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Validation of an instrument for measurement of physical activity in youth

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Abstract **Author Information** **Authors** **Article Outline** **Outline**

This study assessed the reliability and validity of the Previous Day Physical Activity Recall (PDPAR), a self-report instrument designed to measure physical activity in youth. Subjects were randomly selected students in grades 7-12. Test-retest reliability was reported as the correlation between estimated relative energy expenditures determined from two PDPAR administrations completed within 1 h. Interrater reliability was determined by two observers using the scoring protocol. Validity was assessed using footstrikes (pedometer), Caltrac activity counts, and heart rate monitoring as criterion measures. Interrater and test-retest reliability was 0.99 and 0.98, respectively ($P < 0.01$). The correlation between relative energy expenditure from the PDPAR ($kcal \cdot kg^{-1}l \cdot d^{-1}$) and pedometer and Caltrac counts was 0.88 ($P < 0.01$) and 0.77 ($P < 0.01$), respectively. The correlation between percentage heart rate range (HR_{max}-HR_{rest}) and mean energy expenditure from the PDPAR was 0.53 ($P < 0.01$). The correlation between 1-min heart rates > 50% HRR sustained for 20 min and the number of 30-min blocks with a relative energy expenditure of at least four metabolic equivalent tasks(MET) was 0.63 ($P < 0.01$). The PDPAR provides valid and reliable estimates of physical activity and also accurately identifies bouts of moderate to vigorous activity.

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Valid measures of physical activity are needed in the conduct of studies designed to develop effective programs for promotion of physical activity. Physiologic assessment techniques used in laboratory settings, such as measuring oxygen consumption and heart rate, are inappropriate for measuring physical activity in large populations because of their intrusiveness and cost [1,8,10]. For this reason, most physical activity studies have used intervieweror self-administered questionnaires to produce a summary index of the subject's physical activity [5].

Recalls have been a commonly used type of self-report measure of physical activity because they are inexpensive, unobtrusive, and easy to administer[1,14]. However, these instruments have generally provided indices of physical activity that are limited by lack of specificity and have not been fully examined for evidence of reliability and validity. Furthermore, recent research has implied that health benefits associated with physical activity occur not only as a result of structured vigorous exercise but also as a function of total caloric expenditure[6,11], a variable that many recall instruments have been unable to determine with accuracy.

The purpose of this study was to examine the reliability and validity of an innovative physical activity recall instrument for youth, hereafter called the Previous Day Physical Activity Recall (PDPAR). This instrument was designed to address the limitations of other instruments and to provide accurate data on the mode, frequency, intensity, and duration of physical activities.

METHODS

Description of the Instrument

The PDPAR involved completion of a questionnaire that required recall of the previous day's activities for the after school hours (3:00-11:30 p.m.) and their relative intensities. A 1-d recall period was chosen because youngsters have difficulty in accurately recalling their physical activity behavior over longer time periods [14,17]. The instrument was segmented into seventeen 30-min intervals and, as recommended by other researchers [4], used contextual cues to enhance the quality of the data recorded. The instrument provided a numbered list of activities in which youth normally engage. To further enhance the accuracy of the recall, these activities were grouped into the following categories: eating, sleeping/bathing, transportation, work/school, spare time, play/recreation, and exercise/workout.

The student completed the activity mode portion by recording the code number corresponding to the primary activity in which he/she was engaged during the specified 30-min period. Next, for the selected activity, the student rated intensity using the following descriptors: very light (i.e., slow breathing and little or no movement), light (i.e., normal breathing

and movement), medium (i.e., increased breathing and moderate movement), and hard (i.e., hard breathing and quick movement). For each level of intensity, students were provided with cartoon illustrations depicting activities typical of each intensity level.

Scoring Protocol

The scoring protocol for the PDPAR used a specialized grid in which metabolic equivalent task (MET) values corresponding to each level of intensity (very light, light, medium, and hard) are listed for each of 35 activities appearing on the instrument (Table 1). MET levels were taken directly from physical activity energy expenditure lists[2,3,9]. For activities numbers that required a write-in response (job, hobbies, and other), a MET value based on the reported intensity of that activity was obtained from The Compendium of Physical Activities [2]. In situations where the combination of an activity type and intensity combination was considered incompatible (e.g., the activity of "meal" and the intensity rating of "hard"), the cell in question was assigned the MET value of the adjacent less intense cell or the adjacent more intense cell, depending on the activity. If a student made four or more incompatible responses, it was assumed that he or she did not understand the rating scale, and the recall was considered invalid.

