©Journal of Sports Science and Medicine (2004) **3**, 147-159
http://www.jssm.org

Research article

VALIDITY AND RELIABILITY OF PHYSICAL ACTIVITY MEASURES IN GREEK HIGH SCHOOL AGE CHILDREN

Eugenia C. Argiropoulou ✉, Maria Michalopoulou, Nikolaos Aggeloussis and Andreas Avgerinos

Democritus University of Thrace, Department of Physical Education & Sport Sciences, Komotini, Greece

Received: 12 February 2004 / Accepted: 09 June 2004 / Published (online): 01 September 2004

ABSTRACT
The aim of this study was to determine the validity and reliability of 3 physical activity questionnaires in Greek high school children. Forty children participated in the study aged M = 13.73 (SD 0.8 years). The validation study was conducted by comparing an accelerometer (MTI/CSA Model 7164) to 3 questionnaires: a) Three-day Physical Activity Record (3DPAR), b) Four by One-Day Recall Physical Activity Questionnaire (4BY1RPAQ) and c) Physical Activity and Life Style Questionnaire (PALQ). Validity of the 3 self-report questionnaires was assessed against the MTI/CSA accelerometer by comparing the scores obtained by each instrument on the first week of measurement. Reliability was assessed with two consecutive measurements performed two weeks apart. The measures of reliability were assessed by Intra Class Correlation, Typical Error and Limits of Agreement. A two-way ANOVA for repeated measures was performed. Repeated measures were week and day; in order to determine differences between the two scores obtained with the two measurements for MTI/CSA, 3DPAR and 4BY1RPAQ. A paired Student's t-test was performed for the two scores obtained with the PALQ. Post-hoc multiple comparisons were performed using the Bonferroni test. Significance for all parts of the analysis was determined at an alpha level of $p < 0.05$. A paired Student's t-test was performed for the two scores obtained with the PALQ. Results of this study indicated that reliability measured by intra class correlations (ICC) were for MTI/CSA (ICC = 0.52, $p < 0.05$), 3DPAR (ICC = 0.97, $p < 0.01$), 4BY1RPAQ (ICC = 0.70, $p < 0.01$), and PALQ (ICC = 0.52, $p < 0.01$). Significant Pearson product moment correlation coefficients (r) were observed between MTI/CSA and the other instruments, as a measure of validity: 3DPAR ($r = 0.63$, $p < 0.01$), 4BY1RPAQ ($r = 0.62$, $p < 0.01$), and PALQ ($r = 0.53$, $p < 0.01$). The reliability of the four instruments used in this study was acceptable. Validity correlations were also significant for the three self-report instruments used in this study.

KEY WORDS: Physical activity, activity monitors, energy expenditure, children, validity, reliability.

INTRODUCTION

Physical activity appears to have a pervasive effect on health among adults and children (Baranowski et al., 1992). Many of the risk factors for coronary artery disease, hypertension, non-insulin dependent diabetes and osteoporosis seem to arise in childhood and early adolescence (Williams et al., 1981). Several studies have suggested that physical activity in childhood is a determinant of physical activity in adulthood (Dennison et al., 1988; Kuh and Cooper, 1992). Scientific evidence supports the hypothesis that moderate and high levels of physical activity are recognized as behaviours that lead to positive health benefits (Blair et al., 1989). In a longitudinal study performed over a period of 20 years physical activity behaviour was reported for 230 healthy men and women between 13 and 33 years of age (Kemper et al., 2002). Women increased participation in sport and light physical activities other than sport (4-7

METs) and decreased participation in moderate activities (7-10 METs) with no change in the heavy ones (>10 METs). Male subjects increased participation in light and moderate sport activities but decreased participation in heavy activities over time. Although participation in physical activities other than sport decreased, participation in sport activities remained the same.

In order to better understand the relation between physical activity and health more accurate and less restrictive methods for measuring habitual physical activity and energy expenditure of men, women and children are needed (Montoye et al., 1996). Valid and reliable measures of physical activity are needed in the conduct of studies designed to develop effective programmes for promotion of physical activity (Weston et al., 1997). Even though significant steps have been made the development of valid and reliable instruments for assessing physical activity in children and youth remains an important field of interest and scientific concern (Pratt et al., 1999).

The assessment of the behavioural and the physiological aspects of physical activity resulted in the development of different measures (Baranowski et al., 1993). Self-reports have a number of advantages over other measures, but they also have limitations. Those limitations are evident when self report measures are used with children. The major sources of error identified are: the human cognitive processes, the definition of the desired variables, inadequate length of assessment and failure to account for weekday versus weekend and seasonal variations (Baronowski, 1988; Cale, 1994). Language and cultural differences may also impose additional constraints when assessing physical activity in population groups that differ from the ones that the instruments were originally validated for. Self-report methods are considered a cost effective assessment approach that is convenient to administer and feasible when testing large populations (Sallis et al., 1993).

To reduce the errors associated with self report methods in children, objective methods such as motion sensors have been developed. The Computer Science and Applications Inc. (MTI/CSA) uni-axial activity monitor (WAM 7164; Computer Science and Applications Inc., Shalimar, FL) is one example (Ekelund et al., 2001). The MTI/CSA monitor provides a precise tool for measuring changes in acceleration in laboratory settings (Metcalf et al., 2002) and can be useful in a field situation (Sirard et al., 2000). The validation of the MTI/CSA certifies this monitor as valid, reliable and useful device for the assessment of physical activity in children (Trost et al., 1998; Puyau et al., 2002). Its small size and lightness creates an advantage when compared to other direct methods of estimating physical activity such as heart rate monitoring. Other advantages that accelerometers have when compared to other methods of measuring physical activity include storage of movement data for long periods of time, objective estimation of frequency, intensity and duration of physical activity and continuous recording. The continuous recording of physical activity data for future recall excludes problems related to subjective recall that physical activity questionnaires demand (Basset et al., 2000).

Despite the advantages of accelerometers, the energy cost of an activity that includes muscular activity resulting from isometric contractions, from movements of the upper body, from additional load bearing (carrying, lifting, and pushing), and from movement on inclined or soft surfaces will not result in an increase in the number of counts recorded by any uni-axial accelerometer device (Bouten et al., 1994; Hendelman et al., 2000). Additionally accelerometers cannot be used while swimming or during any other activities where water is involved, and their effectiveness is limited in recording activities such as cycling and weight lifting (Basset et al., 2000). Most motion sensors are sensible to velocity changes but not to gradient changes. This lack of sensitivity may be important in laboratory settings but in field studies variations in duration, frequency and intensity which are the most important components of physical activity are still recorded (Montoye et al., 1983).

Four days of measurement, including weekdays and weekend days, should provide acceptable correlations ensuring a representative measure of a child's habitual physical activity in a large field based study (Janz, 1994; Janz et al., 1995; Trost et al., 2000). In the present study children wore the MTI/CSA monitors for 7 consecutive days during the two periods of measurement in order to achieve greater reliability in recording physical activity (Trost et al., 2000; Matthews et al., 2002).

