al., 2020) and their use in research, it is important to gain a better understanding of protocols to improve compliance, monitoring, and in turn result in reliable and valid data collection in adolescent populations. The purpose of the present study is to compare the effects of three consumer-grade accelerometer protocols on wear compliance among adolescents.

Methods

Study Design

A quasi-experimental study was conducted in an urban United States public school district in the Midwest across three middle schools for three years. All students from each middle school were invited to participate in the study through an after-school program. The present study is a 3-wave, 1-year longitudinal study with three different data collection methods using accelerometers.

Intervention

Move More, Get More (MMGM) was an after-school sports sampling program to increase physical activity and physical literacy urban middle schoolers. Study participants were given a Garmin

VivoFit4 accelerometer watch; participant steps and physical activity were measured during the study period. Garmin accelerometers were synced (the accelerometer data is upload to a mobile application via blue tooth technology) to the Garmin Connect mobile application, either by the student themselves or by a research assistant using a tablet. Protocols are described in more detail below. For analyses, Garmin data were collected three times during each academic school year between 2020-2023 in September, December, and April. For more information regarding MMGM protocol, see the published article (Grimes et al, 2022). For continuous wear protocols, lost or broken Garmin devices were replaced up to two times per participant during the study period. For the intermittent wear protocol, lost Garmin devices resulted in incomplete data, as the participants were not given another Garmin device to re-wear.

Accelerometer protocols-

Continuous wear, self-sync

During the 2020-2021 school year, school was held virtually as a result of the COVID-19 pandemic. Therefore, MMGM physical activity sessions were also held virtually immediately after school hours, four times per week through the academic year (September-May). Research staff met participants outside the participant's home to complete enrollment and initialize the accelerometer. The participants were instructed on how to sync their device to a personal or family member's phone or tablet. They were also instructed to sync the device weekly, wear it at all times for the remainder of the school year, and to only take it off minimally as needed. For students who were unable to sync their device to a personal or family device, a MMGM staff conducted home visits to sync the device. Participants were reminded to sync their devices during sessions and if needed, research staff contacted the participant's parents to remind them to sync the device. Data for baseline (September), mid-point (December), and end-point (April) were collected during the week that respective surveys were distributed.

Continuous wear, researcher-sync

During the 2021-2022 year, school resumed in-person and MMGM physical activity sessions were also hosted in-person, afterschool, three to four times per week. The participants were given a device upon enrollment in the program and were instructed to wear it at all times for the remainder of the school year and to only take it off minimally as needed. The devices were either synced by MMGM staff at weekly sessions or done at home on their own device if needed. During sessions, the majority of devices were synced at this time using a research tablet. Data for baseline (September), mid-point (December), and end-point (April) were collected during the week that respective surveys were distributed.

Intermittent wear, researcher-sync

During the 2022-2023 year, school remained in person and MMGM after-school sessions were hosted in-person three to four times per week. The participants were only given their device during the three data points for one week each time; baseline in September, mid-point in December and end-point in April. Students returned their device at the end of each data collection period; upon return, research staff synced the devices using research tablets. At the conclusion of the study year, participants could keep their devices. In the case of student absences or devices not being present at the end of the data collection period, students returned their devices at the next earliest point possible. In some cases, devices were returned weeks later. Additional device data outside the collection periods was not included in any research assessments and only data from the defined data collection periods were considered in further analysis.

Measures

Demographics

Participants demographic variables were assessed using a self-report questionnaire distributed during baseline testing. Participants were asked to report their birth date, sex assigned at birth (Male, Female, Prefer not to say), race by selecting all that apply (American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, and White) and selecting their ethnicity (Hispanic or Latino) by indicating yes or no.

