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Measuring Physical Activity and Sedentary Behavior in Youth with Type 2 Diabetes

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Abstract

Background: Lifestyle interventions that encourage increasing physical activity (PA) and losing weight are critical for overweight and obese youth with comorbid conditions. Assessing PA within such lifestyle intervention efforts requires measurement tool(s) that are both accurate and appropriate for these youth. This research compares PA levels and sedentary behavior in an ethnically diverse cohort of overweight/obese youth with type 2 diabetes using both accelerometry and a questionnaire previously validated in the general youth population.

Methods: Spearman's correlations were used to compare time spent sedentary and in different PA intensities between a questionnaire, the three-day PA recall (3DPAR), and an objective PA measure, the ActiGraph accelerometer, in 236 overweight/obese youth with diabetes.

Results: Spearman correlations between 3DPAR and accelerometer results for total PA were small and not significant (rho = 0.11, $p > 0.05$ for males and females). Correlations for specific PA intensities (moderate/vigorous and light) were also small and not significant. Sedentary time between instruments was significant, but weakly correlated in females (rho = 0.19, $p < 0.05$), but not in males (rho = 0.07, $p = 0.48$).

Conclusions: Subjective PA measures validated in the general youth population may not be the best method for differentiating levels of movement in overweight/obese youth with type 2 diabetes, who spend most of their time in light-intensity activity and sedentary pursuits with little or no time spent in moderate/vigorous-intensity activities. Objective measures such as accelerometers that can capture the lower end of the movement scale are likely the more appropriate measures under these conditions.

Introduction

Lifestyle interventions comprised of increasing physical activity (PA) and decreasing weight in overweight adolescents and youth with comorbid conditions are becoming increasingly prevalent. Assessing PA within these interventions requires instruments that are accurate for the specific population being investigated. Subjective self-report measures such as recall questionnaires have been shown to be reasonable for assessing moderate to vigorous PA levels in relatively healthy adolescents and older youth[1–4] but are much less able to quantify low-intensity activities.[1–3] As a result, it is not possible to assume that recall questionnaires that work reasonably well in more active youth populations will be valid in highly sedentary youth populations.

In contrast, objective measures such as pedometers and accelerometers have been validated for use in youth across the spectrum of activity intensity levels, from those who engage in moderate to vigorous PA to those who spend all of their time between light-intensity activities and sedentary behavior.[4–7] These instruments may be the more appropriate choice for youth in which little moderate/vigorous-intensity activity occurs.

In general it has been shown that overweight and obese individuals with chronic diseases such as diabetes typically spend most of their time between sedentary and light activity and less time in moderate to vigorous PA than healthier individuals.[8–10] We had previously demonstrated that the overweight and obese youth with type 2 diabetes in the Treatment Options for type 2 Diabetes in Adolescents and

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Youth (TODAY) study were reported to spend more time in sedentary behavior than similar age/gender obese youth without diabetes, as reported by accelerometers.[8] Compared to previously published accelerometer data from National Health and Nutrition Examination Survey (NHANES), it also seemed that the TODAY youth likely spent less time in moderate to vigorous activity and more time sedentary than similar age/gender normal weight youth.[11] Therefore, it is unknown if activity questionnaires typically used in the general youth population will be applicable for this population. Being able to adequately assess activity levels in these youth is vital to understanding the effects of low activity levels on health outcomes in highly sedentary youth and to assessing the efficacy of lifestyle interventions designed to increase activity levels.

The aim of the present study is to assess the feasibility of a commonly used subjective recall of PA, previously validated in healthier youth, for capturing typical levels of activity and sedentary behavior in a very sedentary adolescent and older youth population. PA and sedentary behavior are compared between a self-report questionnaire, the three-day PA recall (3DPAR), and an objective recording method, the ActiGraph AM7164 piezoelectric accelerometer (ActiGraph, Pensacola, FL), in a diverse population of overweight/obese individuals aged 10–17 years with type 2 diabetes.

Methods

Study Population

The TODAY study was a randomized, double-blind, parallel-group clinical trial.[12] The primary objective was to compare the three treatment arms (metformin, metformin plus rosiglitazone, and metformin plus an intensive lifestyle program) on time to treatment failure or loss of glycemic control. Informed consent was obtained for all participants and the study was approved by the institutional review boards of each participating institution. Recruited participants were 10–17 year-old males and females with type 2 diabetes under two years duration and a BMI ≥ 85th percentile for age and gender, based on CDC reference curves.[13] All youth with positive plasma concentrations of insulinoma antigen 2 (IA2) and/or glutamic acid decarboxylase (GAD) antibodies and low C-peptide < 0.5 ng/ml or hemoglobinopathies were excluded. Participants were recruited from 15 clinical centers.[12] Baseline data collection for this study took place from 2004 to 2009. Detailed methods, procedures, and primary results of this study have been published.[12,14]

Physical Activity Assessment

Accelerometry. PA data were collected using the ActiGraph accelerometer, a validated measure of habitual PA in children and adolescents.[15] Participants received an accelerometer to wear during waking hours for the seven days prior to their scheduled clinic visit. Inclusionary criteria consisted of having accelerometer data with ≥ 10 hours of wear time on three or more days.