The aim of the present study is to report on the reliability of three questionnaires 3DPAR (Bouchard et al., 1983), 4BY1RPAQ (Cale, 1993) and PARQ (Avgerinos, 2000) when used to record physical activity of Greek High School children. The validity of these instruments was assessed by using the MTI/CSA accelerometer as the criterion standard.

METHODS

Subjects

Forty children (23 boys and 17 girls) ranging in age from 13 to 14 years (mean 13.73 $\pm$ 0.80 years) participated in this study. Subjects were randomly selected and recruited from 7 high schools with the help of the physical education teachers who worked at the schools. The children and their parents were informed about the scope and the procedure that would be followed in this study and all parents signed an informed consent form.

Both body mass and height were recorded for all subjects. Height was measured without shoes by using a wall – mounted tape measure, and body mass was measured using a digital laboratory scale (Seca, Model 770, Olney, MD). Body mass index (BMI) was computed as weight in kilograms divided by height in square meters.

Instruments

Motion Detector MTI/CSA 7164

The MTI/CSA (7164) activity monitor is a small (5.1 x 3.8 x 1.5cm) lightweight (43-45g) uni-axial activity monitor. It is designed to detect acceleration ranging in magnitude from 0.05 to 2.0G with a frequency response from 0.25 to 2.50 Hz (CSA Inc., Shalimar, FL 1995). These parameters allow the detection of normal human motion while rejecting high frequency motion encountered outside these ranges. The filtered acceleration signal is digitized and the magnitude is summed over a user-specified epoch interval. At the end of each interval, the summed value or activity "count" is stored in memory. The stored data can be downloaded to a computer and the integrator can be reset. For the current study a one minute time interval was used. Further technical specification and performance properties have been described elsewhere (Janz, 1994; Melanson and Freedson, 1995; Freedson et al., 1998; 2000; Nichols et al., 2000; Swartz et al., 2000; Ekelund et al., 2000; 2001).

The MTI/CSA accelerometer has been well validated in both children and adolescents against a wide range of outcomes (Freedson et al., 1998; Trost et al., 1998; Freedson and Miller, 2000; Welk et al., 2000; Ekelund et al., 2000; 2001; Brage, et al., 2003). It has been validated against energy expenditure measured by indirect calorimetry and it was found to be a valid tool for quantifying energy expenditure in children and adults during treadmill running and walking. Correlations ranging from $r = 0.50$ to $r = 0.74$ have been reported between the MTI/CSA monitor and heart rate telemetry of children in field settings (Janz, 1994). Additionally the MTI/CSA monitor provided more accurate estimations of energy expenditure when compared to TriTrac and other accelerometers (Welk, et al., 2000). In studies with children, a significant correlation was observed between MTI/CSA activity counts and all energy expenditure estimates using the Doubly Labeled Water method (Ekelund et al., 2001).

Three-day physical activity record

This three-day activity record divides each of the three days (one must be a weekend day) into 96 periods each 15 minutes long. The responder records his/her energy expenditure for each 15 minute period using a scale from 1 (sleep) to 9 (vigorous physical activity and sport). The values of this scale correspond to a range of 1.0 to 7.8 METs and higher. These categories are explained to the participant in material given to him or her for personal use during the completion of the 3DPAR. Approximate median energy cost for each of the nine categories in ($Kcal \cdot kg^{-1} \cdot 15\ min^{-1}$) was used to compute the daily energy expenditure for each individual in kcals (Bouchard et al., 1997). The reliability of this questionnaire has been tested for both children and adults (ICC = 0.86 - 0.95, $p < 0.01$) and its validity has been also reported for children ($r = 0.80$, $p<0.01$) and adults ($r = 0.54$, $p < 0.01$) (Bouchard et al., 1983).

The four by one-day recall physical activity questionnaire

This interviewer administered self-report measure was designed for children aged 11 years and older and is used to gather four days of activity information (2 school days and two weekend days). It consists of two forms: school day and weekend day, the form is segmented into parts: morning, afternoon and evening and contains checklists of activities. The questionnaire measures four dimensions of physical activity: a) physical activity at school, b) sport at school, c) physical activity during leisure time and d) sport during leisure time. Additionally the questionnaire provides an objective scoring system and measure of physical activity in terms of: a) average daily energy expenditure ($Kcal \cdot kg^{-1} \cdot day^{-1}$), b) time spent on moderate physical activity, c) time spent on hard and very hard activity and d) bouts of "huff" and "puff" activity. The final score assigns the responder to one of the following categories: very inactive, inactive, moderately active and active. The reliability and validity of this questionnaire have been tested for 11 to 14 year-old children and have been reported as $r = 0.62$ ($p < 0.05$) (reliability) and $r = 0.61$ ($p < 0.01$) (validity) (Cale, 1994).

Physical activity and lifestyle questionnaire

This self-administered questionnaire is designed to assess the physical activity of youngsters, ages 11 to 18 years. The questionnaire is made up of two parts: Part 1 records participation in physical activity during leisure time in which the responder must record how frequently s/he participates in any of the 27 physical activities listed in the questionnaire. Part 2 assesses the responder's participation in physical activities during the last 7 days. PALQ can be answered in 15 to 25 minutes depending on the age of the responder. The scoring procedure results in a total score of energy expenditure for each responder that can be calculated using the Compendium of Physical Activities (Ainsworth et al., 1993). Subjects are assigned to one of four categories according to their score: very inactive, inactive, moderately active and active. Additionally daily time of participation in vigorous and moderate physical activities and sport can be calculated from the data collected. Only data collected for the second part was used in this study.

Selection of questionnaires used in this study

No self-report and/or interviewer-administered instruments that assess physical activity have been validated for use with Greek High School children (Avgerinos, 2000). The researchers adapted the 3DPAR and the 4BY1RPAQ questionnaires in order to use them with Greek High School children since both questionnaires have been reported as validated and reliable instruments in studies assessing physical activity in children.

The three questionnaires used in this study assess physical activity by estimating energy expenditure either in METs or in Kcal. Additionally, the content and the format of the questions included in 3DPAR and 4BY1RPAQ was modified to be relevant to the cultural characteristics of Greek children. The adaptation from English to Greek language did not require any changes in either the number or meaning of the questions (both questionnaires). Additionally, by using 3DPAR and 4BY1RPAQ we would able to use and provide data, for Greek children, that is comparable with data from studies conducted in other countries and assess how well these instruments can be adapted and used in Greece.

4BY1RPAQ uses the Compendium of Physical Activities (Ainsworth et al., 1993), which is also used by PALQ, a new instrument that has been designed to assess the physical activity of 12-18 year old Greek students. PALQ is the first questionnaire devised in Greece that provides native researchers and Physical Education instructors with the means to assess the habitual physical activity of Greek high school students.

Standard methods were used to translate and adapt the 4BY1RPAQ and the 3DPAR questionnaires. Two pilot studies were conducted in order to: a) check the childern's understanding of the questions and the material included in the translated versions of the two questionnaires, and b) determine the time required to read and complete them. The subjects in these pilot studies were Greek high school students, (n_1 = 6 boys and 4 girls aged 13.57 $\pm$ 0.70 years and n_2 = 8 boys and 7 girls aged 13.64 $\pm$ 0.70 years). Where the subjects had difficulties in understanding the material given to them, additional information was included in the final versions of the questionnaires.