Physical Activity

Physical activity was assessed using the Garmin Vivofit 4. This device measures steps through accelerometry and is manufactured with a battery that is intended to at least 1 year with no charging required. Brand-specific research has shown Garmin wrist accelerometers have higher validity when compared with other high use brands (Fuller et al., 2020). In a systematic review of 158 publications for assessment of consumer wearable devices it was found that Garmin was rated for acceptable results in step count and heart rate (Fuller et al., 2020). Daily steps were aggregated at the week level. To account for non-wear days a daily mean was calculated based on the given week. Days were only included in the analysis if they were considered a valid day. A valid day required ≥8 hours of wear time between the hours of 9 AM and 9 PM and ≥500 steps. Detailed accelerometer procedures can be found in the previously published protocol (Grimes et al., 2022a). These procedures have been used in previous studies (Grimes et al., 2022b; Baughn et al., 2022).

Statistical Analysis

Univariate statistics were conducted for all study variables. A one-way analysis of variance (ANOVA) was conducted to assess between-group differences. All analyses were conducted in SPSS (IBM Corp). An alpha level of 95% was used for all analyses.

Results

Demographics

Table 1 represents participant demographics from each academic year. In the continuous wear, self-synced year, 35.59% (21/59) reported being 12 years old, 20.03% (13/59) reported being 13 years old, and 18.64% (11/59) reported being 11 years old. Race and ethnicity for the continuous wear, self-synced year was closely distributed for White (27.12%, 16/59), Hispanic (23.73%, 14/59), and African American (20.34%, 12/59). In the continuous wear, self-synced year, 57.63% (34/59) participants reported being female. In the continuous wear, researcher synced year, 33.13% (53/160) reported being 13 years old, both ages 11 and 12 consisted of 20.63% (33/160). 49.38% (79/160) reported being African American, 18.13% (29/160) Hispanic, and 11.25% (18/160) White. The continuous wear, researcher-synced year had 53.75% (86/160) Males, 40% (64/160) Females, and 1.88 (3/160) preferred not to say. Lastly, the intermittent wear, researcher synced year had 33.87% (21/62) reported 12-year-olds, both ages 11 and 13 consisted of 19.35% (12/62). 56.45% (35/62) participants reported being African American and 20.97% (13/62) reported being Hispanic. 50% (31/62) of participants in intermittent wear, researcher-synced year reported being female.

Table 1. Demographic results for each study protocol.

	Continuous wear, self-synced (n=59)	Continuous wear, researcher-synced (n=160)	Intermittent wear, researcher-synced (n=62)	*P*-value
	n (%) or mean (SD)	n (%) or mean (SD)	n (%) or mean (SD)	
Age	12.04 (1.04)	12.50 (1.09)	12.11 (1.17)	0.01
Ethnicity				0.82
Hispanic	14 (23.73)	29 (18.13)	13 (20.97)	
Race				.03
African American	12 (20.34)	79 (49.38)	35 (56.45)	
White	16 (27.12)	18 (11.25)	5 (8.06)	
Asian	5 (8.47)	4 (2.5)	2 (3.23)	
Native Hawiian/Pacific Islander	0 (0)	1 (0.63)	0 (0)	
American Indian/ Alaska Native	0 (0)	5 (3.13)	1 (1.61)	
Multiracial	1 (1.69)	7 (4.38)	2 (3.23)	
Sex				0.23
Male	24 (40.68)	86 (53.75)	26 (41.94)	
Female	34 (57.63)	64 (40.0)	31 (50.0)	
Prefer not to say	0 (0)	3 (1.88)	1 (1.61)	

Note: Missing data is a result of mid-intervention enrollments where participants completed follow-up surveys without completing a baseline survey that included demographic questions.

Wear rates

Table 2 describes participant mean valid wear days for each condition. In the continuous wear, self-synced condition, participants had mean valid wear days of 3.05 (SD = 2.00) at baseline, 4.46 (SD = 2.20) at 3 months, and 3.59 (SD = 2.23) and 6 months. In the continuous wear, researcher-synced condition, participants had mean valid wear days of 3.67 (SD = 1.78) at baseline, 4.27 (SD = 2.04) at 3 months, and 3.34 (SD = 2.08) at 6 months. In the intermittent wear, researcher-synced condition, participants had mean valid wear days of 5.40 (SD = 1.83) at baseline, 5.70 (SD = 1.61) at 3 months, and 6.25 (SD = 1.22) at 6 months.

