FIELD VALIDATION OF THE TRITRAC-R3D ACTIVITY MONITOR FOR THE ASSESSMENT OF PHYSICAL ACTIVITY IN OLDER CHILDREN

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ABSTRACT

The purpose of this research project was to assess the convergent validity of the Tritrac-R3D Activity Monitor (Tritrac) as a field measure for assessing physical activity in children over a one week period. The Tritrac is a motion sensor that integrates acceleration in three dimensions to provide an objective measure of physical activity. Forty-four (20 males and 24 females) from grades four through eight were examined to evaluate the convergent validity of the Tritrac against a Caltrac motion sensor, the Physical Activity Questionnaire for Older Children (PAQ-C; Crocker, Bailey, Faulkner, Kowalski, & McGrath, 1997), and the Physical Activity Recall interview (PAR; Sallis et al., 1985). Participants wore the Tritrac and Caltrac motion sensors for seven days that did not contain any special school events. Upon retrieval of the motion sensors, participants completed the PAQ-C and were individually interviewed by trained assistants with the PAR interview. As expected, the Tritrac was highly correlated with the Caltrac ($r = 0.80$). The Tritrac was not, however, significantly related to the PAQ-C ($r = 0.22$), the PAR Total score (sum total of hours that participants engaged in moderate, hard, or very hard activity; $r = 0.15$) and the PAR Daily Average (activity score converted to METs; $r = 0.16$). Issues of compliance and practicality were also considered when assessing the validity of the Tritrac. Approximately 43% of the participants reported not wearing the Tritrac during active periods because of discomfort, interference with activity, and officials/coaches instructions. Results of the

study seriously question the use of the Tritrac as a valid means of quantifying children's physical activity for extended periods of time.

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CHAPTER 1

1.1 INTRODUCTION

Physical activity has been identified as a modifiable risk factor for decreasing the incidence of many diseases. Research in adults has shown that physical activity can prevent or at least minimize the severity of many diseases, such as coronary artery disease, hypertension, atherosclerosis, and diabetes mellitus, depression, osteoporatic fractures and total mortality (Ainsworth, Montoye, & Leon, 1994; Baranowski, Bouchard, Bar-Or et al., 1992). The end stages of many chronic degenerative diseases become apparent primarily during the adult stages of life. The fundamental processes underlying these diseases, however, may actually begin during childhood or adolescence (Despres, Bouchard, & Malina, 1990). Researchers have proposed that physical activity patterns in childhood and adolescence may be a significant determinant of physical activity patterns in adulthood (Malina, 1994). Increased understanding of physical activity in children may allow scientists to develop more appropriate activity intervention strategies that will result in improved future health status (Bar-Or & Malina, 1995). What has yet to be determined is the strength of this relationship between physical activity and the possible onset of disease in children (Baranowski et al., 1992).

In children there has been inconsistent findings concerning the relationship between physical activity and many metabolic health risks, such as lipid profiles or hypertension, questions the role physical activity plays in children's health status (Bar-Or, 1994; Malina, 1994). Some scientists (e.g. Stevens & Caspersen, 1994) have argued that methodological problems may produce inconsistent results in the literature. In particular, the absence of a criterion method for assessing children's physical activity have made determining the true relationship between physical activity and health status difficult (Baranowski, 1991; Bar-Or, 1994; Malina, 1994).

The literature reveals that assessment methods have been employed to quantify physical activity. These have ranged from subjective measures, such as self-report questionnaires and recall interviews, to more objective measures, including direct observation and mechanical/electronic devices (Baranowski et al., 1992; Crocker, Bailey, Faulkner, Kowalski, & McGrath, 1997). Despite the wealth of measurement techniques, no measure has proven to be the "gold standard" to which all other assessments are compared (Bar-Or, 1994; Montoye, Kemper, Saris, & Washburn, 1996).

