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Physical Activity Measurements: Lessons Learned from the Pathways Study

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Abstract

High obesity rates in American Indian children led to Pathways, a randomized school and community-based childhood prevention study. Seven tribes, five universities, the NIH/NHLBI, and four elementary schools partnered. Increasing physical activity (PA) was an important intervention target. PA assessment was based on study objectives, feasibility, and tribal acceptance. A time-segmented analysis was also desired. Two methods were developed during pilot testing, a new PA questionnaire and accelerometry. Together, the methods provided qualitative and quantitative information and showed 3 of 4 sites were able to increase average daily PA, although overall the control versus intervention difference was not significant. The main limitation was inability to distinguish PA among individuals. Accelerometer size and some community concerns led to a protocol based on a single day of wearing time. Newer model triaxial accelerometers which are much smaller and allow sampling of multiple days of activity are recommended for future studies.

Keywords

Physical Activity; American Indian children; Pathways; Accelerometry; Questionnaire

Introduction

Although there is considerable variation across tribes, obesity rates for American-Indian children, adolescents, and adults tend to be higher than corresponding rates for the U.S. population.^{1–4} For example, a 1990 national survey of American Indian school children living on or near reservations showed the overall prevalence of overweight (BMI >85th percentile) was 39 percent for age and gender compared to NHANES II reference data.⁵ A large study involving children from 16 tribes in four Midwestern states also showed age adjusted prevalence of overweight of 39 percent for boys and 38 percent for girls. Age-adjusted prevalences of obesity (BMI >95th percentile) for boys and girls were 22 percent and 18 percent, respectively.⁶ Overweight and obesity rates did not differ markedly by age and gender. This study showed that even at the youngest ages, overweight in American Indian youth was more than twice as likely as U.S. youth overall, and obesity was more than three times as prevalent.

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The associations between adult obesity and adverse health outcomes, including diabetes, coronary heart disease, certain cancers, and respiratory problems are well documented. Although few studies have examined the long-term consequences of pediatric obesity in Indian children and adolescents, overweight and obesity are known to track, predicting grave consequences for the immediate as well as the long-term health of American Indian youth. Type 2 diabetes mellitus, which is strongly associated with obesity, is epidemic among some American Indian populations, and it is now occurring among children and adolescents.^{7, 8} Unless the trend for increasing prevalence of obesity is reversed, American Indian populations and other populations at risk will be burdened by increased rates of diabetes and other chronic diseases.

Recognizing the grave implications of pediatric obesity, Pathways was initiated by the National Heart, Lung and Blood Institute in 1993. A unique collaboration among the NHLBI, five universities, and seven American Indian tribes, Pathways was designed to be culturally appropriate and easily implemented by trained school teachers and other staff. An important step in the development of the Pathways intervention was identification of a set of target behaviors. Extensive formative assessment was collected from teachers, school administrators, food service staff, PE specialists, parents, and students at all field centers. Among other factors, limited opportunities for physical activity at school and in the community were identified as a likely contributor to risk of excess weight.⁹ Limited data from other studies¹⁰ supported the idea that physical inactivity contributed to excess weight gain in American Indian children. Consequently, increasing physical activity and energy expenditure was a priority behavior in Pathways, and methods were developed to assess the effects of the intervention on physical activity. The purpose of this paper is to describe the physical activity methods developed for Pathways, and the lessons learned from their application in American Indian communities.

Methods

Pathways was a large, multi-site, school-based randomized controlled study for the primary prevention of obesity in American Indian school children. The study was implemented in two phases. Phase one was a 3-year project to determine the feasibility of a multi-level school-based intervention in American Indian schools, to conduct formative assessment, and to develop and pilot test measurement protocols, interventions, and approaches to process evaluation.¹¹ Phase 2, the full-scale study, was conducted from 1996 to 2000.¹² The feasibility study was implemented in eight schools at four study centers located in Arizona, New Mexico and South Dakota. During phase 2, the main trial was conducted in 41 different schools at the same sites. The study centers were the Gila River Indian Community/ University of Arizona, partnered with the Tohono O'odham nation; Johns Hopkins University, who partnered with the San Carlos Apache and White Mountain Apache tribes; The University of New Mexico, who partnered with the Navajo Nation; and The University of Minnesota, who partnered with the Sicangu Lakota and Oglala Lakota tribes. The Pathways Coordinating Center was located at the University of North Carolina. The children who participated were in 3rd, 4th and 5th grades, with an average age of 7.5 years. Genders were nearly equally represented. Pathways was approved by all participating tribes and

universities' IRBs (or other relevant independent ethics committees) and parent informed consent and child assent was obtained for all participants.

