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Reliability and Validity of Physical Activity Questionnaires for Children: The Children's Leisure Activities Study Survey (CLASS)

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This study aimed to develop a reliable, valid, and feasible method for assessing physical activity among children ages 5–6 and 10–12 years. Test–retest reliability of a parental proxy questionnaire and a children's self-report questionnaire was assessed in 280 children and parents. The criterion validity of the questionnaires was assessed using accelerometry. The proxy questionnaire provided a reliable measure of the type, frequency, and duration of children's physical activity. Neither version of the questionnaire provided an accurate estimate of individual children's physical activity. To assess the type, frequency, intensity, and duration of children's activity, a combination of questionnaire and objective measures should be employed.

Physical activity is important for health, and promoting physical activity is an important component of national health strategies in developed and developing countries (5,23). Despite the fact that it is recognized as an important public health issue, only poor population-level data regarding children's physical activity are available in Australia. This lack of population data relates, in part, to the universal difficulties associated with measuring physical activity in children. Even though there are a number of techniques for assessing activity, including direct observation, the use of motion sensors, heart-rate monitors, and doubly labeled water, self-report and proxy-report questionnaires are the most common means of assessing physical activity at the population level (15).

Adult physical activity questionnaires generally assess four activity dimensions: type, frequency, duration, and intensity. These multiple dimensions of activity are important because among adults they relate in different ways to various health outcomes (19). The relationship between the four dimensions of children's physical activity and health outcomes, however, is not well understood (19). Most existing children's physical activity questionnaires assess only two or three of the four physical activity dimensions (17). To further our understanding of the relationship between children's physical activity and health outcomes, it is thus

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important that survey measures incorporating all four dimensions of physical activity be developed and used to assess children's physical activity.

The assessment of children's physical activity by means of questionnaires is problematic (24). Children's physical activity is spontaneous and sporadic (4), and younger children such as 5- to 6-year-olds rarely engage in structured or organized physical activity. Children accumulate physical activity through a combination of free play, sport, and transport in different settings throughout the day (4). As a consequence, there is a significant potential for recall error when children self-report their physical activity (15). Furthermore, the use of self-report instruments is not appropriate for children less than 10 years old because of their limited cognitive abilities (15). Whereas proxy reports by parents, guardians, or teachers can be used to assess physical activity in young children, because children's activity is accumulated in so many different settings across the day, the accuracy of proxy report is limited by the respondent's opportunities to observe the physical activity of the child (17).

Assessing physical activity that can occur at home, at school, or in the child's neighborhood and that can be in the form of organized sports, nonorganized sport, walking and cycling for transport, free play, and incidental activity poses a major challenge. A recent review of physical activity measures by Sallis and Saelens (17) identified eight self-report recall instruments used with children age 9 and above and two proxy-report instruments. They concluded that all instruments exhibited acceptable reliability and that all showed some evidence of validity. Of these 10 instruments, the Child/Adolescent Activity Log (CAAL), developed by Garcia and colleagues (8), was the only validated instrument that can be used to assess physical activity type, frequency, intensity, and duration (17). Because CAAL is used as either a 1-day or a 3-day recall, however, multiple administrations are required. Generally, validity is highest for the 1-day recall instruments (17,24); however, the need for multiple administrations to characterize habitual physical activity is a major limitation of this approach. In assessing children's physical activity at the population level, it is important that the instrument selected be reliable, accurate, and feasible. Administering a questionnaire four or five times a week is burdensome for participants and an expensive technique for population surveys.

The aim of this study was to develop a reliable, valid, and feasible method that can be used to assess physical activity behavior in large-scale population studies of primary-school-age children. This article describes the test–retest reliability and the convergent and criterion validity of a self-report physical activity questionnaire for children age 10–12 years and a proxy-report questionnaire for children age 5–6 and 10–12 years.

Methods

Sample and Recruitment

A convenience sample of five state primary schools, three from western metropolitan Melbourne and two from eastern metropolitan Melbourne, were approached, and they agreed to participate in the study. Children who were 5–6 years or 10–12 years of age were eligible to participate. Ethical approval for the study was obtained from the Deakin University Ethics Committee and the Department of Education, Victoria, and informed consent was obtained from the children's parents.