Recently, several authors have argued that "objective" measures should be employed when assessing children's physical activity patterns (Aaron, Kriska, Dearwater, Cauley, & LaPorte, 1995; Welk & Corbin, 1995). Consequently, an increasingly popular measurement method has been motion sensors. The Tritrac-R3D Activity Monitor (Tritrac) is a motion sensor that quantifies physical activity in three dimensions, as opposed to previous models (such as the Caltrac) that only assessed activity in a single dimension. While validation of the Tritrac has seen initial validation in adults (Bouten, Westerterp, Verduin, & Janssen, 1994; Kochersberger, McConnell, Kuchibhatla, & Pieper, 1996; Matthews & Freedson, 1995), few studies have examined its validity in pediatric populations (Epstein, Paluch, Coleman, Vito, & Anderson, 1996; Welk & Corbin, 1995). These pediatric studies have evaluated the Tritrac under laboratory conditions or in very limited duration field studies.

Therefore, given the belief that objective measures are the best technique to assess children's activity and the limited evaluation of the Tritrac, the purpose of the study was to examine the validity of the Tritrac-R3D Activity over an extended period of time in a field setting. Convergent validity of the Tritrac was determined by examining inter-relations with other validated methods, including a 7-day recall questionnaire, a 7-day recall interview, and a single plane mechanical motion sensor. Further validity issues such as participant compliance and instrument practicality were also addressed when assessing the Tritrac.

1.2 REVIEW OF LITERATURE

1.2.1 Physical Activity and Health Relationships

Physical activity has been identified as a modifiable risk factor that has the ability to counter negative health conditions that threaten the quality of individuals' lives (Paffenbarger, Blair, Lee, & Hyde, 1993). Risk factors are physical or behavioral characteristics associated with the advancement of many chronic diseases (Bar-Or, 1994). Studies among adult populations have demonstrated an inverse relationship between physical activity and various negative health conditions, such as cardiovascular disease, coronary artery disease, hypertension, osteoporosis, and non-insulin-dependent diabetes mellitus (Baranowski et al., 1992; Surgeon General, 1996). Additionally, physical activity has been studied with respect to its positive effects such as increasing longevity, improving self-esteem, and reducing depression and anxiety (Surgeon General, 1996). Whereas studies in adult populations have provided support for the positive relationships between physical activity and improved health conditions (Baranowski et al., 1992; Freedson & Melanson, 1996), these relationships have been studied less often in pediatric populations. Conclusive results in research literature do not exist to indicate the true relationship between physical activity and risk factors for chronic diseases in children (Caspersen, Nixon, & DuRant, 1998; Sallis, Patterson, Buono, & Nader, 1988; Saris, 1985). Physical activity researchers are not able to monitor diseases, morbidity, and mortality issues in children as easily as in adult populations since these conditions are rare (Caspersen, Nixon, DuRant, 1998).

A paradigm shift has occurred as to the origins of chronic conditions in physical activity epidemiological research (Baranowski et al., 1992; Bar-Or, 1994). Diseases such as coronary heart disease, hypertension, and osteoporosis were once commonly thought to appear during the adult years. Current research in physical activity proposes that negative health conditions may actually have their antecedents in early childhood or adolescence (Baranowski et al., 1992; Caspersen, Nixon & DuRant, 1998; Saris, 1985). Various models have implied possible relationships between children's physical activity and physical fitness and health status during adult years (Bar-Or, 1994). One model proposed by Blair, Clark, Cureton, and Powell (1989) suggests that physical activity during childhood may affect adult health status in three ways. First, physical activity may directly affect adult health. Second, activity may affect health status via the effects on the health of the child. Third, it may affect the physical activity of the adult, which in turn will affect the health status of the adult. Whichever model is accepted, health-related activity is a reasonable goal for children. Nevertheless, researchers are left with questions because it has yet to be firmly established in the literature whether physical activity during childhood has positive affects on adult health status (Bar-Or & Malina, 1995).

An awareness that negative health conditions begin during the early stages of life is critical for making necessary changes to habitual physical activity and quality of life in adults (Caspersen, Nixon, & DuRant, 1998). It is estimated that as many as 60% of children in the United States exhibit at least one modifiable adult risk factor for coronary heart disease by the age of 12 (Baranowski et al., 1992). Early intervention would allow for increased success in establishing positive modifications that improve quality of life (Saris, 1985). Despite the perceived positive benefits associated with physical activity, habitual levels of physical activity and energy expenditure decline markedly during the second decade of life as shown in the 1988 Campbell Survey on Well-Being in Canada (Stephens & Craig, 1990).

