Comparison of Actiwatch® activity monitor and Children’s Activity Rating Scale in children

KEVIN J. FINN and BONNY SPECKER

School of HPELS, WRC 203, University of Northern Iowa, Cedar Falls, IA 50614-0241; and Ethel Austin Martin Program in Human Nutrition, South Dakota State University, Brookings, SD 57007

ABSTRACT

FINN, K. J., and B. SPECKER. Comparison of Actiwatch® activity monitor and Children’s Activity Rating Scale in children. Med. Sci. Sports Exerc., Vol. 32, No. 10, pp. 1794–1797, 2000. Purpose: The Children’s Activity Rating Scale (CARS) is a rating scale that is used in direct observation of physical activity in children. Direct observation is costly and tedious, and accuracy may decrease as the observation period lengthens. Recently, motion sensors have gained acceptance for assessment of physical activity. The purpose of this study was to compare 6 h of activity levels using simultaneous monitoring of preschool aged children with CARS and the Actiwatch (Mini-mitter Company Inc.) activity monitor. Methods: A total of 40 children had 5–6 h (mean of 5.9 h) of direct observation while wearing a monitor on the waist. Simultaneous 3-min mean CARS scores and 3-min activity counts were matched for each subject. Results: The range for the mean 3-min CARS scores ranged from 1.00 to 4.50. The 3-min activity counts ranged from 0 to 9,695 with a mean of 670 (median 243). The within child correlations between the 3-min CARS score and the 3-min sensor readings ranged from 0.03 to 0.92 (median of 0.74). We found the correlation coefficients were higher in those children who were more active, probably due to the larger ranges in the CARS scores. When using mixed model repeated measures, sensor readings were significantly associated with CARS (P < 0.001). Conclusion: Our results indicate that the 3-min CARS score correlates with 3-min activity counts, favoring the use of the activity monitors in assessing physical activity in preschool-aged children. Key Words: ENERGY EXPENDITURE, OBSERVATION

The report of the Surgeon General on Physical Activity and Health has presented supportive data to suggest that daily physical activity can provide health benefits, including a reduction in the prevalence of obesity, adult-onset diabetes, and risk factors associated with coronary heart disease (CHD). In addition, benefits may include improved bone density, mental health, and health-related quality of life. Thus the recommendation of the Surgeon General’s Report is to encourage all people over the age of 2 yr to engage in moderate daily activity of at least 30 min for general health and prevention of heart disease (14). With specific reference to elementary school-aged children, the Council for Physical Education of the National Association for Sport and Physical Education (NASPE) has recommended that children should accumulate at least 30–60 min of age and developmentally appropriate physical activity on all, or most days of the week (4). For young children (ages 5–9), this group recommends that the greatest portion of accumulated physical activity come from lifestyle activities which include active play and games involving the large muscles of the body.

Assessment of physical activity in preschool-aged children has been performed to describe the present levels of physical activity in these individuals, to define a setting (day-care, playground), and to evaluate interventions that are used to increase physical activity behavior or reduce risk factors for disease. Observers that identify type, and measure frequency and duration of physical activity make direct observations. These observers must be trained in the assessment instrument, and the setting usually makes it necessary to employ at least one observer for each subject. Among the field methods of assessment for this population include direct observation of physical behavior. The Fargo Activity Time-Sampling Survey (FATS) is a 10-s observe-record interval time-sampling procedure coding a child’s behavior into eight categories and three intensity levels for each category (6). The Children’s Activity Rating Scale (CARS) is a rating scale that was developed to provide an activity score representative of energy expenditure in young children (10). It has been used successfully to describe physical activity in young children from different ethnic groups (1,5). Although direct observation is accepted as the standard in this age group, the assessment is costly, recording is tedious, and accuracy may decrease as the observation period lengthens.
Movement assessment devices, or motion sensors, have gained acceptance for assessment of physical activity due to the development of devices that can detect movement continuously in a monitor that has the capability to store data for days (3,15). The Actiwatch® (registered trademark of Mini Mitter Company, Inc., Sunriver, OR) is a long-term activity monitoring device that can be worn on the limb(s) or the torso without discomfort. The compact size (27 mm × 26 mm × 9 mm) of the device is suitable for use in children, although it has not been validated for assessing physical activity in preschool-aged children. The device has been used in sleep studies (11,16,17) and is beginning to be used in energy expenditure studies (13). A recent comparison of activity monitors worn during treadmill walking has provided strong correlations with energy expenditure (9). This method is useful for validating motion sensors for adult activities; however, it may be inappropriate for validating sensor counts in children due to the intermittent nature of the child’s activity patterns. Simultaneous observational data are needed to compare with the Actiwatch activity counts to evaluate it as a useful instrument of physical activity for preschool aged children.