Procedure

The 5- to 6-year-old and 10- to 12-year-old children were given a baseline proxy-report typical-week physical activity questionnaire to take home for one of their parents to complete. Completion time for the proxy-report questionnaire was approximately 10 min. In addition, the 10- to 12-year-old children completed a baseline self-report version of the same questionnaire in class, which took approximately 15 min to complete. This was a guided completion, whereby one of the investigators was present in the class and provided assistance to students as necessary. To assess the repeatability of the questionnaires, the 10- to 12-year-old children completed the self-report questionnaire in class 7 days after the baseline administration. Parents completed a second, identical questionnaire at least 14 days after the baseline administration. To assess the validity of the questionnaires, each child wore a Manufacturing Technology Inc. (MTI; formerly known as Computer Science and Applications) accelerometer around his or her waist for 8 days during waking hours when not bathing or swimming.

Measures

The Children's Leisure Activities Study Survey (CLASS). Two identical questionnaires were developed, one for parents (proxy report) and one for 10- to 12-year-old children (self-report). The instrument was based on existing questionnaires (18,25) and qualitative interviews with 27 families. The questionnaire developed in the present study was based on these measures but modified to examine children's usual physical activity Monday to Friday and Saturday to Sunday.

In the proxy-report CLASS questionnaire, parents were asked about their sex, age, country of birth, marital status, employment status, occupation, and education; the sex of their child; and their relationship to the child in the study. The self-report version of the CLASS questionnaire consisted of five demographic or general items asking about participants' sex, date of birth, teacher's name, school grade, and school.

The proxy-report version of the CLASS questionnaire consisted of an extended checklist of 30 physical activities. For each physical activity in the checklist, parents were asked to circle yes or no, indicating whether their child does that activity during a typical week (Monday to Friday) and during a typical weekend (Saturday and Sunday). "Typical week" was defined as being during the current school term, not including school holidays. If they circled yes, parents were asked to report the frequency of the activity (how many times Monday–Friday and Saturday–Sunday) and the total time their child spent in that activity (minutes or hours Monday–Friday and Saturday–Sunday). The self-report physical activity measure completed by the child was identical to the proxy-report measure. The proxy measure was piloted with 10 parents, and the self-report survey was pilot-tested with 23 Grade 5 children.

Accelerometer. Recent developments in technology have enabled objective assessment of physical activity using small activity monitors (or accelerometers) (10,22). Accelerometers can provide objective estimates of overall physical activity and physical-activity-related energy expenditure among adults (7,13) and among children (22). The MTI Actigraph Model AM7164-2.2C accelerometer is small and lightweight, measuring 5.1 $\times$ 3.8 $\times$ 1.5 cm and weighing only 43 g. The

unit uses an accelerometer to measure motion in the vertical plane, with movement outside of normal human motion being filtered out electronically. The MTI accelerometers were initialized using an IBM-compatible computer with a reader-interface unit that configures the monitor to switch on and off at a specified date and time and downloads data collected in 1-min epochs.

Data Management and Analysis

Reliability. Data were analyzed using SPSS for Windows®, version 11.0. The prevalence of reported participation (yes or no) in the individual physical activity items from the CLASS self-report and proxy-report questionnaires is presented using data from the first administration. Test–retest reliability of reported participation in the individual physical activity items from the questionnaires was determined using percentage agreement. The following interpretations were applied to each percentage-of-agreement value based on Landis and Koch (11): 0%, poor; 1–20%, slight; 21–40%, fair; 41–60%, moderate; 61–80%, substantial; and 81–100%, almost perfect. The reliability of the frequency and duration of children's physical activities was examined using an intraclass correlation coefficient (ICC) and 95% confidence intervals (95% CI). An ICC value of .7 or higher was considered to represent an acceptable level of agreement (20).