There is basis to support the idea that physical activity is a modifiable behavior that has been shown to counteract many of the detrimental aspects that threaten the quality of life (Paffenbarger et al., 1993). Understanding the role of physical activity is increasingly important as there are increasing numbers of sedentary individuals susceptible to possibly life-threatening health conditions (Caspersen, Nixon, & DuRant, 1998). Therefore, it is important to investigate the role of physical activity in specific populations like school-aged children (Ainsworth, Montoye, & Leon, 1994; Gross, Sallis, Buono, Roby, & Nelson, 1990; Sallis, 1991). A major issue is, therefore, the valid assessment of physical activity (Bar-Or, 1994; Baranowski et al., 1992; Crocker et al., 1997).

1.2.2 Issues in Physical Activity Research

Physical activity is an overt observable behavior, and therefore should be a measurable concept (Hensley, Ainsworth, & Ansorge, 1993). Yet, many of the ambiguities relating physical activity and its interaction with health status arise from methodological shortcomings (Saris, 1985). For example, some of the most basic concepts in physical activity assessment have yet to be resolved, including a universally accepted definition of physical activity (Freedson, 1989; Melanson & Freedson, 1996).

1.2.3 Definitions of Physical Activity

Physical activity has been defined from both physiological and behavioral perspectives (Crocker et al., 1997). From the physiological perspective, physical activity is a element of total energy expenditure, which also includes resting metabolism, the thermic effects of food, as well as the growth and maturation process. Physical activity can also be viewed in terms of behavioral factors including intensity, duration, frequency, and muscle groups used. Physical activity may also be classified several ways. It can be considered in terms of specific activities, such as football or basketball, or body parts used (e.g. large or small muscle groups involvement), or the type of movement such as dynamic, isometric, isotonic, concentric, or eccentric activity

(Baranowski et al., 1992). Caspersen, Powell, and Christensen (1985) have suggested the most accepted general definition of physical activity is any bodily movement produced by skeletal muscles resulting in expenditure in energy. However, due to the complexity of quantifying physical activity, and the diversity of definitions, it has been difficult to determine the most appropriate methods of assessment for specific studies (Haskell, Yee, Evans, & Irby, 1993; Marsh & Johnson, 1994). Consequently, due to the differences between approaches in the research, as well as research questions that require specific types of activity assessments, correlations between different types of physical activity assessment methods may be low (Baranowski et al., 1992).

The greatest dilemma that has hampered the study of physical activity assessment has been the lack of a criterion method for physical activity assessment (Bar-Or, 1994; LaPorte, Montoye, & Caspersen, 1985). The absence of this criterion measure, the measure to which all other assessments are compared to, makes it difficult to determine the validity of physical activity measures, and subsequently determining the best methods of assessing activity in children (Ainsworth, Montoye, & Leon, 1994; LaPorte, Montoye, & Caspersen, 1985).

Given the lack of a criterion measurement one research focus in this area is to develop and apply reliable and valid measures of physical activity (Crocker et al., 1997). Although physical activity has been examined from several perspectives providing a wealth of assessment tools and techniques (Ainsworth, Jacobs, & Leon, 1993; Crocker et al., 1997), most do not exhibit reliable psychometric properties for assessment in youth (Sallis et al., 1993).

1.2.4 Criteria for Selection of Measurement Tools

The selection of an appropriate assessment tool should be based on specific criteria of the research and the target population. While no single assessment method proves best for all circumstances, there are more appropriate methods for particular study designs and research questions (Baranowski & Simons-Morton, 1991). The choice of a measurement tool should be based on the reliability, validity, and practicality of the assessment tool (Hensley, Ainsworth, & Ansorge, 1993). Other considerations should include a tool's intrusiveness, influence on participants' activity levels, and feasibility of the assessment technique (Ainsworth, Montoye, & Leon, 1994; Kowalski, Crocker, & Faulkner, 1997; Montoye et al., 1996). For example, if an assessment tool causes a child to change his/her activity pattern then the tool is not a valid means to assess typical activity no matter how accurate the measurement of physical activity. While each measure has its strength and limitations, it is still difficult to determine a measure's validity due to the lack of a criterion measure (Aaron et al., 1995; Freedson, 1989; LaPorte, Montoye, & Caspersen, 1985; Melanson & Freedson, 1996; Montoye et al., 1996).