Accelerometer data was output as activity counts summed over one-minute time intervals. Average total activity counts per day were calculated using summed daily counts detected over monitor wear periods. Time in minutes spent in different activity intensities was calculated using age-specific count ranges corresponding to widely used metabolic equivalent (MET) value cut-points for youth: sedentary (< 1.5 METs), light (≥ 1.50–3.99 METs), moderate to vigorous (≥ 4.0 METs).[16–19] (A MET is an estimate of relative intensity such that one MET represents the energy expenditure for an individual at rest whereas a 10 MET activity requires 10 times that amount).[20] Detailed accelerometer data processing methods related to wear time identification and intensity cut-points have been previously published.[8]

Three-Day Physical Activity Recall. Self-reported PA data were measured using the 3DPAR, a self-administered questionnaire that has been validated to capture habitual PA in similarly aged youth.[21–24] The 3DPAR was administered during the clinic visit, following the participant's wearing of the accelerometer. Participants were asked to recall activity over the time period that coincided with the final three days of accelerometer monitoring.

Trained interviewers guided the questionnaire process. Participants recorded the main activity (from a list of 77) they participated in during each 30-minute time block for each day (6 am – 12 midnight). Standardized intensity values were assigned using published values and cut-points corresponding to the intensity-level categories used for the accelerometer data (sedentary [<1.5 METs], light [≥1.50 – 3.99 METs], moderate/vigorous [≥4.0 METs]).[25] Results were reported as the total number of 30-minute blocks reported per day in the various intensity levels of PA and sedentary behavior.

Statistical Analysis

Analyses were conducted in statistical software SAS (SAS version 9.2; SAS Institute Inc., Cary, NC). Chi-squared tests were used to evaluate the comparisons of the percentages of sex, age, race, and BMI categories between individuals with/without complete data for both the 3DPAR and accelerometer. Mann-Whitney U tests were used to evaluate the comparisons of activity and sedentary levels from the 3DPAR between those individuals with/without accelerometer data. Spearman partial rank order correlations, stratified by gender and controlling for the effect of age, were used to assess the strength of associations between accelerometer output and the results from the 3DPAR.

Results

Population Descriptives

A total of 672 and 242 TODAY trial participants had complete data for the 3DPAR and accelerometer, respectively. A total of 248 (37%) of the participants either refused to wear the monitor or had incomplete records (< 3 valid

Table 1. Demographic Characteristics for the 236 TODAY Trial Youth with Complete 3DPAR and Accelerometer Data

Female gender (%)	60.6
Mean (SD) age (years)	13.8 (2.1)
Race/ethnicity (%)	
Black (Non-Hispanic)	30.1
Hispanic	44.9
Native American	6.4
White (Non-Hispanic)	18.2
Asian (Non-Hispanic)	0.4
BMI category: CDC (%)	
85th–94th percentile	13.4
95th-98th percentile	41.1
≥99th percentile	44.1
BMI category: IOTF (%)	
Overweight	18.6
Obese	
Class I	31.4
Class II/III	48.3

IOTF, International Obesity Task Force; TODAY, Treatment Options for type 2 Diabetes in Adolescents and Youth; 3DPAR, three-day PA recall.

days), with an additional 195 (29%) of the accelerometer records lost due to a computing error. The remaining subsample of 236 adolescents and youth had complete 3DPAR and accelerometer data. Those with/without complete accelerometer and 3DPAR measures were not significantly different (based on $p < 0.05$) in regard to age, gender, race/ethnicity, BMI, or reported activity from the 3DPAR (data not shown).[8] The demographic characteristics of the 236 adolescents and youth with complete activity data are presented in Table 1.

Physical Activity Levels

Table 2 contains median PA and sedentary time reported by the accelerometer (in minutes/day) and the 3DPAR (in number of 30-minute blocks/day) by sex. The reported median number of 30-minute blocks/day spent in total PA (light + moderate/vigorous intensity) from the 3DPAR was 15.5 (range 6.0 – 29.0) blocks/day for males and 16 (range 3.5 – 26.5) blocks/day for females. The recorded median minutes/day spent in total PA from the accelerometer was 368.6 (range 182.2 – 631.8) minutes/day for males and 369.6 (range 185.7 – 577.2) minutes/day for females.