The CLASS questionnaire data were converted to units of time (minutes per week) spent in moderate-intensity, vigorous-intensity, and combined moderate- and vigorous-intensity (total) physical activity. Activities were classified as moderate or vigorous by assigning metabolic equivalent units (METs) at rest according to values published in the *Compendium of Physical Activities* (1). The CLASS questionnaire consisted of 18 activities classified as moderate-intensity (3–5.9 METs): baseball or softball, bicycling, dance, downball, gymnastics, household chores, physical education class, playground equipment, playing in playhouse, playing with pets, school sport class, scooter, skateboard, trampoline, travel to school by walking, travel to school by bicycling, walking for exercise, and walking the dog. Twelve activities were classified as vigorous (6+ METs): aerobics, Australian-rules football, basketball, jogging or running, netball, rollerblading, skipping, soccer, swimming for fun, swimming laps, playing tag or chasey, and playing tennis or bat tennis.

Examination of the proportion of children participating in each activity revealed that very few children, if any, played badminton, so this item was dropped from all analyses. The reliability of self-reported and proxy-reported frequency and duration of each of the remaining 29 physical activities and of children's moderate-intensity, vigorous-intensity, and total physical activity was examined using an ICC. In addition, an analysis of reliability of self-reported and proxy-reported time children spent in moderate, vigorous, and total physical activity was performed by child's sex, parental education (≤12 years, >12 years), and child's activity level (MTI movement counts dichotomized at the median).

Convergent Validity. To assess the convergent validity between the proxy-report and self-report measures for 10- to 12-year-olds, type, intensity, frequency, and duration of children's physical activity were examined using ICCs.

Criterion Validity. To be consistent with the CLASS questionnaire data, the MTI data were expressed as time (minutes per week) spent in moderate- and vigorous-intensity activities, which were determined by applying the age-specific

energy-expenditure prediction equation developed by Freedson and colleagues (7): METs = 2.757 + (0.0015 · counts · min^{-1}) – (0.08957 · age [years]) – (0.000038 · counts · min^{-1} × age [years]). For example, 1,017–3,695 counts/min were classified as moderate-intensity physical activity (3–5.9 METs) for 10-year-old children. In addition, because not all the children wore the MTI for each of the 8 days (14 of the 10- to 12- year-olds and 8 of the 5- to 6- year-olds failed to wear the MTI every day), only children who recorded more than 10,000 movement counts per day for a minimum of 4 days were included in the analyses. Our experience has shown that it is considered unlikely that the accelerometer has been worn if the movement counts total less than 10,000. To maximize the number of cases included in analyses, the survey and MTI data were reduced to minutes of physical activity per day (for days the MTI was worn).

To assess the individual-level validity of the survey instruments, correlations between the MTI data (minutes in moderate, vigorous, and total physical activity per day determined by the Freedson formula) and questionnaire data (minutes in moderate, vigorous, and total physical activity per day) were performed using Spearman's rank-order testing. In addition, self-reported and proxy-reported total physical activity per day were correlated with MTI raw movement counts per day. An analysis of the self-reported and proxy-reported time children spent in moderate-intensity, vigorous-intensity, and total physical activity was also performed by child's sex, parental education (≤12 years, >12 years), and child's activity level (MTI movement counts dichotomized at the median).

To assess the group-level validity of the survey instruments, the mean difference and 95% CI (minutes per day) for moderate-intensity, vigorous-intensity, and total physical activity were calculated by subtracting the mean MTI minutes from the proxy-reported minutes. This was repeated for the self-report measure. To examine the level of error (for the sample) associated with self-reported and proxy-reported duration of moderate-intensity, vigorous-intensity, and total physical activity, box-and-whisker plots were graphed. Error was calculated by subtracting duration (minutes per day) recorded by the MTI from self-reported and proxy-reported duration.

Results

Characteristics of Participants

The sample of younger children comprised 58 children age 5–6 years (79% from schools in western metropolitan areas of Melbourne) with a mean age of 5.3 years (± 0.5), 63% of whom were boys. The mean age of parents (n = 58, 91% women) was 37.4 years (± 6.2). Parents were mostly Australian born (77%) and currently married (90%). Twenty-two percent were employed full-time, 30% were employed part-time, and 35% were engaged full-time in home duties.