1.2.5 Measures of Physical Activity

Over 30 techniques and devices (LaPorte, Montoye, & Caspersen, 1985) have been developed to assess physical activity. Techniques have ranged from simple single-item questionnaires to highly precise laboratory assessments. A reason for the numerous methods of assessment may be that there are many inter-correlated dimensions of physical activity (LaPorte, Montoye, & Caspersen, 1985). For example, some instruments have been designed to assess overall energy expenditure, whereas others assess specific aspects of frequency, intensity, duration, or type of movement. Confusion in the literature has resulted in studies examining different dimensions of physical activity while using the same construct definition (LaPorte, Montoye, & Caspersen, 1985). For each aspect of physical activity, there may be a particular measurement tool that will most appropriately assess that particular dimension.

Measures of physical activity can be divided into two separate general categories based on whether participants or others need to recall and recall physical activity.

Subjective measures and objective measures of physical activity. Subjective measures of physical activity are dependent upon the cognitive ability to recall and in some cases record their activity. These measures include; recall questionnaires, interviews, diaries, and surveys. A technique called direct observation (e.g. Children's Activity Rating; DuRant, Baranowski, Puhl et al., 1993) depend on observers ability to observe and classify participant's activity. Objective measures of physical activity are not dependent upon individuals recall. Specific measurement tools that have been used previously in this category include the doubly-labeled water method, heart rate monitors, and mechanical motion sensors (Freedson & Melanson, 1996).

1.2.5.1 Subjective Measures of Physical Activity

Direct observation techniques can assess activity in various environments, although it has been primarily been used in preschool children (Klesges, Eck, Hanson et al., 1990). Direct observation is very labor intensive and costly due to training observers, length of observation periods, cost of equipment, and an involved data coding process. The environment must be conducive for observer or videotape presence (Freedson & Melanson, 1996). It is also difficult to assess populations accurately that are highly mobile. Observation periods are often confined to short periods and may not accurately reflect habitual physical activity patterns (Freedson & Melanson, 1996; Montoye et al., 1996). Observer interaction resulting in changes in the participant's habitual activity patterns is a problem that needs to be considered (Montoye et al., 1996). Thus, the validity of direct observation is still questionable when assessing physical activity levels (Freedson & Melanson, 1996).

Another type of subjective measure, surveys commonly measure levels of activity. These surveys include diaries, recall surveys, quantitative history, and general surveys. Surveys require participants to report the nature and detail of the physical activity within a defined time frame. The time can be as short as five minute intervals to as long as one year. Data collection can be carried out through personal or telephone interviews, self-administered questionnaires, or mail surveys (LaPorte et al., 1985). The various survey methods are described below.

Diaries assess activity by having participants periodically logging the specific type and duration spent in physical activities. Records of specific activities can be maintained, or broader intensity categories ranging from moderate to very heavy can be recorded (Montoye et al., 1996). Diaries may be useful in that they provide information about both quantity and quality of physical activity (Hensley et al., 1993). The advantages of diaries include low cost and the ability to collect data from numerous subjects simultaneously (Montoye et al., 1996). Nevertheless, the logging of activities can often be tedious and may result in recording errors that may not accurately reflect activity levels. There is also the possibility of participants intentionally altering scores for social comparison reasons. Therefore, some researchers have questioned the validity and practicality of dairies (Freedson & Melanson, 1996; LaPorte et al., 1985; Montoye et al., 1996; Saris, 1985).

Interview surveys have similar benefits to questionnaires. The interviews can be structured to assess the type, frequency, intensity, and duration of physical activity (Haskell et al., 1993). Interviews offer particular advantages by allowing the interviewer to probe and gather detailed information about physical activity patterns and of specific activities (Sallis et al., 1985). Interviews also share many of the same shortcomings as questionnaires, such as lack of standardization, participant memory recall deficiencies, and data contamination due to social desirability.