Based on the MET level obtained from the grid, each 30-min block was assigned a rate of relative energy expenditure (1 MET = 1 kcal·kg^{-1}·h^{-1}). These values were used to derive estimates of total daily energy expenditure, energy expenditure during specific periods of time, and energy expenditure in specific activities. Assigned MET levels were also used to determine the number of 30-min blocks in which relative energy expenditure was four METs or greater (moderate to vigorous physical activity).

Subjects

A total of 119 randomly selected junior and senior high school students from the Columbia, South Carolina, metropolitan area participated in a series of reliability and validity studies. All students provided written informed consent in a manner approved by the Institutional Review Board of the University of South Carolina.

Reliability of the PDPAR

Interrater reliability. The subjects for this substudy were randomly selected students in grades 8-11 from the student populations of two high schools. Of the 112 students participating, 92% were white, the median age was 15 yr, and there were equal numbers of boys and girls. Students completed the PDPAR in the morning on seven consecutive days, and one day's PDPAR was randomly selected for use in this substudy. One investigator used the scoring protocol for the selected PDPAR and determined a total relative energy expenditure in kcal·kg^{-1} for the after school period. Another researcher then took the same PDPAR and, using the same protocol, determined a total relative energy expenditure. Each researcher also isolated those recalled activities that were in the play/recreation and exercise/workout categories on the PDPAR. They then determined the total relative energy expenditure by the subject in each of those types of activities. A Pearson correlation coefficient was calculated between kcal·kg^{-1} totals as determined by the two different researchers.

Test-retest reliability. The subjects in this substudy were 90 seventh and eighth grade students, 88% of whom were white with a median age of 14 yr and approximately two-thirds of whom were boys. Students completed the PDPAR for the previous day at the beginning of their physical education class. They then filled out a second questionnaire related to knowledge of cardiovascular fitness and participated in their class activities for 30 min. At the end of that time, the same students completed a second PDPAR, recalling the same day. The instruments were then scored by a single investigator. The Pearson correlation between the kcal·kg^{-1} totals for the two recalls was taken as a measure of the test-retest reliability.

Validity of the PDPAR Instrument

Pedometer and Caltrac counts. The subjects for this substudy were 48 students in grades 7-12. Students wore both a pedometer and a Caltrac Personal Activity Computer (Hemokinetics, Madison, WI) (preset to record counts) for the period of time between the end of school and bedtime. The students were told only that they were helping test the mechanical instruments and were unaware that they would be recalling their after school activities. The next morning at school the students completed the PDPAR for the period of time they had worn the pedometers and caltracs. Pearson correlation coefficients were determined for the pedometer counts and the Caltrac counts versus the total relative energy expenditure as estimated from the PDPAR.

Heart rate monitoring. Subjects for this substudy were 26 students (14 boys and 12 girls) ages 15-18, 75% of whom were white. Each student wore a Polar Vantage XL heart rate monitor (Polar CIC Inc, Port Washington, NY) during after school hours. The monitor was programmed to record minute-by-minute heart rates which were downloaded to a computer. The next morning at school the students completed the PDPAR for the period of time they had worn the heart rate monitors.

Three types of analyses were performed. The first analysis determined the within-subject correlation between mean percent of heart rate range (% HRR) for each 30-min period and the estimated rate of relative energy expenditure for each 30-min block of the PDPAR ($kcal \cdot kg^{-1} \cdot h^{-1}$) Heart rate range (HRR) was calculated as HR_{max}-HR_{rest} where HR_{max} was estimated from the formula 220 age, and HR_{rest} was taken as the mean of the five lowest 1-min heart rates recorded during the measurement period. Following calculation of HRR, all heart rates(HR_{raw}) within each 30-min block were converted to a% HRR using the formula (HR_{raw}/HRR) × 100 and averaged to produce mean% HRR.