The sample of older children consisted of 111 children age 10–12 years (mean age = 10.6 ± 0.8 years) who were recruited from five state primary schools (51% from schools in eastern metropolitan areas of Melbourne). The same number of parents as children (n = 111) completed both administrations of the questionnaires. Two parents, however, provided extreme proxy reports of their child's moderate-intensity physical activity (more than 24 hr/day) and were subsequently removed from all analyses. Girls made up 63% of the 10- to 12-year-old group, and 83% of

parents or guardians were women. The mean age of parents was 40.3 years (± 5.9). Most parents were Australian born (75%) and were currently married (69%). Thirty-six percent were employed full-time, 32% were employed part-time, and 21% were engaged full-time in home duties. To assess the consistency of older and younger children's physical activity measured by the MTI across the 8 days, ICC correlations revealed that moderate, vigorous, and total activity were significantly correlated (0.7, 0.8, and 0.8, respectively). These results were consistent for boys and girls.

Reliability of the Questionnaires

Individual Physical Activity Items. The test–retest reliability (percentage agreement) of the moderate and vigorous individual items (items listed in data-management section) in the proxy-report and self-report CLASS questionnaires ranged from 62% to 94%, displaying substantial to almost perfect agreement (11). (Full information regarding individual activities is available from the author.)

Activity Frequency and Duration. Table 1a and 1b show the repeatability of the proxy-reported and self-reported frequency and duration of individual activities and of overall moderate-intensity, vigorous-intensity, and total physical activity. Self-reported physical activity frequency had acceptable reliability for 11 of the 29 items, and self-reported physical activity duration had acceptable reliability for just 8 of the 29 items. The proxy-report measure of 5- to 6-year-olds' physical activity had a similar number of items with acceptable reliability for frequency (11 out of 29) and duration (8 out of 29). The proxy-report instrument assessing 10- to 12-year-olds' physical activity, however, had more acceptable levels of reliability. The repeatability of the items assessing the frequency and duration in overall moderate, vigorous, and total activity was acceptable for proxy-report items but not for the self-report measure.

Reliability analysis by child's sex, parental education, and activity level of the child showed that there were a small number of differences in reliability scores for the proxy- and self-report instruments. For example, parents proxy-reporting how much time their 5- to 6-year-old boys spent in moderate-intensity physical activity were less reliable (ICC = .38) than parents reporting for girls (ICC = .72). Proxy-reporting of younger children's moderate-intensity physical activity duration was less reliable among parents who had 12 years or less education (ICC = .35) than among those who had a university education (ICC = .75). This finding, however, was reversed for parents proxy-reporting their older children's vigorous physical activity duration, with parents who had 12 years or less education reporting more reliably (ICC = .89) than did parents with a university education (ICC = .32). Children whose activity level was below the median had lower test–retest reliability scores for self-reported time spent in moderate physical activity (ICC = .15) than those of children who were more active (ICC = .6). There were no other differences in the reliability of the self-report measure by demographics or by activity level.

Convergent Validity of the Questionnaires

A high number of items (24 out of 29) had 70% agreement or more between the proxy-report and self-report questionnaires for 10- to 12-year-olds (Table 2a and

Table 1a Test–Retest Reliability of the Proxy-Report and Self-Report Items in the CLASS Questionnaires for Vigorous Physical Activity (6+ METs)

	Frequency ICC (95% CI) Test–Retest			Duration ICC (95% CI) Test–Retest		
	Proxy Report			Proxy Report		
Activity	5–6 yrs	10–12 yrs	Self-report, 10–12 yrs	5–6 yrs	10–12 yrs	Self-report, 10–12 yrs
Tag/Chasey	.77***	.79***	.38**	.71***	.56***	.07
Swimmming for fun	.12	.60***	.61***	.33	.51***	.64***
Jogging/Running	.84***	.53***	.31*	.61***	.51***	.20
Tennis/Bat tennis	.77***	.85***	.59***	.37*	.92***	.62***
Swimming laps	.59***	.31*	.36**	.46**	.54***	.30*
Rollerblading	.64***	.74***	.79***	.59***	.76***	.17
Australian-rules football	.45**	.41**	.37**	.49**	.67***	.71***
Basketball	.23	.91***	.79***	.12	.94***	.92***
Skipping	.31	.26	.40**	.19	.04	–.02
Soccer	.34*	.77***	.75***	–.04	.80***	.74***
Netball	NA	.93***	.43***	NA	.86***	.42**
Aerobics	NA	.54***	.73***	NA	.28*	.34**
Total vigorous physical activity	.87***	.75***	.42**	.81***	.62***	.41**