Self-report measures are the most common and practical method of evaluating physical activity in population studies (Lamb & Brodie, 1990). This is in part to minimal costs, little participant inconvenience, low staff burden, ease of administration, and their ability to collect relatively large amounts of data in a short period of time (Crocker et al., 1997). Questionnaires used for both adults and children are frequently used (Jacobs, Ainsworth, Hartman, & Leon, 1993; Sallis, 1991). Self-report measures, however, have several potential sources of error. First there is a lack of standardized activities. Some questionnaires exclude certain activity domains which may account for low correlations among self-report measures (Baranowski, 1988; Jacobs et al., 1993). The second limitation is related to cognitive processes during memory recall (Patterson et al., 1988). There are concerns that recalled information may not be accurate. This may be especially problematic in children as perceptions of activity are limited (Klesges et al., 1990; Klesges & Klesges, 1987; Saris, 1985). Children tend to overestimate vigorous activity levels and underestimate time spent during regular activities (Saris, 1985). Baranowski (1988) suggested that memory recall can be increased with the aid of retrieval cues. Other sources of data contamination may occur due to biases, social desirability or comparison, and misinterpretations (Crocker et al., 1997).

1.2.5.2 Objective Measures of Physical Activity

Objective measures of physical activity are not dependent on the participants recall or the ability of the experimenter to correctly record and classify activity. One objective technique is the doubly labeled water method for estimating energy expenditure in both laboratory and field research. Participants ingest water with a known concentration of hydrogen and oxygen isotopes. Energy expenditure is then determined from the elimination differences of the two isotopes (Montoye et al., 1996). Oxygen uptake for a period of time can be calculated by measuring the concentrations of labeled hydrogen and oxygen in the urine and from this energy expenditure can be determined (Hensley, Ainsworth, & Ansorge, 1993; Montoye et al., 1996). The doubly labeled water technique appears to be an accurate technique for measuring physical activity, and is considered the most reliable method to assess physical activity in field studies when assessing over multiple days (Saris, 1992; Montoye et al., 1996). Doubly labeled water is limited due to its relatively high cost ($300-$500 U.S.) and complexity of application and analysis of samples (Hensley, Ainsworth, & Ansorge, 1993; Saris, 1985; 1992). A major limitation of this technique is that it offers information only about total energy expenditure and does not provide data during specific time intervals or activities (Montoye et al., 1996; Saris, 1986). Another serious limitation is that it is limited to overall energy expenditure. It does not reveal any information about intensity, frequency, and duration parameters. These parameters may be critical for specific types of health, such as cardiovascular fitness.

Technological advances have lead to the development of mechanical and electronic devices to assess physical activity by directly recording movement. These devices, which provide more objective measures of activity include heart rate monitors, stabilometers, pedometers, electronic motion sensors, and accelerometers (Ainsworth, Montoye, & Leon, 1994; Freedson & Melanson, 1996). Potential limitations of these devices include cost, technical/mechanical failures, and intentional tampering (Bray, Wong, Morrow, Butte, & Pivarnik, 1994; Haskell et al., 1993; Kowalski, Crocker, & Faulkner, 1997). These various techniques are described below.

Heart rate monitors have been used to collect physical activity data (Saris, 1985). Heart rate monitors directly measure a physiological parameter known to be related to physical activity, providing continuous data reflecting both intensity and duration of the participants physical activity (LaPorte et al., 1985). Monitoring heart rate is simple and places little demands on the participant (Saris, 1985). Activity levels are determined on a linear relationship between heart rate and energy expenditure (Blair, 1984; Freedson & Melanson, 1996). Several factors can effect an individual's heart rate, including climatic conditions body composition, ambient temperature, type of muscular contraction, type of activity, fatigue, drugs (e.g. caffeine) and emotional stress (Bar-Or & Malina, 1995; Freedson & Melanson, 1996; Haskell et al., 1993; LaPorte et al., 1985). Due to individual differences, regression equations must be developed for each individual to determine heart rate and oxygen consumption (LaPorte et al., 1985).

This procedure greatly increases the time and expense of heart rate monitoring. Nevertheless, heart rate monitors may provide fundamental information when used in association with other measures, such as motion sensors (Hensley et al., 1993).