Study Design

The study was designed to compare the criterion method, the MTI/CSA, against a single-interviewer administered questionnaire and two self-report methods of assessing physical activity. The study entailed 14 days of children's involvement. In order to provide a measure of reliability and/or behaviour stability, each questionnaire was administered twice and for a two week interval. Additionally, the subjects wore the MTI/CSA accelerometer twice for seven consecutive days (2 non consecutive weeks) during the same days that they responded to the questionnaires. Activity monitoring data was collected for 14 days.

All interviews were conducted in an environment familiar to the subject (school or home). Subjects were encouraged to maintain their daily physical activity schedule and in case of illness the study was discontinued. The MTI/CSA accelerometer was placed in a carrying pouch and participants were shown how to place the pouch on a belt at waist level on the right anterior axillary line. The investigator checked the functionality of the monitor every morning during the period of the study. Consistent and proper placement was emphasized, and subjects were told to wear the monitor at all times (day and night), even while sleeping, and to remove it only if the monitor would get completely wet, such as when showering or swimming. The investigators trained the subjects how to attach and detach the accelerometer. During both pilot studies, subjects would repeatedly forget to put on the MTI/CSA monitor as they were getting ready to go to school in the morning. This observation was the reason behind the decision to advise the children to continuously wear the MTI/CSA monitor. As a result, MTI/CSA data was collected for a period of 24 hours each day, which was also the case for the data from the questionnaires used in this study. Compliance was monitored by investigators every morning as the children arrived at school. The MTI/CSA was initialized according to the manufacturer's specifications. The epoch interval was set for 1 minute. At the end of the 7-day recording period, the investigator used a reader interface unit to download the MTI/CSA data (counts) to a desktop computer. The data was then stored in an Excel file for further analysis.

The 3DPAR was completed by the children and returned to the investigator at the end of the third day. The 4BY1RPAQ was administered by the investigator for two weekdays and two weekend

Table 1. The results of MTI/CSA, 3DPAR, 4BY1RPAQ and PALQ for the first (A Data) and the second (B Data) measurement days (Kcals). Data are means (±SD).

	CSA (counts· min $^{-1}$)	3DPAR (Kcal)	4BY1RPAQ (Kcal)	PALQ (Kcal)
A Data	400 (168) n = 33	2 292 (658) n = 39	2 036 (492) n = 40	2 113 (566) n = 40
B Data	465 (215) n = 18	2 285 (503) n = 21	2 125 (426) n = 21	2 169 (408) n = 21

days and referred to the physical activity undertaken by the subject the previous day. The third questionnaire (PALQ) was completed just after the end of the seven-day period during which the subjects wore the MTI/CSA accelerometer. Data collection was completed within a period of one month since changes in weather conditions over long periods of time could affect the children's habitual physical activity. The possible effects due to weather changes were observed during the pilot study. The above procedure ensured that the questionnaires were recorded during identical periods of time, their guidelines were satisfied and activity recall from the completion of another questionnaire was minimized. Moreover, this design enabled the researchers to comparatively evaluate the data of all the measures of physical activity used in this study. (However, comparative evaluation is not discussed in this paper).

Statistical Analysis

The physical characteristics of the children were summarized using descriptive statistics. For reliability, intraclass correlation coefficients (ICC) were calculated for the repeated administrations of the MTI/CSA, the 3DPAR, the 4BY1RPAQ and the PALQ, using appropriate two-way ANOVA models (Baumgartner, 1989). A two-way ANOVA with repeated measures (week x day) was performed in order to determine differences between scores obtained during the two measurements for MTI/CSA, 3DPAR and 43BY1RPAQ. Post-hoc multiple comparisons were performed using the Bonferroni test. Significance for all parts of the analysis was determined at an alpha level of $p<0.05$. A paired Student's t-test was performed for the two scores obtained with the PALQ. Two additional measures of reliability were also computed for the MTI/CSA, the 3DPAR, the 4BY1RPAQ and the PALQ: the typical error (Hopkins, 2000) and the limits of agreement (LOA) (Bland and Altman, 1986). Pearson product moment correlation coefficients between the MTI/CSA and the three questionnaires were used to assess their validity.

RESULTS

Participants Physical Characteristics

Boys' (n = 23) body mass (mean $\pm$ SD) was 58.7 $\pm$ 12.2 kg, their height was 1.66 $\pm$ 0.11m and their BMI was 21.3 $\pm$ 3.54. Girls' (n = 17) body mass (mean $\pm$ SD) was 52.1 $\pm$ 10.8 kg, their height was 1.60 $\pm$ 0.07m and their BMI was 20.3 ± 3.3. From the BMI readings obtained in this study, boys resulted between the 75th and 85th percentile distribution and girls resided between the 50th and the 75th percentile. (National Center for Health Statistics, USA, 2000), both groups being between the normal range (Himes and Deitz, 1994).

The mean ± SD for the 4 instruments obtained during the first and second measurement period is presented in Table 1. Original 4BY1RPAQ and PALQ data was transformed from METs to Kcal.

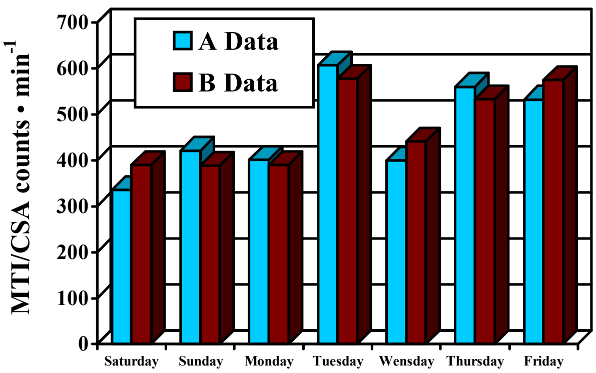

Figure 1. Average MTI/CSA scores (counts·min^{-1}) for the first (A Data) and the second measure (B Data).

Reliability and Consistency

MTI/CSA

Average MTI/CSA scores (counts·min^{-1}) for the first (A Data) and the second measure (B Data) were presented in Figure 1. The ICC for average MTI/CSA counts·min^{-1} across the two weeks of measurement was 0.52 ($p<0.05$). The ICCs for the separate days were: Saturday ICC = - 0.49, Sunday ICC = 0.66, Monday ICC= 0.42, Tuesday ICC = 0.55, Wednesday ICC = 0.48, Thursday ICC = 0.65 and Friday ICC = 0.35. The typical error for MTI/CSA between the two weeks of measurement was 1099.05counts·min^{-1} and the respective LOAs were 38.84 ± 3139.68 counts·min^{-1}. The typical error and the LOAs for the separate days were for: Saturday 265.68 and 55.68 ± 758.97 counts·min^{-1}, Sunday 129.15 and -33.82 ± 368.96 counts·min^{-1}, Monday 121.64 and -11.03 ± 347.48 counts·min^{-1}, Tuesday 259.10 and -28.58 ± 740.17 counts·min^{-1}, Wednesday 207.78 and 41.45 ± 593.58 counts·min^{-1}, Thursday 221.78 and -26.98 ± 633.56 counts·min^{-1} and Friday 299.32 and 42.03 ± 835.08 counts·min^{-1}. No significant (week x day) interaction was reported ($F_{1,17}$ = 0.003, p > 0.05), and no significant main effect for the factors week, ($F_{1,17}$ = 0.009, p > 0.05) and day ($F_{1,17}$ = 0.577, p > 0.05).

