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RESEARCH METHODS

Surveillance of Youth Physical Activity and Sedentary Behavior With Wrist Accelerometry

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Introduction: Accurate tracking of physical activity (PA) and sedentary behavior (SB) is important to advance public health, but little is known about how to interpret wrist-worn accelerometer data. This study compares youth estimates of SB and moderate to vigorous PA (MVPA) obtained using raw and count-based processing methods.

Methods: Data were collected between April and October 2014 for the National Cancer Institute's Family Life, Activity, Sun, Health, and Eating Study: a cross-sectional Internet-based study of youth/family cancer prevention behaviors. A subsample of 628 adolescents (aged 12–17 years) wore the ActiGraph GT3X+ on the wrist for 7 days. In 2015–2016, SB and MVPA time were calculated from raw data using R-package GGIR and from activity counts data using published cutpoints (Crouter and Chandler). Estimates were compared across age, sex, and weight status to examine the impact of processing methods on behavioral outcomes.

Results: ActiGraph data were available for 408 participants. Large differences in SB and MVPA time were observed between processing methods, but age and gender patterns were similar. Younger children (aged 12–14 years) had lower sedentary time and greater MVPA time (p-values <0.05) than older children (aged 15–17 years), consistent across methods. The proportion of youth with ≥ 60 minutes of MVPA/day was highest with the Crouter methods ($\sim 50\%$) and lowest with GGIR ($\sim 0\%$).

Conclusions: Conclusions about youth PA and SB are influenced by the wrist-worn accelerometer data processing method. Efforts to harmonize processing methods are needed to promote standardization and facilitate reporting of monitor-based PA data.
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INTRODUCTION

The promotion of physical activity (PA) in children and adolescents is an important public health priority.[1] An established body of literature specifically indicates that regular participation in moderate to vigorous PA (MVPA) can lead to improvements in physical fitness, metabolic risk profiles, bone health, and mental health as well as reductions in body fatness.[2] Another public health consideration is minimizing youth sedentary behavior (SB), which is considered independent from PA.[3] Evidence indicates that children and adolescents spend approximately 7 hours/day being sedentary.[4,5] Moreover, excessive time spent sedentary is associated with adverse

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cardiometabolic health profiles[6–8] and with decreased fitness[9] in youth.

Research on youth PA patterns and behavior has emphasized the use of accelerometry-based activity monitors owing to their ability to quantify the amount and temporal patterns of movement. However, efforts to utilize these monitors for surveillance applications have been hampered by lack of consensus on data processing methods and inherent limitations of accelerometer data as an indicator of behavior.[10] The challenges have been further compounded by the variability in PA outcomes because of the use of different devices, monitoring locations, and processing methods. Historically, the hip has been a primary attachment site for research using accelerometry-based devices. However, recent epidemiology studies (e.g., National Health and Nutrition Examination Survey, UK Biobank) have chosen to use wrist-worn monitors, in part, because of improved wear compliance of participants.[11] Emphasis in recent years has also been placed on processing of raw accelerometer data rather than monitor-specific "movement counts" with the goal of improving accuracy of assessment as well as comparability across monitors.[10] Methods have been proposed to process raw acceleration[12] and activity count data[13,14] from wrist-worn accelerometers for youth. Given that the use of different processing methods can lead to different conclusions about youth activity levels (and relations to health), it is essential to clearly understand the potential implications of using one method over the other on activity outcomes in youth surveillance research. Therefore, the purpose of this study was to evaluate youth PA and SB using different wrist processing techniques, and to examine the impact of alternative methods on activity patterns by gender, age group, and weight status.

METHODS

Study Design

Data were collected between April and October 2014 as part of the National Cancer Institute's Family Life, Activity, Sun, Health, and Eating (FLASHE) Study: a cross-sectional, Internet-based surveillance study of youth/family behaviors related to cancer prevention. Additional details on the methodology of FLASHE are reported in this journal issue.[15,16] Briefly, parent participants were recruited from the Ipsos Consumer Opinion Panel. Eligibility criteria included being aged ≥18 years and living with at least one child aged 12–17 years for at least 50% of the time; one eligible adolescent from the household was randomly chosen. Using balancing techniques, the selected sample for screening was balanced on sex of the panel member, Census division, household income, household size, and race/ethnicity. FLASHE participants were randomly selected to participate in the Survey-Only group or the Survey + Motion Study group. Youth in this latter group were asked to wear an ActiGraph GT3X+ on their dominant wrist for 24 hours over 7 days. The ActiGraph, along with specific instructions on the device's appropriate use, was mailed to each participant. Each adolescent provided signed assent, and their parent or guardian provided signed informed consent before participation. The FLASHE Study was reviewed and approved by the U.S. Government's Office of Management and Budget, National Cancer Institute's Special Studies IRB, and Westat's IRB. Data were collected between April and October 2014. Height and weight were self-reported by the adolescents. Weight status was defined according to the Centers for Disease Control and Prevention growth charts (5th–85th percentile being normal weight, ≥85th percentile being overweight/obese).[17] Age was dichotomized: 12–14 years or 15–17 years.

Data Management

Raw ActiGraph accelerometer files were downloaded and then converted to 5-second epoch count data using the ActiLife software, version 5.0. Non-wear time periods captured with the algorithms of Choi et al.[18] and sleep time (10:00PM–6:00AM) were removed from both raw and count data for direct comparison. As data were collected across several time zones, the authors took into account time zone differences when processing data to standardize waking hours. The procedures for each data processing method are described below.

Raw accelerometer data. Raw acceleration data (collected at 100 Hz) were processed using the R-package GGIR, which is designed for processing multiday raw accelerometer data.[19] GGIR consists of two major processing components: Part 1 and Part 2. Part 1 generates an epoch-specific acceleration summary variable, called Euclidian Norm Minus One, which is calculated by subtracting the gravitational force from the vector magnitude of the three axis. Part 2 produces only "daily-level summary" files based on the acceleration summary data generated from Part 1. The daily summaries in Part 2 are generated using the intensity-specific milli-g cutpoints from Hildebrand and colleagues'[20] regression equations. However, these cutpoints only estimate minutes of moderate (3 METs) and vigorous (6 METs) PA and are therefore unable to classify SB. Moreover, given that children have higher resting metabolic rates, the use of standard METs (i.e., 3.5 mL/kg/minute) needs to be adjusted to capture these differences.[21] For instance, METs <2 and >4 can provide more-accurate classifications of children's SB and MVPA, respectively.[22] Therefore, instead of using Part 2, the authors first derived milli-g cutpoints for SB (2 METs) and MVPA (4 METs) using the regression equations of Hildebrand et al.[20] (Appendix Table 1, available online). Those cutpoints were then applied to the acceleration data (generated from Part 1) to obtain sedentary and MVPA time for every 5 seconds. This customized procedure was undertaken in Stata/SE, version 12 (syntax available upon request), and the authors verified that daily-level MVPA estimates from this procedure were identical to those from Part 2 of GGIR.

Activity counts data. Intensity-specific time estimates were determined using two sets of cut points: one developed by Crouter and colleagues[23] and one developed by Chandler et al.[13] Each series of cutpoints included two separate sets of thresholds: one for vertical axis (VA) activity counts and one for vector magnitude (VM). The Crouter equations for VA counts assume 1.0 MET when aggregated 5-second VA counts are ≤35; otherwise,

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