A number of different measurement approaches have been described for assessing children's activity,^{13–16} but no specific method can be identified as the best option for all studies. Selection of an appropriate instrument depends on the specific research question being addressed as well as the relative importance of accuracy and practicality. For example, accurate measures of energy expenditure using doubly-labeled water, indirect calorimetry, or heart rate calibration equations may be needed for certain clinical studies, but the cost and inconvenience would make them impractical for field-based assessments on larger samples. The “accuracy-practicality” trade-off presents a more challenging predicament with children than with adults. Because of developmental differences, especially in their ability to think abstractly and to perform detailed recall,^{17, 18} children are less likely to make accurate self-report assessment than adults.

Methods for physical activity assessment in Pathways were selected based on 1) their appropriateness for a large scale field study, 2) the objective, which was to assess the effects of the intervention on physical activity, and 3) acceptance in all tribal communities. In addition, the ability to assess activity during specific times of the day was a desirable attribute since a time-segmented analysis had the advantage of providing maximum information for addressing ancillary questions that might arise during the development and conduct of the study. The feasibility of a method was also judged on the basis of the method's reliability, affordability, complexity, and intrusiveness, and on the amount of burden placed on the children and the schools. Many methods were deemed infeasible for Pathways. For example, the doubly-labeled water method, while desirable for estimating energy expenditure directly, was too costly, and ingestion of the isotope was unacceptable in some communities. Similarly, heart rate monitoring, which is correlated (if calibrated) with energy expenditure and useful for time-segmented analysis, was judged as overly intrusive and rejected by some communities because parents objected to children wearing the electrodes and telemetry unit, which are held against the skin with surgical tape. Direct observation was rejected because of its intrusiveness, especially at home, and because of the staff time required to observe physical activity in communities that are separated by long distances. Activity diaries were considered overly burdensome and of questionable accuracy in young children.

Two methods, recall questionnaires and use of motion sensors, were found acceptable to all tribal communities, satisfied the other feasibility criteria, and in combination, provided the desired information. Detailed protocols have been published elsewhere.^{18, 19} The Pathways questionnaire was designed to assess activity during the preceding 24h using a checklist format and was self-administered in groups with assistance from trained staff. Children examined a standard list of activities developed from past surveys and from the Pathways formative assessment. A section for reporting whether children participated in PE and recess, and whether they watched television or videos or played video and computer games was also included. For each activity, children indicated whether they engaged in it “none,” “a little,” or “a lot” during 3 segments (providing the possibility of segmented analyses) of the day: before-school, during-school, and after-school.

Recognizing the potential limitations of the questionnaire, the Pathways team selected the TriTrac accelerometer in order to obtain a more objective estimate of total physical activity. Unlike its uniaxial predecessors, the TriTrac accelerometer was capable of measuring acceleration in 3 planes, making it more sensitive to horizontal movement. Other advantages included its light weight and solid state circuitry with no external controls, rendering it more tamper proof than other accelerometers. Most importantly, the TriTrac provided up to 14 days of minute-by-minute recordings that could be downloaded directly to a computer for objective, user-defined, time-segmented analysis of activity.

Results

The physical activity assessment protocols were tested in a pilot study of 117 third grade American Indian children from six communities participating in Pathways, and the TriTrac accelerometer was tested in a subsample of 80 of the same children. Standard protocols were followed,¹⁸ and the study was designed to facilitate comparisons among the two methods. Data were collected over two consecutive days with the initial day selected at random within a school. The TriTrac was secured in a fanny pack worn around the waist. The PAQ was administered after one day of measurement with the TriTrac accelerometer so that the methods sampled identical intervals. Details of data collection are published elsewhere.¹⁸ Of note, when the PAQ was administered, children were asked to first recall activities engaged in before school on the day of the recall, followed by activities after school and during school on the preceding day. This procedure was followed to test whether more recent activities would be more accurately reported and hence better correlated with the TriTrac accelerometer results. Complete PAQ data were obtained for all 117 children. The children had little difficulty understanding the PAQ and could complete it in the classroom setting in 30 minutes or less with staff assistance. Walking, running, basketball, outdoor play and games, along with games such as tag, chase, and hopscotch, were the activities most commonly reported. Sedentary activities such as watching television or video games and playing video games were also common before and after school.²⁰ The frequencies for participation in various activities were similar across the different communities from different geographic regions of the United States.