Note. NA = not applicable, i.e., zero participation rate.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 1b Test–Retest Reliability of the Proxy-Report and Self-Report Items in the CLASS Questionnaires for Moderate Physical Activity (3–5.9 METs)

	Frequency ICC (95% CI), Test–Retest			Duration ICC (95% CI), Test–Retest		
	Proxy Report			Proxy Report		
Activity	5–6 yrs	10–12 yrs	Self-report, 10–12 yrs	5–6 yrs	10–12 yrs	Self-report, 10–12 yrs
Walking and talking in the school yard	.49**	.40**	.62***	.90***	–.01	.37**
Physical education class	.69***	.48***	.71***	.69***	.56***	.54***
Bike riding	.38*	.52***	.56***	.84***	–.01	.61***
Household chores	.56***	.69***	.56***	.22	.06	.75***
Scooter riding	.58***	.83***	.70***	.47**	.44***	.49***
Sport class	.20	.38**	.48***	.31	.47***	.20
Walking to school	.94***	.85***	.86***	.90***	.85***	.69***
Walking for exercise	.37*	.54***	.45***	.69*	.39**	.47***
Dance	.78***	.73***	.15	.68***	.73***	.79***
Downball/4 square	.64***	.67***	.75***	.52**	.58***	.61***
Walking the dog	–.01	.87***	.67***	.54***	.80***	.34**
Other organized sport	.60***	.28***	.50***	.41*	.75***	.36**
Skateboarding	.72***	.68***	.59***	.63***	.87***	.21
Individual exercise	.69***	.57***	.58***	.05	.31	.35**
Baseball/Softball	.00	.65***	.82***	.00	.85***	.83***
Gymnastics/Calisthenics	.07	.90***	.94***	.91***	.96***	.98***
Cycling to school	–.03	.46***	.71***	–.04	.64***	.14
Total moderate physical activity	.74***	.67***	.57***	.49***	.58***	.37**
Overall total physical activity (Tables 1a and 1b)	.83***	.69***	.36**	.76***	.74***	.24

Note. NA = not applicable, i.e., zero participation rate.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 2a Percentage Agreement and Spearman's Correlations (r_s) of 10- to 12-Year-Old Children's Vigorous Physical Activity (6+ METs) Between Proxy-Report and Self-Report Items

Activity	Type, % agreement	Frequency, r_s	Duration, r_s
Tag/Chasey	61.3	.33***	.30**
Swimmming for fun	68.1	.42**	.26
Jogging/Running	55.9	.21	.28**
Tennis/Bat tennis	8.0	.58***	.62***
Swimming laps	8.5	.53***	.57***
Rollerblading	72.0	.40***	.32***
Australian-rules football	86.4	.36***	.37***
Basketball	85.4	.16	.43***
Skipping	85.7	.50***	.34***
Soccer	85.7	.54***	.49***
Netball	81.2	.47***	.46***
Aerobics	9.6	.49***	.48***
Total vigorous physical activity	58.6	.13	.19*

*$p < .05$. **$p < .01$. ***$p < .001$.

2b). Thirteen of the items were correlated at .45 or higher for frequency and duration; the correlation for overall moderate, vigorous, and total physical activity between the two instruments, however, was poor.

Criterion Validity of the Questionnaires

To assess the individual-level validity of the questionnaires, Spearman's rank-order correlations (r_s) were performed. Table 3 shows the low correlations between MTI (minutes per day) and duration (minutes per day) of physical activity reported in the proxy-report questionnaire data for both age groups and for the self-report questionnaire. The only significant correlation was between the MTI and proxy-reported vigorous activity for 10- to 12-year-olds. A moderating validity analysis by children's sex, parental education, and activity level of the children found that there were no differences in validity for the proxy- and self-report instruments.