3D Physical Activity Record.
The ICC for the two 3day periods of measurement was (ICC = 0.97, p < 0.01). When ICC was calculated for each day of measurement separately, weekdays gave higher ICC readings (weekdays 1 and 2 ICC = 0.97, p <0.01) than the weekend day (ICC =0.88, p < 0.01). The typical error and the LOAs for 3DPAR between the two 3day periods of measurement were 382.51 and -375.30 ± 1092.72 Kcals respectively. The typical errors for weekend day, weekday 1 and weekday 2 were respectively 276.36, 119.78 and 131.48 Kcals. The corresponding LOAs were -230.60 ± 789.49 Kcals, -66.12 ± 342.19 Kcals and -78.58 ± 375.60 Kcals. No significant (week x day) interaction was reported ($F_{1,20}$ = 2.746, p > 0.05). The total scores between the 2 weeks of measurement were not significantly different ($F_{1,20}$ = 3.178, p > 0.05). A significant main effect was reported for the factor: day ($F_{1,20}$ = 9.172, p<0.01). A Bonferroni post-hoc test revealed that the weekend day scores (Sunday) of the 2 weeks of measurement were significantly different (Figure 2).

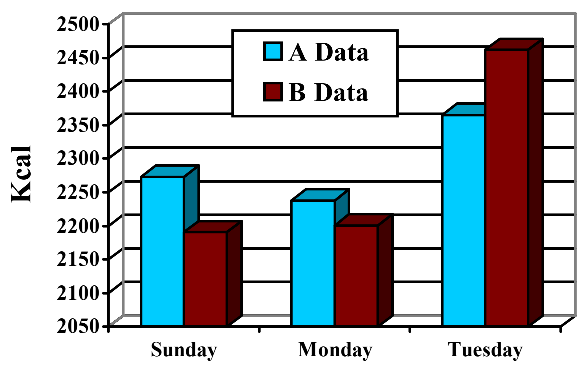

Figure 2. Average energy expenditure (Kcal) per day recorded with 3DPAR for the first (A Data) and the second measure (B Data).

4BY1 Recall Physical Activity Questionnaire
The ICC for the two 4day periods of measurement was (ICC = 0.70, p < 0.01). When ICC was calculated for each day of measurement separately weekdays had higher correlation coefficients (weekday 1 ICC = 0.83, p < 0.01, & weekday 2 ICC = 0.89, p < 0.01,) than weekend days (Saturday ICC = -0.30, p > 0.05, and Sunday ICC = 0.47, p > 0.05). The typical error and the LOAs for 4BY1RPAQ between the two 4day periods of measurement were 7.94 and -4.37 ± 22.67 METs respectively. The typical errors for each of the weekend days were equal to 4.77 METs and for each of the two weekdays were respectively 1.25 and 2.25 METs. The corresponding LOAs were 0.10 ± 13.63, -3.25 ± 13.64, -0.81 ± 3.56 and –0.40 ± 6.44 METs. No significant (week x day) interaction was reported ($F_{1,20}$ = 0.020, p > 0.05). No differences were reported between the total scores of the 2 weeks of measurement ($F_{1,20}$ = 10.108, p > 0.01). A significant main effect was reported for the factor: day ($F_{1,20}$ = 4.624, p < 0.05). A Bonferroni post-hoc test revealed that Sunday scores of the 2 weeks of measurement were significantly different.

Physical Activity and Lifestyle Questionnaire
The ICC for the two periods of measurement was (ICC = 0.52, p < 0.05). The typical error and the limits of agreement, for PALQ, between the two periods of measurement were respectively 2.39 and –1.88 ± 6.82 METs. The physical activity score for the first week was significantly different from the score of the second week (t = 2.547, p < 0.05). Average energy expenditures (METs) recorded with 4BY1RPAQ per day and PALQ for the first (A Data) and the second measure (B Data) were presented in Figure 3.

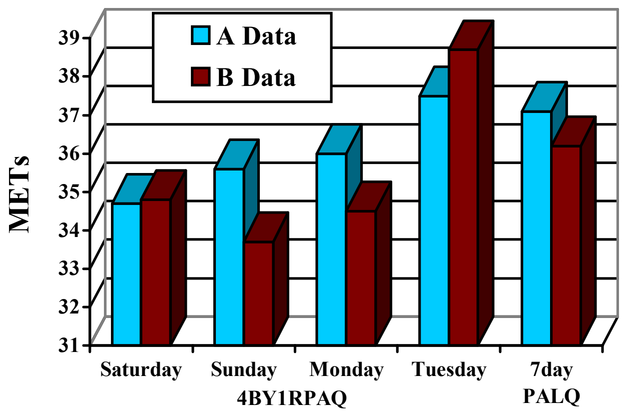

Figure 3. Physical activity in terms of: average energy expenditure (METs) recorded with 4BY1RPAQ per day and PALQ for the first (A Data) and the second measure (B Data).

Validity of the Physical Activity Instruments
MTI/CSA vs. 3D Physical Activity Record.

Table 2. Validity: Pearson product moment correlations (r) of 3DPAR, 4BY1RPAQ, and PALQ with MTI/CSA.

	Correlations of MTI/CSA (counts· min^{-1})				
	Weekend day 1	**Weekend day 2**	**Week day 1**	**Week day 2**	**Average scores**
3DPAR		.56**	.09	.64**	.63**
4BY1RPAQ	.38**	.54**	.46**	.65**	.62**
PALQ					.53**

The correlation between 3DPAR (kcal) and MTI/CSA (counts·min^{-1}) for the respective days was moderate ($r = 0.63$, $p<0.01$) (Table 2). The correlations of each of the three individual days between the 3DPAR and the MTI/CSA monitor were significant for weekend day 2 ($r = 0.56$, $p<0.01$) and for the weekday 2 ($r = 0.64$, $p<0.01$).

MTI/CSA vs. 4BY1RPAQ Recall Physical Activity Questionnaire

The average correlation between the 4 days of 4BY1RPAQ (METs) and the MTI/CSA counts·min^{-1} was moderate ($r = 0.62$, $p < 0.01$, Table 2). The correlations of each of the four days between the 3DPAR and the MTI/CSA monitor were also significant for both weekend days (Saturday $r = 0.38$, $p < 0.01$ and Sunday $r = 0.54$, $p < 0.01$) and weekdays (Monday $r = 0.46$, $p < 0.01$ and Tuesday $r = 0.65$, $p < 0.01$).

MTI/CSA vs. Physical Activity and Lifestyle Questionnaire

The average correlation between the 7 days of PALQ (METs) and the respective days of MTI/CSA (counts·min^{-1}) was moderate ($r = 0.53$, $p < 0.01$, Table 2).