A second analysis determined the between-subject correlation coefficient between mean% HRR and the estimated mean rate of energy expenditure over the entire after school period ($kcal \cdot kg^{-1} \cdot h^{-1}$). Rates of relative energy expenditure were calculated from the PDPAR using (a) mode only; (b) intensity only; and (c) the usual scoring protocol, which used both mode and intensity. For mode only, a single MET level was assigned to each of the activities listed on the instrument irrespective of the level of intensity chosen. For intensity only, each 30-min block was assigned a MET level based solely on the reported intensity of the activity (very light, light, medium, hard), irrespective of the activity chosen.

A third analysis using the heart rate data was performed to examine the validity of the PDPAR as an estimator of participation in moderate to vigorous physical activity. The threshold for moderate to vigorous activity was taken as a relative energy expenditure of at least four METs, while a heart rate greater than or equal to 50% HRR was taken as the physiologic indicator of moderate to vigorous physical activity. For the purpose of this analysis, the number of 30-min intervals in which the subject's heart rate was at least 50% HRR was determined in three different ways. The first, using the least stringent criterion, categorized a block as moderate to vigorous activity if the heart rate met the minimum requirement at least 10 min of the total 30-min time. A second criterion categorized a block as moderate to vigorous activity if the heart rate met the minimum requirement for at least 15 min of the total 30-min time. The third criterion categorized a block as moderate to vigorous activity if the heart rate met the minimum requirement for at least 20 min of the total 30-min time. Pearson correlation coefficients were calculated for the number of 30-min intervals at or above 50% HRR (using each of the criterion above) and the number of 30-min blocks reported at four METs or greater based on mode only, intensity only, and both mode and intensity.

RESULTS

Reliability

The interrater reliability coefficient for estimated relative energy expenditure for the entire day was 0.99 ($P < 0.01$). The coefficient for estimated relative energy expenditure in play/recreation and exercise workout activities was 0.99 ($P < 0.01$), and 1.0($P < 0.01$), respectively. The test-retest reliability correlation coefficient for the PDPAR administered twice in one hour was 0.98 ($P< 0.01$).

Validity

Caltrac and pedometer. Pearson correlation coefficients between total pedometer counts and estimated total relative energy expenditure, and total Caltrac counts and estimated total relative energy expenditure were 0.88 and 0.77, respectively ($P < 0.01$).

Heart rate monitoring. Within-subject correlations between mean% HRR for each 30-min interval and estimated rate of relative energy expenditure for each 30-min block ranged from -0.62 to 0.90 (mean r = 0.32) and generally failed to reach statistical significance. The six significant correlations($P < 0.01$) ranged from a low of 0.72 to a high of 0.90.

Between-subject correlation coefficients between mean% HRR and mean estimated rate of energy expenditure for the entire after school period are shown in Table 2. Only mean energy expenditure rates derived from both mode and intensity were found to be significantly related to mean% HRR for the after school period. (r = 0.53, $P < 0.01$).

Table 3 displays the Pearson correlation coefficients found between the number of 30-min intervals reported at an estimated energy expenditure of at least four METs based on (a) mode only; (b) intensity only; and (c) both mode and intensity and the number of 30-min intervals with (a) 10 min; (b) 15 min; and (c) 20 min of heart rates greater than or equal to 50% HRR. Significant correlation coefficients were observed for the number of recalled blocks with an intensity of four METs and the number of 30-min intervals in which heart rate was 50% HRR for 20 min or longer. Of these, the highest correlation was found when the scoring protocol prescribed for the PDPAR (using both mode and intensity) was used (r = 0.63, $P < 0.01$).

DISCUSSION

This study established the reliability and validity of a physical activity recall instrument (PDPAR) that was designed to overcome some of the limitations associated with instruments used previously with youth. The strong test-retest reliability coefficient (r = 0.98) indicated that subjects' recall of their previous day's physical activities was stable when reported twice within 1 h. The interrater reliability of 0.99 was evidence that the scoring protocol for the PDPAR could be used consistently by different investigators.