Analyses to assess the group-level validity of the CLASS questionnaires showed that the mean difference between proxy-reported moderate activity and the MTI for 5- to 6-year-olds was –135.8 min/day (95% CI: –155.3 to –116.2), for vigorous activity was –5.0 min/day (95% CI: –13.3 to 3.4), and for total physical activity was –140.7 min/day (95% CI: –164.9 to –116.6). Among 10- to 12-year-olds, the mean difference between proxy-reported moderate activity and the MTI was –19.3 min/day (95% CI: –32.3 to –6.3), for vigorous activity was 30.5 min/day (95% CI: 21.8–39.2), and for total physical activity was 11.2 min/day (95%

Table 2b Percentage Agreement and Spearman's Correlations (r_s) of 10- to 12-Year-Old Children's Moderate Physical Activity (3–5 METs) Between Proxy-Report and Self-Report Items

Activity	Type, % agreement	Frequency, r_s	Duration, r_s
Tag/Chasey	61.3	.33***	.30**
Walking and talking in the school yard	86.6	.27**	.20*
Physical education class	69.5	.02	.05
Bike riding	63.2	.29***	.38***
Household chores	71.0	.16	.30***
Scooter riding	81.4	.62***	.43***
Sport class	72.5	.20*	.27**
Walking to school	85.7	.76***	.65***
Walking for exercise	57.6	.16	.23**
Dance	84.3	.55***	.48***
Downball/4 square	57.4	.35***	.35***
Walking the dog	82.8	.68***	.69***
Other organized sport	74.0	.38***	.31***
Skateboarding	87.4	.34***	.39***
Individual exercise	81.4	.39***	.28**
Baseball/Softball	9.8	.68***	.61***
Gymnastics/Calisthenics	97.8	.84***	.79***
Cycling to school	95.6	.61***	.61***
Total moderate physical activity	84.7	.07	.14
Overall total physical activity (Tables 2a and 2b)	89.2	.14	.25**

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3 Criterion Validity (Spearmans Correlations [R_s] and 95% Confidence Intervals [CI]) of the Proxy-Report and Self-Report Items in the CLASS Questionnaires Measuring Physical Activity Duration

	Spearman Correlation (r_s), 95% CI		
	Proxy Report		
Activity	5–6 yrs	10–12 yrs	Self–report, 10–12 yrs
Moderate physical activity	–.06	.07	.02
Vigorous physical activity	–.04	.24**	–.04
Total physical activity	–.04	.09	–.04
Total MTI raw movement counts/day	.05	.11	.06

Note. MTI = Manufacturing Technology, Inc.
**$p < .01$.

CI: –6.9 to 29.4). For the self-report measure, the mean difference between proxy-reported moderate activity and the MTI data was –21.5 min/day (95% CI: –35.4 to –7.7), for vigorous activity was –23.1 min/day (95% CI: 13.6–32.5), and for total physical activity was 1.5 min/day (95% CI: –17.2 to 20.3).

Figure 1 illustrates the error range for duration (minutes per day) across the physical activity intensities for the survey data (proxy and self-report for 10- to 12-year-olds and proxy report for 5- to 6-year-olds). In the box plots, the boxes represent the interquartile range (50% of error values), and the dot in the boxes represents the median. The lines that extend from the box (whiskers) represent the highest and lowest values, excluding outliers. "O" symbolizes outliers. For 5- to 6-year-old children, the proxy-report questionnaire shows bias for total and moderate physical activity, as illustrated by the median points. For both surveys, the greatest error is in the moderate and total physical activity data, with wide ranges for both of these categories. For example, for any individual 10- to 12-year-old in the sample, his or her self-reported total physical activity could vary by ± 200 min/day (95% CI). It is interesting that the duration of vigorous-intensity physical activity seems to have been reported with the least error compared with the accelerometer, appearing to be relatively unbiased for both surveys (see Figure 1). There is little to differentiate between the self-reported and proxy-reported questionnaires in assessing physical activity duration among the older children.