Motion sensors include such instruments as pedometers and accelerometers. Accelerometer technology allows for measurement of acceleration forces produced by movement (Kochersberger et al., 1996). One such mechanical device is the Caltrac Personal Activity Computer (Caltrac; Muscle Dynamics, Inc., Torrance, CA; Haskell et al., 1993). The Caltrac assesses quantity and intensity of vertical movement as either caloric expenditure or as activity counts (Bray et al., 1994). The Caltrac has been shown to be a valid assessment tool of physical activity in children when compared with direct observation (Mukeshi, Gutin, Anderson, Zybert, & Basch, 1990; $r = 0.62$) and when tested for reliability in a lab setting against heart rate and oxygen uptake (Sallis, Buono et al., 1990; $r = 0.89$). However, the Caltrac does not reflect increases in energy expenditure due to the increased intensity or resistance, or to movement in other than the vertical plane (Haskell et al., 1993; Montoye et al., 1996). The Caltrac also cannot assess activity in specific time segments. Other problems include participants not wearing the device, participants tampering with the Caltrac's external controls, and the fact the Caltrac cannot be worn in water, such as during swimming (Kowalski, Crocker, & Kowalski, 1997).

Advancements in motion sensor technology have led to the development of more sophisticated motion sensors. While the Caltrac measures acceleration only in a vertical plane, the Tritrac-R3D Activity Monitor (Tritrac; Hemokinetics Inc., Madison, WI) assesses physical activity in three planes. Validation studies with the Tritrac-R3D have been limited in sample size, short evaluation periods, and few studies have investigated its practicality and validity in children outside a laboratory setting (Epstein et al., 1996; Welk & Corbin, 1995).

1.2.6 Assessment of Physical Activity in Children and Adolescents

In view of the importance of health issues surrounding physical activity, accurate assessment is particularly important as it can ultimately influence programs and services that may aid in individuals attaining or maintaining positive health status (Hensley, Ainsworth, & Ansorge, 1993; Kaman & Patton, 1994). The development and assessment of physical activity adequate physical activity instruments in children is an important step in researching the role of activity in health (Janz, 1994). Many measures have not been shown to be acceptable to answer research questions, especially in pediatric populations (Bar-Or, 1994; Freedson & Melanson, 1996).

Assessment of physical activity in children is more difficult to adults. Physical activity patterns of children tend to be sporadic and anaerobic, while physical activity patterns of adults tend to be more consistent in nature (Bar-Or & Malina, 1995; DuRant et al., 1993). Furthermore, children do not have the same cognitive abilities of adults to recall specific activity information related to type, frequency, intensity, and duration (Baranowski et al., 1992). In many cases, measures of physical activity originally developed for adults are not necessarily valid when applied to children (Sallis et al., 1985; Saris, 1986; Wallace, McKenzie, & Nader, 1985). Researchers cannot presume that children have the ability to respond in a similar manner as adults (Sallis, 1991). This becomes more critical since assessment techniques for young children have been predominantly subjective in nature, with self-report measures being the most common method (Crocker et al., 1997). Due to children's limited perceptual and memory capacities when using subjective measures of assessment objective measures, such as motion sensors, may be a suitable alternative for assessing children's physical activity (Sallis, 1991).

1.2.7 The Tritrac-R3D Activity Monitor (Tritrac)

The Tritrac-R3D Activity Monitor (Tritrac; Hemokinetics Inc., Madison, WI) is a new motion sensor that has been proposed as a good method to assess activity in children and other target populations (Chen & Sun, 1997; Coleman, Saelens, Wiedrich-Smith, Finn, & Epstein, 1997; Epstein, et al., 1996; Kochersberger et al., 1996; Lamb, & Eston, 1997; Matthews & Freedson, 1995; McMurray, Harrell, Bradley, et al., 1998; Sherman, Morris, Kirby, et al., 1998; Welk, & Corbin, 1995). The Tritrac offers advantages over the previous single-dimension designs (Haskell et al., 1993; Meijer, Westerterp, Koper, & Ten Hoor, 1989). The Tritrac incorporates three accelerometers, oriented at right angles to one another (Matthews & Freedson, 1995). The planes assessed are: medio-lateral (x), vertical (y), and antero-posterior (z) [Coleman et al., 1997; See Appendix A]. The instrument collects data of each of the planes in user-defined time samples, and calculates a composite movement score, labeled the "vector magnitude" ($[x^2 + y^2 + z^2]^{0.5}$) for all three directions (Epstein et al., 1996). Additional advantages of the Tritrac include internal data storage, no external controls which can be manipulated by participants, and individual physiological statistics to allow for calculation of various parameters (Welk & Corbin, 1995; Matthews & Freedson, 1995; See Appendix B). The Tritrac features durable construction with a serial interface, allowing data to be stored for up to 14 days before being downloaded directly into a computer for statistical analysis (Welk & Corbin, 1995). The Tritrac is 2.5 x 6.75 x 10cm, weighting 227-grams (Kochersberger et al., 1996), making it small and easy to wear.