Thus, the purpose of this study was to compare CARS and Actiwatch activity monitor by using simultaneous monitoring of preschool aged children.

METHODS AND PROCEDURES

Subjects. This study is conducted as part of a larger longitudinal study (South Dakota Children’s Health Study) designed to investigate the interaction of physical activity and calcium intake on bone mass accretion. Written consent was obtained from the child’s parent and the Human Subjects Committee approved protocol. At baseline, all children had 6 h of direct observation and 48-h motion sensor measurements. For this study, forty 3–4-yr-old children were observed for levels of physical activity in a child-care setting while wearing a motion sensor during a 6-h period.

Children’s Activity Rating Scale. CARS was used in the direct observation to measure activity levels each minute between 9 a.m. and 3 p.m. Common activities by preschool aged children are classified into five levels according to a rating system developed by Puhl et al. (10). The level 1 activities are sedentary. The level 2 activities are sedentary but include movement of the limbs or torso. Level-3 to -5 activities are labeled as translocation (moving the body from one location to another). The speed or intensity of the activities determines the level. By using the coding rules by Puhl et al. (10), a level of physical activity observed for 3-s duration or repeated in brief duration (<3 s) at least three times within 15 s are recorded using a standard score sheet. Only one activity at each level is recorded, with up to five scores being recorded within each min. All levels within the minute were then averaged, and the mean minute CARS score was recorded. All study observers followed a standardized training protocol involving an orientation of the CARS and scoring videotapes of children both in daycare settings and during gross motor activity classes. During the initial stages of the study, two study observers scored one child. These scores were compared, and 10-min averages were within ±10%. Any new observers after the start of the study were required to score a child in the presence of the experienced observer until a comparative score within ±10% was obtained. A total of eight observers were used in this study. Each observer was limited to 120 min of continuous monitoring, and each subject was scored by no more than two study personnel. Each observer scored each minute as indicated by a watch that was synchronized to the internal clock in the activity device.

Actiwatch activity monitor. The Actiwatch activity monitor contains an omni-directional sensor capable of detecting acceleration in two planes. Sensitive to 0.01 gravity (0.098 m s\(^{-2}\)), this type of sensor integrates the degree and speed of motion and produces an electrical current that varies in magnitude. An increased degree of speed and motion produces an increase in voltage. The monitor stores this information as activity counts. The maximum sampling frequency is 32 Hz (8). For this study, the activity monitor was placed on the waist of each subject with the base of the instrument positioned against the lumbar spine using a belt on which the device was secured. This orientation allowed for sensing of body acceleration during forward/backward and left/right motions. The position on the torso has been shown to provide a better measure of reliability as compared with wearing on the wrist and/or ankle using a similar type of movement-sensing device (2). This placement on the lower back was selected because it tends to minimize the time children play with the sensor. All six devices used in this study were tested for variation within and between monitors while simultaneously worn on an adult while walking and running on a treadmill for 16 min at various speeds (4 min at each speed). The intra-monitor coefficient of variation ranged from only 1.8 to 5.6% for minute to minute variability at the speeds tested. The minute to minute coefficients of variation between monitors at speeds of 3.22, 6.44, 9.65, and 12.78 km h\(^{-1}\) were calculated to be 17%, 11%, 8%, and 10% respectively. For this study, the monitors were programmed to store total activity counts per minute during the observation period. These activity counts were downloaded into a spreadsheet until analysis.