DISCUSSION

Promotion of physical activity in children and adolescents and the understanding of different aspects of physical activity state the need for valid and reliable assessment instruments. If data gathered is not accurate then valuable information may be lost and progress in understanding physical activity behaviour and its relationship to health behaviour may be hindered.

Reliability

The results in this study suggest MTI/CSA is a reliable instrument to monitor physical activity in children. Moderate but acceptable reliability (ICC = 0.52) was observed between the first and the second week of measurement. This finding is in accordance with the results of other reliability studies conducted with heart rate monitors and motion sensors in children and youngsters (Freedson and Evenson, 1991; DuRant, et al., 1992; 1993; Janz et al., 1992; 1994; 1995). In general though, the reliability studies that used the test re-test paradigm presented medium to high correlations.

In this study, the term reliability refers to the consistency of scores of measurement differentiating between inter-instrument reliability. Different experimental designs (test re-test reliability measured up to 12 times in one day and 3-6 months later) and statistical analysis (Intraclass Correlation Coefficient, Pearson product moment correlation coefficient and ANOVA) employed in studies assessing the reliability of one instrument limit drastically the possibilities of making meaningful comparisons between their findings.

Reliability of the three questionnaires was tested for the first and the second week of measurement and all reliability measures reported high correlations for the 3DPAR (ICC = 0.97) medium correlation for the 4BY1RPAQ (ICC = 0.70), and low correlation for the PALQ (ICC = 0.52). Even though energy expenditure scores of the weekend day were significantly higher for the first week of measurement when compared to the second week, high correlations were provided for the weekdays (Monday, ICC = 0.97 and Tuesday ICC = 0.97) as well as between the weekend day (Sunday ICC = 0.88). These findings are in accordance with the results of the study conducted by Bouchard and his colleagues (1983) ($r = 0.96$).

Reliability was moderate for 4BY1RPAQ between the first and the second week of measurement. However, lower correlations were observed between the separate days of the first and second week. For weekdays reliability scores were higher (Monday ICC = 0.83 and Tuesday ICC = 0.89) than weekend days (Saturday ICC = -0.30 and Sunday ICC = 0.47). Physical activity scores were not different between the two weeks of measurement but physical activity scores of the first Sunday were significantly higher when compared to Sunday scores of the second week. This difference in physical activity was also reported with data collected with the 3DPAR. The lower physical activity scores recorded for the second Sunday may be due to the fact that with repeated activity interviews subjects are inclined to underreport physical activity (Kemper et al., 1983). This effect may be more apparent in a weekend day during which no structured activities which take place - are easier for children to recall, are included in their daily schedule.

The PALQ demonstrated the lowest reliability of all the instruments used in this study and according to the results physical activity recorded during the first week was significantly higher when compared to the second week. Scores were not produced for weekend days and weekdays since this instrument does not provide data for separate days within the week.

Test-re-test reliability of children's physical activity questionnaires varies from r = 0.20 (Andersen and Haraldsdottir, 1993) to r = 0.98 (Weston et al., 1997). Age has been positively related with the reliability of questionnaires with higher correlations being recorded with older children and youngsters when compared with children about under the age of 10 years. A significant disadvantage of these instruments refers to limitations related to accuracy of recall and subjective interpretations of the questions (Sallis, 1991). In the present study when the PALQ was used subjects had difficulty recalling events and activities that had already been recorded with the other 2 questionnaires. Evidence for memory decay (Baranowski, 1988) comes also from a study that included the comparison of 7-day self reported activity of children at a diabetic camp with a diary of their activity maintained by their camp counselor. The children could with reasonable accuracy recall the activity of the previous day, but had great difficulty with day's further back in time (Wallace et al., 1985). Daily logs – diaries are not used very often with children and youngsters (Bouchard et al., 1983; Freedson and Evenson, 1991). This has probably to do with the effort needed to consistently complete the daily log. (Children in the present study had similar difficulties in completing the 3DPAR).

Reliability is affected by the duration between repeated measurements of physical activity. Relatively low correlations were presented for the 7-day Physical Activity Recall (Sallis et al., 1993) when data collection was repeated 4 to 6 days later. A different corelation was obtained when a third set of data was collected 2 to 3 days later. Studies longer in duration (Aaron et al., 1993; Andersen and Haraldsdottir, 1993) would probably be useful in determining a subject's behavioural consistency related to physical activity. Even though an instrument may be reliable behavioural changes may weaken the statistical interpretation of the reliability data (Kohl et al., 2000).

Validity

One goal of this study was to examine the validity of using the MTI/CSA as a criterion standard of the physical activity questionnaires used in this study.

Validation studies with objective measures of physical activities (motion sensors) in children and youngsters presented low, moderate (Klesges and Klesges, 1987; Ballor et al., 1989; Mukeshi et al., 1990; Noland et al., 1990; Sallis et al., 1990; Freedson and Evenson, 1991; Bray et al., 1994; Janz, 1994; Welk and Gorbin, 1995) and high correlations (Trost et al., 1998).

Self reports are the most commonly checked instruments for validity in children and adolescents. The criterions of convergent validity most commonly used are the methods of doubly labeled water (DLW), direct observation and electronically and mechanical monitoring of physical activity (Noland et al., 1990; Sallis et al., 1990; 1993; 1996; Simons-Morton et al., 1994; Janz et al., 1995; Weston et al., 1997). In their review Sirard and Pate (2001) considered 3 types of measures of physical activity in children and adolescents: primary, secondary and subjective measures. Direct observation, doubly labeled water and indirect calorimetry were considered the primary standards for assessment of physical activity. Heart rate monitors, pedometers and accelerometers were considered secondary measures because they provide an objective assessment of physical activity. Surveys, self – report questionnaires, interviews, proxy-reports and diaries were considered as subjective techniques (Sirard and Pate, 2001).

When motion sensors were used for the validation of self report measures with children 10 years and older, correlation coefficients ranged form r = 0.03 (Janz et al., 1994) to r = 0.88 (Weston et al., 1997). In the present study correlation between the MTI/CSA and the three questionnaires was moderate, (r = 0.63, r = 0.62 and r = 0.53, $p<0.01$) for the 3DPAR, 4BY1RPAQ and PALQ, respectively. This range in variability is possibly due to differences in the design and philosophy of the questionnaires used and in the duration of monitoring physical activity.

The relationship between accelerometry and energy cost is highly dependent on the type of activity being performed. Therefore it may be in appropriate to apply equations based on laboratory tasks or locomotion to free living situations in attempts to quantify energy expenditure resulting from physical activity or to classify activity levels (Hendelman et al., 2000). No single regression equation appears to accurately predict energy expenditure based on acceleration scores for all activities (Basset et al, 2000). The vertical acceleration of the body can be measured quite accurately, but the relationship with measured energy expenditure (METs) differs depending on the type of physical activity performed (Basset et al., 2000). Moreover converting accelerometer counts to units of energy expenditure may provide inaccurate estimates because of the additional measurement error (Sirard and Pate, 2001).