TriTrac estimates of activity (average vector magnitude) were obtained on 52 of 80 children who gave assent. Poor subject compliance due to failure to wear the instrument for the prescribed time, failure to return the TriTrac accelerometer to school, return of the accelerometer by the wrong child or school, or opened fanny pack were the main causes of missing data (n=17). Data were lost in another 11 cases because of failure to create or properly download data files, which may have been due to equipment or operator error. Spearman rank-order correlations were calculated between average vector magnitudes (from TriTrac) and PAQ activity indexes for the 52 children with both accelerometer and PAQ data. The correlations were low and non-significant for the periods before-school and after-school, averaging $r = 0.15$, and somewhat higher for the time period during school ($r = 0.41$). Both methods ranked after school as the most active time of day. However, TriTrac showed during-school activity was higher than before-school activity, whereas the PAQ suggested more activity occurred before-school than during school.

Concern over data loss in the initial pilot led to a follow-up study on 76 children. Several new procedures were followed to reduce data loss, including more intensive staff training on instrument initialization and downloading of files. Also, incentives were given to children who returned unopened fanny packs at the designated times, and teachers and parents were asked to more closely monitor the children and encourage them to wear the fanny packs. Using these procedures, compliance was improved, fewer data were lost during downloading, and overall missing data were reduced from 35 percent to ~20 percent.

Based on the pilot studies, Tritrac accelerometry and PAQ were deemed feasible and were adopted for the full scale Pathways study. Baseline and follow-up assessments of physical activity using Tritrac were obtained in 574 (33.7 percent of sample) and 457 (26.8 percent of sample) of Pathways participants at baseline and follow-up, respectively. Almost 700 boys and girls completed yearly administrations of the PAQ. Both measures showed that the Pathways intervention failed to significantly increase physical activity, even though accelerometry data indicated that average PA was almost 10 percent higher in intervention versus control schools, which was an encouraging result.¹⁹ The PAQ, which was administered more frequently, also showed intervention schools had higher activity than controls, although there was a tendency (by PAQ) for activity levels to decline with increasing age.²⁰

Discussion: Lessons Learned

Ideally, a method for assessing physical activity would provide information regarding the frequency, duration, intensity and mode of physical activity over several days, which in combination would provide an index approximating energy expenditure. Context is also often desirable. The methods employed in Pathways provided much, but not all of this information. The PAQ and accelerometer were acceptable in all of the communities and schools, and they did prove useful for comparing group differences between intervention and control schools. However, there were some significant limitations, most notably, the inability to distinguish accurately levels of activity among individual children.

The limitations of physical activity questionnaires in young children are well described.^{15–17} Children have difficulty recalling discrete episodes of physical activity and cannot accurately report frequency, intensity, and duration of activity, especially if asked to recall activity over several days. Reading comprehension is also a concern, especially when English may not be the family's primary language. This was not a problem in Pathways, as the questionnaire was self-administered with assistance. The Pathways protocol required a staff member to read the checklist aloud while other staff circulated throughout the classroom to ensure students followed along and to provide assistance. Using class time to administer the PAQ, however, was one reason repeated administrations to assess multiple days of activity was not feasible. It was also apparent that children could not accurately recall activities beyond the immediate past 24 hours, the main reason multiple days were not assessed during a single administration.

Despite its limitations, the PAQ provided information that was deemed valuable in Pathways. For example, mode of activity was of interest, as the intervention targeted the

increase of selected activities that were expected to contribute to higher overall activity and decrease of sedentary activities such as television watching and video games which would lead to lower overall PA. A unit of American Indian games was also developed, and it was of interest to determine whether children experienced them. Context was also of interest. The PAQ included questions that addressed whether children had engaged in physical education or recess on the day that was recalled, and whether the activity had occurred before, during, or after school. This information, along with the accelerometer recordings and knowledge of when school began and ended and when PE and recess were held, made it possible to derive accelerometer-based estimates of physical activity during various periods of the day. These analyses showed that activity was higher on days when children had PE class and recess, and that activity was higher during the school day compared to before and after-school.¹⁹