The results of the validity substudies indicate that estimates of relative energy expenditure and participation in episodes of moderate to vigorous physical activity could be determined from data provided on the PDPAR instrument. At first, the highly variable and generally nonsignificant within-subject correlation coefficients between mean% HRR and estimated rate of energy expenditure for each 30-min block could be viewed as problematic. However, when mean% HRR and mean estimated energy expenditure were examined over the entire after school period across all subjects, the correlation was markedly higher. This suggests that the subjects did recall with accuracy the mode and intensity of their activity but often did not accurately recall the specific 30-min time block during which they engaged in an activity. The utility of taking into account both the mode and intensity of the selected activity was borne out by the data in Table 2.

In the design of the PDPAR it was important that the recall instrument not only provide a summary measure of activity but that it also detect participation in specific bouts of activity that were of moderate to vigorous intensity. The significant correlation coefficients shown inTable 3 support the conclusion that the subjects tended to accurately report episodes of moderate to vigorous activity. Other researchers have found that youths over-report the time they spend in vigorous activities and underreport time spent in sedentary activities[12,13]. However, this observation could not be substantiated here. Again, the utility of the prescribed, two-component scoring protocol used with the PDPAR was substantiated by the higher correlation coefficients between the number of 30-min blocks rated at 4 METs or greater as derived from both mode and intensity and the number of 30-min blocks with heart rates at or above 50% HRR.

Sallis [14] has reviewed 22 studies reporting validity and reliability of physical activity self reports in youth. Only one of these studies used an instrument that provided information on mode, intensity, and duration of physical activity, but neither its validity nor reliability had been established [18]. Other instruments, reviewed by Sallis [14], that provide an

estimate of energy expenditure had reliability and validity coefficients lower than those observed for PDPAR. Sallis et al. [15] used a 1-d recall instrument to estimate energy expenditure in physical activity and reported correlation coefficients of 0.45 with the Caltrac and 0.38 with the heart rate monitor. Sallis et al. [16] utilized a 7-d recall and found a test-retest reliability of 0.79 ($P < .01$) in eighth graders and correlation coefficients between energy expenditure in vigorous activity and heart rate data of 0.45 ($P < 0.05$) in eighth graders and 0.57 ($P < 0.01$) in eleventh graders. Therefore, the reliability and validity of the PDPAR compare favorably with those of other self-report physical activity instruments[14]. This may, in part, be attributable to differences in the populations studied, the use of both mode and intensity to characterize relative energy expenditure, and the short test-retest period used in this study.

A further strength of the PDPAR is its flexibility. It provides data that can be reduced in different ways depending on the needs of the investigator. The PDPAR can provide summary information on the estimated relative energy expenditure across a specified period of time. Also, it can record individual bouts of physical activity at or above specified levels of relative energy expenditure. Emerging evidence indicates that accumulated moderate physical activity and structured bouts of vigorous activity are important[7,11]. It is important that participation in both types of physical activity can be detected with this specific instrumentation. Also PDPAR can provide data about an individual's participation in sedentary activities such as eating, doing homework, or television watching.

Our validation of PDPAR is subject to limitations imposed by the criterion measures of physical activity. Physiological data generally have been thought to be valid criteria for the measurement of behavior, especially physical activity. However, use of footstrikes, activity counts, and heart rate as criterion measures introduces a source of random measurement error[14]. Thus, variability in these measures unrelated to one's ability to recall their physical activity on the previous day may have attenuated the correlations with estimated relative energy expenditure as calculated from the PDPAR.

The PDPAR yields a point prevalence view of physical activity that is a 1-d snapshot. Therefore, it is necessary to administer the recall instrument on several occasions to get a more complete picture of habitual physical activity and energy expenditure patterns. Future studies should assess the minimum number of 1-d recalls that provide the most accurate assessment of activity over a longer period of time (e.g., a week or a month).

This study of reliability and validity uses a study population of youth at the seventh- to twelfth-grade level. At some younger age, it is presumed that a child would be unable to complete the current recall instrument in an accurate manner. Future studies should establish an age limit below which the instrument would lack reliability and validity because of cognitive limitations of the subjects.

In summary, the instrument examined in this study was found to be acceptably valid and reliable. Furthermore, the results of this study demonstrate that the PDPAR gives an acceptable estimate of relative energy expenditure over the course of an 8 h recording period and also accurately identifies bouts of moderate to vigorous activity. As studies are conducted to assess the current physical activity levels of youths and to design interventions to increase those levels, the PDPAR may be used as a valid and efficient measurement tool.

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