A validation study conducted by Sallis and colleagues (1993) included 4 instruments used by 66 children of the fourth grade in classroom settings allowing the comparison between questionnaires of different format and the Caltrac activity monitor. Correlations were consistently lower for the second administration of each instrument. With relatively low correlations the authors suggested some combination of monitoring devices and self-report may be a prudent step to increase validity (Sallis et al., 1993). Different methods of assessing physical activity are not measuring identical properties or components. Total physical activity is a function of the type of stimulus (mode of exercise), the intensity at which the stimulus is performed, and the duration of a single episode. Over an extended period, the frequency with which an exercise is performed is also important. For example, one type of electronic monitor may not measure the intensity of physical activity as well as a recall instrument or a diary may, but the monitor may more accurately measure duration. If this true, researchers may need to use multiple methods to more completely assess all components of physical activity (Kohl et al., 2000). Because of the limitations of any of the practical field methods of assessing energy expenditure and physical activity, there must be attempts to combine approaches in an effort to improve validity (Montoye et al., 1996).

The main findings of this study were the relatively high correlation of MTI/CSA and 3DPAR and the moderate correlations observed between MTI/CSA and the other instruments tested in this study. In a study by Sirard and colleagues (2000) the 3DPAR and MTI/CSA assessed similar patterns of physical activity in young adults.

In a previous study in which 3DPAR was compared to CALTRAC and 4 other physical activity questionnaires no significant correlations were found (Miller et al., 1994). One of the explanation that the authors suggested was that 3DPAR uses 9 physical activity categories that were insufficiently described and subjects were forced to interpret of each category resulting in misunderstandings In our study, this last element was present but its effect was minimized since the investigator met frequently with the subjects in order to complete the 4BY1RPAQ and provided further clarification when needed.

The participants in this study reported that unstable weather conditions (cold and rain) throughout short periods of this study affected their habitual physical activity. Difficulties were reported concerning the use of the physical activity index, which is included in the 3DPAR and when completing the PALQ, subjects were forgetting events and activities that had already been recorded with the other two questionnaires. The procedure of completing three questionnaires during the same period of time disturbed the participants since they had to meet with the researcher that "checked their schedule" on four consecutive days in order to complete the 4BY1RPAQ. The time children went to bed the night before the first weekday was not recorded by the 4BY1RPAQ. Even though the MTI/CSA monitor is a small and lightweight device, subjects reported having to wear specific underwear and clothing in order to keep it properly attached to their body.

Despite the limitations of accelerometers, objective monitoring of physical activity in population based samples of children and adolescents appears to be a feasible alternative to traditional self-report methods (Trost et al., 2002). The accelerometers provide the necessary objectivity that paper and pencil techniques lack and are not as expensive as the doubly labeled water technique (Sirard et al., 2000). The DLW method measures total energy expenditure over longer periods and therefore provides a good estimate of average daily energy expenditure. However, the high cost of the stable isotopes and sophisticated analysis techniques that are required by this method limit its usefulness in epidemiological studies (Ekelund et al., 2001). Additionally, the DLW method provides no data regarding brief periods of peak energy expenditure (Montoye et al., 1996). Lastly, accurate dietary records must be obtained during the measurement period for the energy expenditure calculations (Sirard and Pate, 2001).

CONCLUSIONS

In conclusion, the assessment of physical activity in children and adolescents faces several limitations. A predominant characteristic of human behaviour is interpersonal and intrapersonal variability. Only a combination of the available instruments would be able to respond to this variability when assessing physical activity in children and adolescents. Self-report instruments and accelerometers are probably able to quantify only gross fluctuations in physical activity. Additionally, continuous monitoring over long periods of time may disturb habitual physical activity. The results of this study lead to the conclusion that all 4 instruments were valid and reliable in recording physical activity when used with children, since the instruments were able to detect changes in physical activity and the respective energy cost.

REFERENCES

Aaron, D.J., Kriska, A.M., Dearwater, S.R., Anderson, R.L., Olsen, T.L., Cauley, J.A. and Laporte, R.E. (1993) The epidemiology of leisure physical activity in an adolescent population. *Medicine and Science in Sport and Exercise* **25**,847-853.

Ainsworth, B.E., Haskell, W.L., Leon, A.S., Jacobs, D.A., Montoye, H.J., Sallis, J.F. and Paffenbarger, R.S. (1993) Compendium of physical activities: classification of energy costs of human physical activities. *Medicine and Science in Sport and Exercise* **25**, 71-80.

Andersen, L.B. and Haraldsdottir, J. (1993) Tracking of cardiovascular disease risk factors including maximal oxygen uptake and physical activity from late teenager to adulthood: an 8-year follow-up study. *Journal of Internal Medicine* **234,** 309-315.

Avgerinos, A., Argiropoulou E.C., Almond, L. and Michalopoulou M. (2000) A new instrument for evaluating energy expenditure: convergent validity and reliability of the physical activity and lifestyle questionnaire (PALQ). *Sport Performance and Health* **4**, 281-300.

Ballor, D.L., Burke, L.M., Knudson, D.V., Olson, J.R. and Montoye, H.J. (1989) Comparison of three methods of estimating energy expenditure: caltrac, heart rate, and video analysis. *Research Quarterly for Exercise and Sport* **60**, 362-368.

Baranowski, T. (1988) Validity and reliability of self-report measures of physical activity: an information-processing perspective. *Research Quarterly for Exercise and Sport* **59,** 314-327.

Baranowski, T., Bouchard, C., Bar-Or,O., Bricker, T., Heath, G., Kimm, S.Y.S., Malina, R., Obarzanek, E., Pate, R., Strong, W.B., Truman, B. and Washington, R. (1992) Assessment, prevalence, and cardiovascular benefits of physical activity and fitness in youth. *Medicine and Science in Sports and Exercise* **24**, S237-S247.

Baranowski, T., Thompson, W.O., Durant, R.H., Baranowski, J. and Puhl, J. (1993) Observations on physical activity in physical locations: Age, gender, ethnicity, and month effects. *Research Quarterly for Exercise and Sport* **64**, 127-193.

Basset, D.R., Ainsworth, B.E., Swartz, A.M., Strath, S.J., O'Brien, W.L. and King, G.A. (2000) Validity of four motion sensors in measuring moderate intensity physical activity. *Medicine and Science in Sports and Exercise* **32**, S471 –S480.

Baumgartner, T.A. (1989) Norm-referenced measurement: reliability. In: *Measurement concepts in physical education and exercise science.* Eds: M.J. Safrit and T.M. Wood. Champaign, IL: Human Kinetics.

Blair, S.N., Kohl III, W.K., Paffenbarger, R.S., JR., Clark, D.G., Cooper, K.H. and Gibbons, L.W. (1989) Physical fitness and all-cause mortality: a prospective study of health men and women. *Journal of the American Medical Association* **262**, 2395-2401.

Bland, J.M. and Altman, D.G. (1986) Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* **8**, 307-310.

Bouchard, C., Tremblay, A., Leblanc, C., Lortie, G., Savard, R. and Theriult, G. (1983) A method to assess energy expenditure in children and adults. *The* American *Journal of Clinical Nutrition* **37**, 461-467.