Results of the one-way ANOVA suggest that mean valid days were significantly higher at baseline (F=27.52, p<0.001) and 6 months (F=9.98, p<0.001) of the intermittent wear, researcher-synced condition than for both the continuous wear conditions, and significantly higher at 3 months (F=4.05, p<0.05) for the continuous wear, research-synced condition.

Table 2. Wear-time compliance as measured by mean valid days for each study protocol

Protocol	Baseline		3 Month		6 Month	
	n (%)	Mean valid days (SD)	n (%)	Mean valid days (SD)	n (%)	Mean valid days (SD)
Continuous wear, self-synced (n=59)	59 (100)	3.05 (2.00)	25 (42.37)	4.64 (2.20)	39 (66.10)	3.59 (2.23)
Continuous wear, researcher-synced (n=162)	162 (100)	3.67 (1.78)	51 (31.48)	4.27 (2.04)	53 (32.72)	3.34 (2.08)
Intermittent wear, researcher-synced (n=62)	60 (100)	5.40**[a] (1.83)	23 (38.33)	5.70*[b] (1.61)	12 (22.64)	6.25**[a] (1.22)

*<.05

**<.001

[a] Mean valid days were significantly greater than both baseline and 6-month in the intermittent wear, researcher-synced condition than for continuous wear, self-synced or continuous wear, researcher-synced conditions.

[b] Mean valid days were significantly greater in 3-months in the intermittent wear, researcher-synced condition than in the continuous wear, researcher-synced condition.

Discussion

The purpose of the present study is to compare the effects of three accelerometer protocols for consumer-grade wrist-worn devices on wear compliance among adolescents. The three protocols include 1) continuous wear, self-sync; 2) continuous wear, researcher-sync; and 3) intermittent wear, researcher-sync. The overarching results of this study indicated that the intermittent wear, researcher-synced protocol significantly improved accelerometer wear-time in adolescents. As a result, the physical activity data had improved completeness and validity.

Previous research has found that four days of accelerometer-measured physical activity data are needed for reliable estimates (Antczak et al., 2021; Cain et al., 2013). Each data collection point for the intermittent wear, researcher-synced protocol had a mean greater than 5 days, exceeding the general consensus of four days of valid data. On the other hand, mean days for the other protocols at baseline and six months were <4 days and would not provide reliable estimates of physical activity.

Overall, low rates of wear-time compliance may be associated with the demographic makeup of the study sample. Previous research has found that overweight, non-white, and children from lower socioeconomic backgrounds had lower compliance rates than their counter parts (Rich et al, 2013). The current sample tends to be low-income, as defined by the school district's eligibility to provide free lunch to all students, based on the community socio-economic conditions (Kansas City Public Schools, n.d.). Additionally, this study's sample is nearly 75% non-white. Therefore, this study provides evidence that suggests intermittent, researcher-synced protocols may be a promising strategy to improve physical activity monitoring and measurement in minority and low-income populations.

The present study is not without limitations. The COVID-19 pandemic significantly changed programming, social activities, and behaviors and may have affected the continuous wear, self-sync and the continuous wear, researcher-synced protocols. Additionally, the study is limited by the varying sample sizes, high attrition rates, lost or broken devices, and missing demographic data from several participants. Study strengths include this being the first of its kind to compare protocols for wear compliance for consumer-grade wrist-worn accelerometers in adolescents. Additionally, this study focuses on a population that has been shown in previous research to have lower accelerometer compliance rates than other groups, filling a much-needed gap.

Conclusion

The present study presented three accelerometer protocols and suggests that intermittent wear with syncing performed by researchers significantly improved wear-time compliance compared to continuous wear protocols. Researchers should weigh the benefits of each protocol to desired priorities of their current studies. Future research should continue to explore protocols that increase both wear-time compliance and simultaneously examine intervention attrition in similar study samples.

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