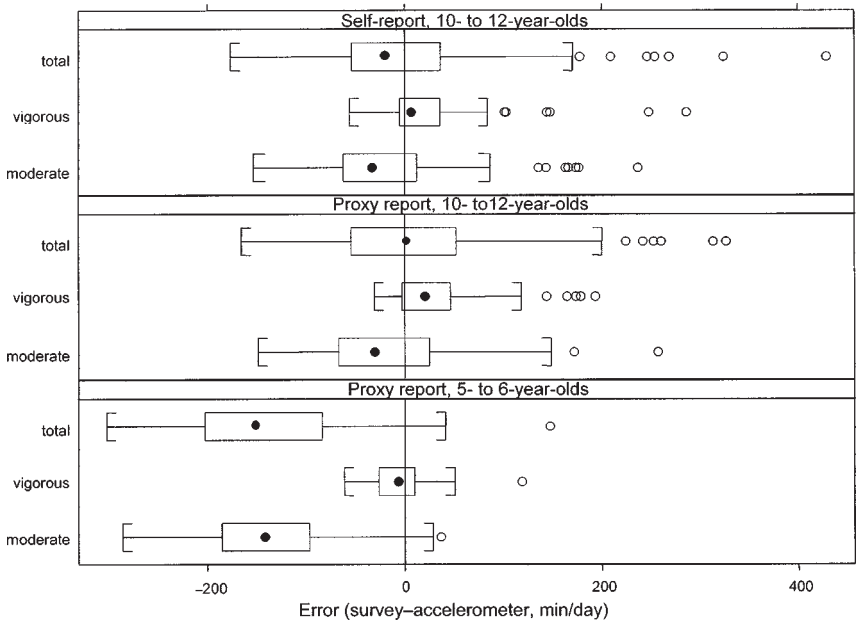

Figure 1 — Box-and-whisker plots of the error (survey–accelerometer, min/day) for the proxy-report and self-report CLASS questionnaires, by total physical activity, vigorous physical activity, and moderate physical activity.

Discussion

In this study we found that the proxy-report version of the CLASS questionnaire provided reliable estimates of physical activity among 5- to 6-year-old and 10- to 12-year old children. In addition, for many of the individual physical activity items, the self-report instrument had acceptable reliability. The validity of both the proxy- and the self-report instruments, however, was poor in estimating physical activity participation for individuals. The reliability estimates of the CLASS questionnaires are consistent with other methodological studies that have found retest correlations ranging from .60–.79 for 7-day recalls with older children (17). Also consistent with the present study, previous research validating 7-day recalls using accelerometry have reported low correlations (r = .11–.47) (6,16). Sallis and colleagues (18) reported self-administered physical activity survey and accelerometer correlations between .22 and .43. An interview-administered survey in the same study was found to have higher validity for fifth-grade children (r = .63) than for third-grade children (r = .47).

Our study found that, on average, children underestimated the time they spent in moderate physical activity by 21 min/day and the time they spent in vigorous physical activity by 23 min/day, suggesting that children this age cannot accurately report physical activity duration. In contrast, Sallis found that, on average, children overestimated their physical activity by 29 min using the self-administered physical activity checklist and by 48 min in interviews (18). It has previously been demonstrated that children under 10 years of age might not have the cognitive ability to accurately recall their physical activity (3). It is interesting that parents were equally poor at accurately estimating their children's physical activity duration.

A significant aspect of this study is that, to our knowledge, there are no validated proxy measures of children's usual physical activity. The only published validated proxy measures of children's physical activity that we could locate require parents and teachers to log children's activities over a 3- to 4-day period (8,12). This is more burdensome for parents and teachers and more expensive to collect and collate. The CLASS proxy instrument had acceptable reliability, but, as noted earlier, less than desirable validity. Proxy-report instruments have limitations in as much as they presuppose that the person completing the survey knows what the child is doing most of the time, but in the case of school-age children, few parents would be aware of how much and what type of activity their children are performing at school. This is reflected in the very poor correlations between self-reported and proxy-reported frequency and duration of sports classes and physical education classes. These findings highlight some of the difficulties in measuring children's physical activity.