Bouchard, C. (1997) Three-day physical activity record. *Medicine and Science in Sport and Exercise* **29**, S19-S24.

Bouten, C.V.C., Westerterp, K., Verduin, M. and Janssen, J. (1994) Assessment of energy expenditure for physical activity using a triaxial accelerometer. *Medicine and Science in Sport and Exercise* **26**, 1516-1523.

Brage, S., Weddekopp, N., Andersen, L.B. and Froberg, K. (2003) Influence of step frequency on movement intensity predictions with the CSA accelerometer: a field validation study. *Pediatric Exercise Science* **15**, 277-287.

Bray, M.S., Wong, W.W., Morrow, J.R. Jr, Butte, N.F. and Pivarnik, J.M. (1994) Caltrac versus calorimeter determination of 24-h energy expenditure in female children and adolescents. *Medicine and Science in Sport and Exercise* **26,** 1524-1530.

Cale, L. (1993) *Monitoring physical activity in children*. Doctoral thesis. Loughborough University of Technology.

Cale, L. (1994) Self-report measures of children's physical activity: Recommendations for future development and a new alternative measure. *Health Education Journal* **53**, 439-453.

Computer Science and Applications Inc. (1995) *Activity Monitor Users Manual Model 7164.* Shalimar Florida.

Dennison, B.A., Straus, J.H., Mellits, E.D. and Charney, E. (1988) Childhood physical fitness tests: predictor of adult physical activity levels? *Pediatrics* **82**, 324 – 330.

DuRant, R.H., Baranowski, T., Davis, H., Thompson, W.O., Puhl, J., Greaves, K.A. and Rhodes, T. (1992) Reliability and variability of heart rate monitoring in 3-, 4-, or 5-yr old children. *Medicine and Science in Sports and Exercise* **24**, 265-271.

DuRant, R.H., Baranowski, T., Davis, H., Rhodes, T., Thompson, W.O., Greaves, K.A. and Puhl, J. (1993) Reliability and variability of indicators of heart rate monitoring in children. *Medicine and Science in Sports and Exercise* **25**, 389-395.

Ekelund, U., Yngve, A., Sjöström, M., and Westerterp, K. (2000) Field evaluation of the Computer Science and Application's Inc. activity monitor durring running and skeing training in adolescent athletes. *International Journal of Sports Medicine* **21**, 586-592.

Ekelund, U., Sjöström, M., Yngve, A., Poortvliet, E., Nilsson, A., Froberg, K., Wedderkopp, N. and

Westerterp, K. (2001) Physical activity assessed by activity monitor and doubly labeled water in children. *Medicine and Science in Sports and Exercise* **33**, 275-281.

Freedson, P.S. and Evenson, S.K. (1991) Familiar aggregation and physical activity. *Research Quarterly for Exercise and Sport* **62**, 384-389.

Freedson, P.S., Melanson, E. and Sirard, J. (1998) Calibration of the Computer Science and Applications, Inc. accelerometer. *Medicine and Science in Sport and Exercise* **30**, 777-781.

Freedson, P.S. and Miller, K. (2000) Objective monitoring of physical activity using motion sensors and heart rate. *Research Quarterly for Exercise and Sport* **71**, S21-S30.

Hendelman, D., Miller, K., Bagget, C., Debold, E. and Freedson, P. (2000) Validity of accelerometry for the assessment of moderate intensity physical activity in the field. *Medicine and Science in Sport and Exercise* **32**, S442-S449.

Himes, J.H. and Deitz, W.H. (1994) Guidelines for overweight in adolescent preventive services: recommendations form an expert committee. *American Journal of Clinical Nutrition* **59**, 307-316.

Hopkins, W.G. (2000) Measures of reliability in sports medicine and science. *Sports Medicine* **30**, 1-15.

Janz, K.F., Golden, J.C., Hansen, J.R. and Mahoney, L.T. (1992) Heart rate monitoring of physical activity in children and adolescents: the Muscatine Study. *Pediatrics* **89**, 256-261.

Janz, K.F. (1994) Validation of the CSA accelerometer for assessing children's physical activity. *Medicine and Science in Sports and Exercise* **26**, 369-375.

Janz, K.F., Witt, J. and Mahoney, L.T. (1995) The stability of children’s physical activity as measured by accelerometry and self-report. *Medicine and Science in Sports and Exercise* **27**, 1326-1332.

Kemper, H.C.G., Dekker, H.J.P., Ootjers, M.G., Pst, G.B., Ritmeester, J.W., Snel, L., Splinter, P., Strom Van Essen L. and Verschuur R. (1983) Growth and health of teenagers in the Netherlands: survey of multidisciplinary longitudinal studies and comparison to recent results of a Dutch study. *International Journal of Sports Medicine* **18**, s140-s150.

Kemper, H.C.G., Verhagen, E.A.L.M., Milo, D., Post, G.B., Van Kenthe, F., Van Mechelen, W., Twisk, J.W.R. and DeVente W. (2002) Effects of health information in youth on adult physical activity: The Amsterdam Growth and Health Longitudinal Study. *American Journal of Human Biology* **14**, 448-456.

Klesges, L.M. and Klesges, RC. (1987) The assessment of children’s physical activity: a comparison of methods. *Medicine and Science in Sports and Exercise* **19**, 511-517.

Kohl, H.W., Fulton, J.E. and Carpersen, C.J. (2000) Assessment of physical activity among children and adolescents: A review and synthesis. *Preventive Medicine* **31**, S54-S76.

Kuh, D.J. and Cooper, C. (1992) Physical activity at 36 years: patterns and childhood predictors in a longitudinal study. *Journal of Epidemiology and Community Health* **46**, 114-119

Matthews C.E, Ainsworth B.E, Thompson R.W and Bassett D.R Jr. (2002) Sources of variance in daily physical activity levels as measured by an accelerometer. *Medicine and Science in Sports and Exercise* **34**, 1376-1381.

Melanson, J. and Freedson, P.S. (1995) Validity of the Computer Science and Applications, Inc. (CSA) activity monitor. *Medicine and Science in Sports and Exercise* **27**, 934-940.

Metcalf, B.S., Curnow, J.S.H., Evans, C., Voss, L.D. and Wilkin, T.J. (2002) Technical reliability of the CSA activity monitor: The Early Bird Study. *Medicine and Science in Sports and Exercise* **34**, 1533-1537.

Miller, D.J., Freedson, P.S. and Kline, G.M. (1994) Comparison of activity levels using the Caltrac accelerometer and five questionnaires. *Medicine and Science in Sports and Exercise* **26**, 376-382.

Montoye, H.J., Washburn, R., Servais, S., Ertl, A., Webster, J.G. and Nagle, F.J. (1983) Estimation of energy expenditure by a portable accelerometer. *Medicine and Science in Sports and Exercise* **15**, 403-407.

Montoye, H.J., Kemper H.C.G, Saris W.H.N. and Washburn, R.A. (1996) *Measuring physical activity and energy expenditure*. Human Kinetics.

Mukeshi, M., Gutin, B., Anderson, W., Zybert, P. and Basch, C. (1990) Validation of the CALTRAC movement sensor using direct observation in young children. *Pediatric Exercise Science* **2**, 249-254.