Statistical analysis. Descriptive analysis was performed on all minutes CARS scores and Actiwatch activity counts during the observation period. Three minutes of CARS scores and simultaneous Actiwatch activity counts were grouped and matched within a subject’s data file. We chose 3 min as a minimal matching increment that would ensure a majority of overlap between the two methods of assessment in the case of a small misalignment of the internal clock of the monitor and the watch used by the observer. The CARS scores for each of the 3 min were averaged and the three-min activity counts were obtained by summing the three 1-min counts. A correlation coefficient for the relationship between CARS scores and sensor counts over the 6-h observation period was obtained for each child (within-child correlation) and the median and range of these scores were compared, and 10-min averages were within ±10%. Any new observers after the start of the study were required to score a child in the presence of the experienced observer until a comparative score within ±10% was obtained. A total of eight observers were used in this study. Each observer was limited to 120 min of continuous monitoring, and each subject was scored by no more than two study personnel. Each observer scored each minute as indicated by a watch that was synchronized to the internal clock in the activity device.

Actiwatch activity monitor. The Actiwatch activity monitor contains an omni-directional sensor capable of detecting acceleration in two planes. Sensitive to 0.01 gravity (0.098 m s\(^{-2}\)), this type of sensor integrates the degree and speed of motion and produces an electrical current that varies in magnitude. An increased degree of speed and motion produces an increase in voltage. The monitor stores this information as activity counts. The maximum sampling frequency is 32 Hz (8). For this study, the activity monitor was placed on the waist of each subject with the base of the instrument positioned against the lumbar spine using a belt on which the device was secured. This orientation allowed for sensing of body acceleration during forward/backward and left/right motions. The position on the torso has been shown to provide a better measure of reliability as compared with wearing on the wrist and/or ankle using a similar type of movement-sensing device (2). This placement on the lower back was selected because it tends to minimize the time children play with the sensor. All six devices used in this study were tested for variation within and between monitors while simultaneously worn on an adult while walking and running on a treadmill for 16 min at various speeds (4 min at each speed). The intra-monitor coefficient of variation ranged from only 1.8 to 5.6% for minute to minute variability at the speeds tested. The minute to minute coefficients of variation between monitors at speeds of 3.22, 6.44, 9.65, and 12.78 km h\(^{-1}\) were calculated to be 17%, 11%, 8%, and 10% respectively. For this study, the monitors were programmed to store total activity counts per minute during the observation period. These activity counts were downloaded into a spreadsheet until analysis.

Statistical analysis. Descriptive analysis was performed on all minutes CARS scores and Actiwatch activity counts during the observation period. Three minutes of CARS scores and simultaneous Actiwatch activity counts were grouped and matched within a subject’s data file. We chose 3 min as a minimal matching increment that would ensure a majority of overlap between the two methods of assessment in the case of a small misalignment of the internal clock of the monitor and the watch used by the observer. The CARS scores for each of the 3 min were averaged and the three-min activity counts were obtained by summing the three 1-min counts. A correlation coefficient for the relationship between CARS scores and sensor counts over the 6-h observation period was obtained for each child (within-child correlation) and the median and range of these scores were compared, and 10-min averages were within ±10%. Any new observers after the start of the study were required to score a child in the presence of the experienced observer until a comparative score within ±10% was obtained. A total of eight observers were used in this study. Each observer was limited to 120 min of continuous monitoring, and each subject was scored by no more than two study personnel. Each observer scored each minute as indicated by a watch that was synchronized to the internal clock in the activity device.

Actiwatch activity monitor. The Actiwatch activity monitor contains an omni-directional sensor capable of detecting acceleration in two planes. Sensitive to 0.01 gravity (0.098 m s\(^{-2}\)), this type of sensor integrates the degree and speed of motion and produces an electrical current that varies in magnitude. An increased degree of speed and motion produces an increase in voltage. The monitor stores this information as activity counts. The maximum sampling frequency is 32 Hz (8). For this study, the activity monitor was placed on the waist of each subject with the base of the instrument positioned against the lumbar spine using a belt on which the device was secured. This orientation allowed for sensing of body acceleration during forward/backward and left/right motions. The position on the torso has been shown to provide a better measure of reliability as compared with wearing on the wrist and/or ankle using a similar type of movement-sensing device (2). This placement on the lower back was selected because it tends to minimize the time children play with the sensor. All six devices used in this study were tested for variation within and between monitors while simultaneously worn on an adult while walking and running on a treadmill for 16 min at various speeds (4 min at each speed). The intra-monitor coefficient of variation ranged from only 1.8 to 5.6% for minute to minute variability at the speeds tested. The minute to minute coefficients of variation between monitors at speeds of 3.22, 6.44, 9.65, and 12.78 km h\(^{-1}\) were calculated to be 17%, 11%, 8%, and 10% respectively. For this study, the monitors were programmed to store total activity counts per minute during the observation period. These activity counts were downloaded into a spreadsheet until analysis.