Whereas there was some variation in the reliability of the surveys by demographic variables, the validity of the surveys did not differ markedly by sex, parent's education, or child's activity level. In addition, there were similar levels of error found in each of the survey instruments across the sample. In comparing the self-report and proxy-report instruments for 10- to 12-year-olds, however, there were many individual activities such as soccer, aerobics, tennis, and walking or cycling to school that were highly correlated between the two surveys. The activities with the highest agreement were generally the ones that were either organized sport activities or habitual or routine moderate-intensity activities (e.g., walking to

school). The box-and-whisker plots showed that self- and proxy-reported vigorous-intensity activity had the least amount of error. This finding is consistent with other studies that have shown that vigorous-intensity physical activity is typically reported with the least error (21). This could be a consequence of the fact that these types of activities are more structured, habitual, or distinct and tend to be more easily recalled by children and their parents. Similar findings have also been reported previously in studies of adults (14). Further research on this phenomenon is recommended.

For the younger children, the validity of the instrument was less than satisfactory at the individual level. Parents might be unable to quantify their children's physical activity because the activities younger children perform tend to be less structured, involving free play that is intermittent in nature (2). The physical activity checklist included in the questionnaire might not have adequately captured these types of free-play activities. Furthermore, the checklist was primarily derived from existing measures of older children's physical activity and pilot data from 10- to 12-year-olds. It is clear that further research is required to perfect the assessment of young children's physical activity in large samples. It could be the case that other methodological approaches or combinations of approaches, such as observations and objective measures, are more appropriate for this age group (24). The survey data from the checklist, however, do provide valuable information regarding the types of physical activity s in which young children engage.

The conversion of the individual physical activity items from the questionnaires to moderate-intensity and vigorous-intensity physical activity categories is a limitation of this study. Activities were classified based on metabolic expenditure as published in the *Compendium of Physical Activities* (1); this compendium, however, was developed based on studies of adults and the expenditures listed in it might not be equivalent to the energy expended by children in the same activities. The use of accelerometry to validate children's physical activity questionnaires might also be limited. Although accelerometry has been found to be acceptable (for 1 day, $r = .42–.47$; for 6 days, $r = .81–.84$) for assessing intensity of children's physical activity (10), they underestimate physical activity because they cannot be worn during aquatic activities such as swimming and underestimate the intensity of effort associated with walking or running up hills (10). It is also important to note that the cut-off levels used to estimate minutes in moderate, vigorous, and overall physical activity were derived from laboratory-based studies with adults, and the application of these cut-offs with children might have resulted in substantial error. Nevertheless, when the raw movement counts from the MTI accelerometer were correlated with total reported time spent in physical activity for the self-report and proxy-report instruments, there was no change in the correlation estimates. It is important to note that the MTI/CSA and the self-report and proxy report were not coincident in time, and it is also possible that the week the accelerometer was worn was not a typical week because of illness, injury, or extraordinary circumstances for some children.

A strength of the present study is that it examined the reliability and validity of several dimensions of children's physical activity questionnaires, including activity type, frequency, duration, and intensity. Until we better understand the relationship between children's physical activity and health, it is important that all of these activity dimensions be assessed. Whereas the CLASS questionnaires were not expected to be sensitive enough to detect absolute physical activity values at

an individual level (e.g., for use in intervention research), the poor rank-order correlation between the surveys and accelerometry demonstrates that the questionnaires did not rank the children's physical activity levels in an order that was consistent with the objective measure. When a group-level estimate is desired, however, an advantage of the CLASS instrument is that it can be administered on a single occasion, with children and parents able to complete it within a short time frame. Group-level analysis showed that, with the exception of moderate physical activity in younger children, proxy means will generally fall within 30 min/day of their MTI "true" values, which will be sufficient accuracy for many applications. The CLASS instrument is inaccurate even at the group level, however, for the valid measurement of moderate activity in younger children.

For the purpose of public health research, it is important not only to gather data on the amount of physical activity in which children engage but also to gain an understanding of what these behaviors are. Accelerometry as an objective measure shows promise, with participants in this study finding the device acceptable to wear for the 8-day period and the accelerometers appearing to be quite robust in surviving the everyday activities of the young children in the sample. Accelerometry does not, however, provide the important physical-activity behavioral and contextual information that is critical for the development of strategies to promote physical activity among children. Thus, reliable and valid survey instruments are essential. Welk and colleagues (24) argue that using multiple methods to assess children's physical activity enables triangulation of the results and a more comprehensive account of children's physical activity participation. We recommend a combination of proxy report, self-report, and objective measures (using accelerometry or pedometry) for assessing children's physical activity behavior.

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