The Tritrac accelerometer has been shown to have acceptable reliability and validity when assessing adult's physical activity in a lab setting (Chen & Sun, 1997; Sherman, Morris, Kirby, et al., 1998). Kochersberger and colleagues (1996) examined the reliability, validity, and stability of the Tritrac in an elderly population (mean age = 76 years) over a period of 3 to 7 days. Participants included 40 residents of a nursing home, 36 individuals in an in-home non-aerobic exercise program, and 10 community participants in an aerobic exercise program. Validation of the Tritrac included an examination of its ability to identify different levels of physical activity. Convergent validity was examined by comparing the Tritrac to the Actigraph, a wrist-worn accelerometer (Ambulatory Monitoring, Ardsley, NY). Test-retest validity of the Tritrac was examined using a shaker table as well as during treadmill walking. Testing revealed that the Tritrac had significant test-retest reliability ($\underline{r} = 0.97$). The study also showed that the Tritrac was sensitive enough to discriminate between activities of varying intensity. Convergent validity with the Actigraph was reported as $\underline{r} = 0.77$. From this study, the Tritrac appears to be a reliable and valid instrument in assessing physical activity in an elderly population. It is important to note, however, that 20% of the subjects did not comply with wearing the device. This issue may be of great importance when considering the Tritrac as an assessment tool.

Sherman and colleagues (1998) conducted a study using the Tritrac to assess the physical activity of adults in a lab setting. Sixteen participants investigated the whether Tritrac could be used to estimate daily energy expenditure during rest (pre- and post-exercise) and during three different intensities activity on a treadmill (40-70% of peak oxygen consumption). A significant relationship was found between energy expenditure determined from indirect calorimetry and that calculated by the Tritrac ($\underline{r} = 0.96$). Analysis of variance found there to be no difference in the energy expenditure between the two methods at rest before exercise and during the three different intensities of ambulatory exercise. Thus, the Tritrac also appears to provide valid estimates of energy expenditure.

Further validation of the Tritrac to assess energy expenditure was compared against a whole-room indirect calorimeter under close-to-normal living conditions for 53 men and 72 women for two 24-h periods (Chen & Sun, 1997). Estimated energy expenditure from the Tritrac was correlated with the measured total energy expenditure from the whole room calorimetry for the 2 days (r = 0.93). However, the Tritrac significantly underestimated total energy expenditure as well as energy expenditure for physical activities. Investigators developed their own equations to predict energy expenditure. These equations estimated energy expenditure with higher accuracy based on subjects' physical characteristics and body acceleration compared to the manufacture's equations.

Matthews and Freedson (1995) also investigated the capability of the Tritrac in estimate daily energy expenditure. Twenty-five men and women (mean age = 26.7 years) wore the Tritrac for 7 days. Results from the Tritrac were compared to a three-day physical activity log (PAL; Bouchard, Tremblay, Leblanc, Lortie, Savard, & Therialt, 1983) and a recall interview (SDR; Blair, 1993). It was found that the Tritrac was correlated to the PAL and the SDR (r = 0.82 and r = 0.77, respectively). The Tritrac significantly underestimated free-living energy expenditure when compared with the PAL and SDR (2552.7 vs. 2915.5 $kcal \cdot d^{-1}$ and 2530.0 vs. 2840.3 $kcal \cdot d^{-1}$, respectively). It is also possible that the PAL and SDR measures are overestimating energy expenditure.