Comparison of 3DPAR and Accelerometer

The age-adjusted Spearman rank order correlations between the accelerometer and the 3DPAR results indicated that there was little association between the output of the two measures (Table 2). Time spent in moderate to vigorous PA or total PA in minutes/day from the accelerometer was not significantly correlated with time spent in moderate to vigorous or total PA, respectively, from the 3DPAR for

Table 2. Comparisons between Physical Activity Related Variables Derived from the AM7164 Accelerometer and the 3DPAR Questionnaire[a]

	Accelerometer median (range) minutes/day	3DPAR median (range) 30-minute blocks/day	Spearman coefficient[b]
Males $n = 93$			
Light-intensity PA	330.0 (288.8 – 380.3)	12.5 (4.0 – 23.5)	0.01
Moderate/vigorous intensity PA	24.8 (1.3 – 126.3)	2.5 (0 – 15.5)	0.15
Total PA (light + moderate/vigorous)	368.6 (182.1 – 631.8)	15.5 (6.0 – 29.0)	0.11
Sedentary behavior	487.2 (183.0 –1040.7)	13.0 (0 – 22.0)	0.07
Females $n = 143$			
Light-intensity PA	346.4 (185.7 – 577.2)	12.5 (3.0 – 26.5)	0.14
Moderate/vigorous intensity PA	14.7 (0 – 81.5)	2.0 (0 – 13.5)	0.15
Total PA (light + moderate/vigorous)	369.6 (185.7 – 577.2)	16.0 (3.5 – 26.5)	0.11
Sedentary behavior	467.3 (186.0 – 1015.3)	11.5 (1.0 – 26.5)	0.19*

PA, physical activity; 3DPAR, three-day PA recall.

[a]The units for the accelerometer (minutes/day) and 3DPAR (30-minute blocks) reflect the recording timeframe of each instrument.

[b]Partial correlations controlling for the effect of age.

*$p < 0.05$.

males or females ($p > 0.05$). Recorded minutes/day spent sedentary from the accelerometer had a weak significant correlation with recorded 30-minute blocks/day spent sedentary from the 3DPAR in females (rho = 0.19, $p = 0.02$), but not in males (rho = 0.07, $p = 0.48$).

Discussion

Assessment tools are needed that can accurately quantify typical PA and inactivity levels in the least active population subgroups that have the greatest need for intervention. Previous research suggests that the 3DPAR is a useful tool for gaining qualitative information about activity as well as an acceptable relative measure of moderate and vigorous intensity PA in the general adolescent and older youth population aged 10 years or more (compared to accelerometer results).[21–24] Spearman correlations for this population of overweight/obese adolescents and older youth with type 2 diabetes indicate a much weaker agreement between the 3DPAR and accelerometer results for quantitative levels of PA and sedentary behaviors than was seen in the general population.[26–28] This is likely due to the fact that activity in the TODAY trial participants was mostly limited to that of light intensity, and self-report measures of PA are not as valid for assessing light activity compared to objective measures like accelerometers.[1–3]

The findings of this study could have important implication for clinical research and interventions involving highly sedentary, overweight and obese youth, like the TODAY trial cohort. Our results suggest that the use of recall questionnaires including the 3DPAR for assessing PA and sedentary behavior may lead to overestimation of PA and underestimation of sedentary behavior in these youth. Invalid estimates of time spent in PA and sedentary behavior as seen in this study's results could affect (1) the ability to assess the success of interventions at improving activity-related behaviors and (2) the ability to understand the relationships between PA, sedentary behavior, and important intervention-related health outcomes in these youth such as weight loss and glycemic control. Therefore the results of this study would suggest the use of accelerometers for quantifying activity and sedentary behavior levels in youth with comorbid conditions, like the TODAY trial cohort.

Both accelerometers and recall questionnaires are not considered to have a high participant burden.[29,30] Due to their ease of scoring and lower cost of administration, questionnaires have been considered to have a lower overall burden than accelerometers.[29–31] However, over the past decade the cost of validated accelerometers has continued to decrease, making accelerometers more feasible for a wider variety of clinical applications.[32–35] It should also be noted that questionnaires like the 3DPAR can provide qualitative information on activity behaviors that currently cannot be obtained using objective measurement instruments. Therefore it has been previously suggested that using an objective measure to assess quantitative levels of PA and sedentary behavior coupled with a subjective measure to collect qualitative information related to activity behaviors may be important to gaining a more complete picture of a participant's activity than could be gained from objective measures alone.[36,37] In the TODAY study there was not a criterion measure to assess how well the 3DPAR was able to correctly identify qualitative aspects of activity, such as type of activity performed. Therefore, based on our results we could not support or negate the use of the 3DPAR for assessing qualitative aspects of activity behaviors in this cohort.

In summary, these analyses indicate subjective recall measures like the 3DPAR may not be appropriate for relative assessments of time spent in both PA and sedentary time in this population of highly sedentary overweight and obese adolescents and older youth with type 2 diabetes. Instead, accurately quantifying PA levels in highly sedentary adolescent and youth populations may require objective measures, such as accelerometers. Unfortunately, as the general population becomes more sedentary and spends less time in moderate/vigorous activity, a reexamination of the feasibility of using subjective recall measures for detecting the relative quantity of PA and sedentary behavior in these adolescents and older youth may have to be considered.

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Author Disclosure Statement

There are no conflicts of interest to report.

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