National Center for Health Statistics & National Center for Chronic Disease Prevention and Health Promotion. (2000) *2 to 20 years: girls body mass index-for-age percentiles*. U.S. Department of Health and Human Services.

Nichols, J.F., Morgan, C.G., Chabot, L.E., Sallis, J.F. and Calfas, K.J. (2000) Assessment of physical activity with the Computer Science and Applications Inc., Accelerometer: laboratory versus field validation. *Research Quarterly for Exercise and Sport* **71**, 36-43.

Noland, M., Danner, F., Dewalt, K., McFadden, M. and Kotchen, M. (1990) The measurement of physical activity in young children. *Research Quarterly for Exercise and Sport* **61**, 146-153.

Pratt, M., Macera, C.A. and Blanton, C. (1999) Levels of physical activity and inactivity in children and adults in the United States: current evidence and research issues. *Medicine and Science in Sport and Exercise* **31**, S526-S533.

Puyau, M.R, Adolph, A.L, Vohra, F.A. and Butte N.F. (2002) Validation and calibration of physical activity monitors in children. *Obesity Research* **10**, 150-157.

Sallis, J.F., Buono, M.J., Roby, J.J., Carlson, D. and Nelson, J.A. (1990) The Caltrac accelerometer as a physical activity monitor for school-age children.

Medicine and Science in Sport and Exercise **22**, 698-703.
Sallis, J.F. (1991) Self-report measures of children's physical activity. *Journal of School Health* **61**, 215-219.
Sallis, J.F., Condon, S.A., Goggin, K.J., Roby, J.J., Kolody, B. and Alcaraz, J.E. (1993) The development of self-administered physical activity surveys for 4th grade students. *Research Quarterly for Exercise and Sport* **64**, 25-31.
Sallis, J.F., Buono, M.J., Roby, J.J., Micale, F.G. and Nelson, J.A. (1993) Seven-day recall and other physical activity self-reports in children and adolescents. *Medicine and Science in Sport and Exercise* **25**, 99-108.
Sallis, J.F., McKenzie, T.L. and Alcaraz, J.E. (1993) Habitual physical activity and health-related physical fitness in fourth-grade children. *American Journal of Diseases of Children* **147**, 890-896.
Sallis, J.F., Strikmiller, P.K., Harsha, D.W., Feldman, H.A., Ehlinger, S., Stone, E.J., Williston, J. and Woods, S. (1996) Validation of interviewer –and self-administered physical activity checklists for fifth grade students. *Medicine and Science in Sport and Exercise* **28**, 840-851.
Simons-Morton, B.G., Taylor, W.C. and Huang, I.W. (1994) Validity of the physical activity interview and Caltrac with preadolescent children. *Research Quarterly for Exercise and Sport* **65**, 84-88.
Sirard, J.R., Melanson, E.L., Li, L. and Freedson, P.S. (2000) Field evaluation of the Computer Science and Applications, Inc. physical activity monitor. *Medicine and Science in Sports and Exercise* **32**, 695-700.
Sirard, J.R., and Pate, R.R. (2001) Physical activity assessment in children and adolescents. *Sports Medicine* **31**, 439-454.
Swartz, A.M., Strath, S.J., Basset, D.R., Obrien, Jr., L.O., King, G.A. and Ainsworth, B.E. (2000) Estimation of energy expenditure using CSA accelerometers at hip and wrist sites. *Medicine and Science in Sport and Exercise* **32**, S450 – S456.
Trost, S.G., Ward, D.S., Moorehead, S.M., Watson, P.D., Riner, W. and Burke, J.R. (1998) Validity of the computer science and applications (CSA) activity monitor in children. *Medicine and Science in Sports and Exercise* **30**, 629-633.
Trost, S.G., Pate, R.R., Freedson, P.S., Sallis, J.F. and Taylor, W.C. (2000) Using objective physical activity measure with youth: How many says of monitoring are needed. *Medicine and Science in Sport & Exercise* **35,** 426-431.
Trost, S.G., Pate, R.R., Sallis, J.F., Freedson, P.S., Taylor, W.C., Dowda, M. and Sirard, J. (2002) Age and gender differences in objectively measured physical activity in youth. *Medicine and Science in Sports and Exercise* **34**, 350-355.
Wallace, J.P., McKenzie, T.L. and Nader P.R. (1985) Observed versus recalled exercise behaviour: A validation of seven day exercise recall for boys 11 to 13 years old. *Research Quarterly for Exercise and Sport* **56**, 161-165.
Welk, G.J. and Gorbin, C.B. (1995) The validity of Tritrac-R3D activity monitor for the assessment of physical activity in children. *Research Quarterly for Exercise and Sport* **66**, 202-209.
Welk, G.J., Blair, S.N., Wood, K., Jones, S., and Thompson, R.W. (2000) A comparative evaluation of three accelerometry-based physical activity monitors. *Medicine and Science in Sports and Exercise* **32**, S489-S497.
Weston, A.T., Petosa, R. and Pate, R.R. (1997) Validation of an instrument for measurement of physical activity in youth. *Medicine and Science in Sports and Exercise* **29**, 138-143.
Williams, C.L., Carter, B.J., and Wynder, E.L. (1981) Prevalence of selected cardiovascular and cancer risk factors in a pediatric population: the "Know Your Body" Project, New York. *Preventive Medicine* **10**, 235 – 250.

AUTHORS BIOGRAPHY

Eugenia C. ARGIROPOULOU
Employment
Democritus University of Thrace, Dept. of Physical Education & Sport Sciences, Komotini, Greece.
Degree
PhD
Research interests
Physical activity in youth.
E-mail michal_07030@yahoo.com

Maria MICHALOPOULOU
Employment
Ass. Prof. Democritus University of Thrace Dept. of Physical Education & Sport Sciences, Komotini, Greece.
Degree
PhD
Research interests
Physical activity and health promotion in the elderly, motor learning.
E-mail michal_07030@yahoo.com

Nikolaos AGGELOUSSIS
Employment
Ass. Prof. Democritus University of Thrace Dept. of Physical Education & Sport Sciences, Komotini, Greece.
Degree
PhD
Research interests
Biomechanics, research methods.

Andreas Avgerinos
Employment
Loughborough University of Technology, UK
Degree
PhD
E-mail: avgerino@phed.auth.gr

KEY POINTS

- The PALQ demonstrated a moderate reliability (0.52) and validity (0.53) in recording physical activity.
- A relatively high correlation was observed between the MTI/CSA and 3DPAR and a moderate correlation was observed between MTI/CSA and the 4BY1RPAQ tested in this study.
- Only a combination of the available instruments would be able to respond to the interpersonal and intrapersonal variability when assessing physical activity in children and adolescents. Self-report instruments and accelerometers are probably able to quantify only gross fluctuations in physical activity.
- All 4 instruments used in this study were valid and reliable in recording physical activity when used with children, since the instruments were able to detect changes in physical activity and the respective energy cost.

✉ **Dr. E.C. Argiropoulou**
Democritus University of Thrace, Dept. of Physical Education & Sport Sciences, Komotini 69100 GREECE.