The Tritrac R3D accelerometer provided an objective estimate of activity in Pathways. The Tritrac was selected primarily because it provided user-defined, segmented (e.g., minute-by-minute recordings) recordings that were downloadable. The Tritrac R3D was one of the earliest tri-axial accelerometers. Tri-axial accelerometry is thought to have advantages in children,^{21–23} given their typical patterns of activity (e.g., episodic; brief bursts of intense movement followed by bouts of light and sedentary activity)¹⁶ and the type of their PA (climbing, jumping, etc.) compared to adults. Pathways was not designed to determine whether triaxial accelerometry was better than uniaxial accelerometry and more studies comparing methods against a suitable criterion such as doubly-labeled water or observation are needed.^{23–25}

The accelerometry protocol in Pathways had two main limitations: Tritrac R3D size and wearing time. Although the Tritrac was lightweight, its dimensions (10.9 × 6.8 × 3.3 cm) were larger than some other instruments, and it was not easily worn on the child's belt or waistband. Accelerometry was novel in these communities, and there was some concern regarding safety, for example, some parents expressed concern about possible injury if the child fell. Consequently, the Pathways protocol called for sealing the instrument wrapped in padding in a fanny pack, which was worn around the waist. Community concerns and the potential burden of wearing the fanny pack for several days led to the decision to have children wear the accelerometer for a single 24 hour period despite evidence at the time that multiple days of assessment provided a better measure of typical activity.²⁶ Studies since Pathways have confirmed that 4–7 days of assessments are needed to obtain an accurate estimate of physical activity when detecting differences among individuals is an interest.^{25, 27} Sampling multiple days in Pathways would have provided better discrimination among children and enhanced analyses designed to investigate mediators of physical activity. A smaller instrument, which could be clipped to the child's belt and would likely be accepted as less intrusive, may have been approved for multiple days of wearing. Newer, smaller tri-axial accelerometers are now available (e.g., RT3, Stay Healthy, Inc.; Monrovia, CA; Actigraph GT3X, Actigraph, Pensacola, FL). A tri-axial pedometer has also been developed (HJ-303, Omron Health Care, Inc.), although validation studies on these instruments need to be done. Nevertheless, depending on the objectives of the study, pedometers present a low cost alternative to accelerometers, which are significantly more expensive.²⁵

Accelerometry can be used to objectively quantify time spent in activity of various intensities, e.g., moderate intensity activity and vigorous intensity activity. Since Pathways, studies have been done calibrating accelerometers against criterion-methods (such as using validating against oxygen consumption during PA) of energy expenditure and exercise intensity.^{24, 28–31} However, calibration studies performed in a laboratory with exercise performed on a treadmill or cycle ergometer may not translate well to field conditions. A variety of factors such as instrument placement and body morphology and composition may affect the relationship between accelerometer performance, exercise intensity, and energy expenditure. Cutpoints developed with a specific instrument for a specific population are not necessarily generalizable, and there is a need for systematic studies to compare and validate various instruments in children with different physical characteristics when engaged in similar activities. McClain and Tudor-Locke²⁵ have recently reviewed studies of pedometers and accelerometers in children and provide a thorough overview of consideration for instrument selection in children. Cliff et al.²³ have also published a helpful review of methodological considerations for using accelerometers in very young children.

In summary, Pathways clearly showed the feasibility and utility of physical activity questionnaires and accelerometry in American Indian communities. The Pathways PAQ was developed after extensive process evaluation and reflects the typical activities engaged in by children in diverse American Indian communities in different regions of the country. The PAQ is recommended for gathering qualitative information and can provide an index of activity capable of demonstrating group, but not individual, differences in physical activity. Although the Tritrac R3D accelerometer provided an objective measure of physical activity, one day of measurements was not adequate to discriminate among individuals. Today's smaller accelerometers may be more acceptable and would allow multiple days of assessment, which are needed if discrimination among individuals is a goal. Whether triaxial accelerometry is better in children than uniaxial accelerometry remains unresolved. Downloadable accelerometers and pedometers which support time-segmented analyses are desirable, although it is important to select instruments that have been validated in the study population under the conditions of interest if estimating activity intensity and energy expenditure is the goal.

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