Statistical analysis. Descriptive analysis was performed on all minutes CARS scores and Actiwatch activity counts during the observation period. Three minutes of CARS scores and simultaneous Actiwatch activity counts were grouped and matched within a subject’s data file. We chose 3 min as a minimal matching increment that would ensure a majority of overlap between the two methods of assessment in the case of a small misalignment of the internal clock of the monitor and the watch used by the observer. The CARS scores for each of the 3 min were averaged and the three-min activity counts were obtained by summing the three 1-min counts. A correlation coefficient for the relationship between CARS scores and sensor counts over the 6-h observation period was obtained for each child (within-child correlation) and the median and range of these scores were compared, and 10-min averages were within ±10%. Any new observers after the start of the study were required to score a child in the presence of the experienced observer until a comparative score within ±10% was obtained. A total of eight observers were used in this study. Each observer was limited to 120 min of continuous monitoring, and each subject was scored by no more than two study personnel. Each observer scored each minute as indicated by a watch that was synchronized to the internal clock in the activity device.
correlation coefficients are given. Mixed model repeated measures analysis also was performed to compare the child’s activity counts with the CARS score. Statistics were performed using SAS software (Cary, NC).

RESULTS

A total of 40 children had 5–6 h of direct observation while wearing a sensor on the waist. The mean (± SD) weight and height for the 40 children (24 girls, 16 boys) were 16.81 (± 2.55) kg and 102.4 (± 5.9) cm, respectively. Thirty-eight of the children were Caucasian.

On average the children were observed 355 min (5.9 h). Analysis of the minute CARS scores showed a mean (± SD) of 1.6 (± 0.2) for the children over the total period, with a range of 1.1 to 2.0. Over the 5- to 6-h observation period, the minute CARS score of less than 2.0 was recorded 66% of the time, whereas scores of 2.0–2.9 were recorded 26% of the time. Five percent of the total time the CARS scores were between 3.0 and 3.9, whereas slightly less than 1% of the minute scores were 4.0 or greater.

The range for the mean 3-min CARS scores was 1.0–4.5. The 3-min sensor counts ranged from 0 to 9,695 with a mean of 670 (median 243). The within-child correlation coefficients between the 3-min CARS score and the 3-min sensor readings over the 5–6 h of observation ranged from 0.03 to 0.92 with a median of 0.74.

To determine whether the relationship between the CARS score and the sensor counts varied according to the activity level of the child, we investigated the relationship between the children’s correlation coefficients (within-child correlation) and their different measures of activity. A positive relationship was observed between the within-child correlation coefficients and either the mean 3-min CARS (r = 0.37, P = 0.02) or mean sensor counts (r = 0.31, P = 0.05). These results indicate that the relationship between the CARS scores and motion sensor counts, or correlation coefficients, were better in those children who were more active. By using mixed model repeated measures, sensor counts were significantly associated with CARS scores.

DISCUSSION

Our results indicate that the motion sensor counts determined by the Actiwatch are correlated with direct observation of activity as assessed by the CARS. Our findings are similar to correlations reported by Klesges and Klesges (7) in which the hourly readings of the Caltrac correlated with observer scores using the Fargo Activity Time-Sampling Survey (FATS) observational system. Although both the

REFERENCES


This work was supported by NIH grant R01 AR45310.

Address for correspondence: Kevin J. Finn, School of HPELS, WRC 203, University of Northern Iowa, Cedar Falls, IA 50614-0241; E-mail: kevin.finn@uni.edu.