1.2.8 Use of the Tritrac to Assess Physical Activity in Children

Few studies have used the Tritrac as a measure of physical activity in children. Coleman and colleagues (1997) examined the relationship between the Tritrac's vectors, heart rate and diary self-report in obese children. Thirty-five obese children, eight to 12 years old, were examined over a three-day assessment period. Correlations between the Tritrac MET scores (one MET is the value of resting oxygen uptake relative to total body mass and is generally given the value of 3.5 milliliters of oxygen per kilogram of body mass per minutes; Caspersen, Nixon, & DuRant, 1998) scores and heart rates (r = 0.71) were significantly higher than those between self-report and heart rate (r = 0.36) or between Tritrac and self-report (r = 0.38). When individual vectors of the Tritrac were compared to other measures of activity, the composite vector magnitude score accounted for more variance in both the self-report and heart rates, than any of the single vectors. Thus, the use of multiple direction assessment of the Tritrac may offer distinct advantages over the previous uni-dimensional accelerometers of the past.

Epstein, Paluch, Coleman, Vito, and Anderson (1996) assessed the predictors of activity in a sample of 59 obese children. Physical activity was measured using the Tritrac and by an invalidated self-report/diary method. Self-report measures were then converted to MET's using the Compendium of Physical Activities. Children wore the Tritrac for two weekdays after school and during one full weekend day. Participants noted times that they wore the Tritrac and times that they were not able to wear the Tritrac (e.g. swimming). The self-report recording sheets were divided into segments of the day and behaviors and times spent in activities were recorded. The Tritrac and self-report measures were moderately correlated (r = 0.46). The self-reported activity energy expenditure was significantly greater than the Tritrac energy expenditure calculation.

Welk and Corbin (1995) conducted a study to validate the Tritrac as an assessment tool to be used with children. Thirty-two boys, ages 10-12 years, participated in the study which involved simultaneous monitoring of physical activity using three instruments; a telemetry-based Polar Vantage XL Heart Rate Monitor (Polar Electro, Kampala, Finland), a Tritrac (Hemokinetics, Inc., Madison, WI), and a Caltrac motion sensor (Muscle Dynamics, Inc., Torrance, CA). Participants were monitored on three separate school days with all three instruments over an eight-month period. Children wore the motion sensors and heart rate monitor for one day and returned the following day to school with the equipment. Results showed that the Tritrac was moderately correlated with the heart rate monitor (r = 0.58) and highly correlated with the Caltrac (r = 0.88). The Tritrac's facility for breaking down the data in a minute-by-minute manner revealed correlations between the Tritrac and the heart rate monitors were highest during the participants free play situations, such as lunch/recess and after school. This may be due to the lack of variance in activity scores due to the lack of activity during the school hours for children. Welk and Corbin did not report the stability among Tritrac assessments over the three assessment days.

McMurray and colleagues (1998) completed a study examining the validity of a computerized physical activity recall (CAR) to assess activity and energy expenditure in youth using the Tritrac-R3D Activity Monitor. Twenty-five girls and twenty boys in grades 6 through 8 (Mean age = 11.8 years) were examined. Participants used the CAR to assess five consecutive days of physical activity, during which were randomly assigned to wear the Tritrac activity monitor for one of these days. This procedure was repeated with twenty-two participants one to two weeks later. Results show that the Tritrac and CAR were moderately correlated ($\underline{r}$ = 0.51) to each other.

1.2.9 Study Design: Convergent Validity of the Tritrac-R3D Activity Monitor

A high priority of physical activity research is the development of valid and reliable assessment tools, especially for children (Sallis, Simons-Morton, et al., 1992). Although the Tritrac motion sensor may offer researchers an objective tool to quantify physical activity, its validity for collecting long-term field data in children has yet to be determined. The lack of a "gold standard" in physical activity research poses a problem for assessing the validity of a measurement tool (Aaron et al., 1995; Melanson & Freedson, 1996; Montoye et al., 1996). Therefore, it may be more applicable to examine convergence of measurements to establish and assess validity of a physical activity measure (Kowalski, Crocker, & Kowalski, 1997). Inter-correlating various field measures have been used in previous validation studies. Studies examining convergent validity of physical activity in children have employed the use of motion sensors, self-report measures, activity ratings, and recall interviews (Kowalski, Crocker, & Faulkner, 1997; Kowalski, Crocker & Kowalski, 1997).

The purpose of this study was to determine the validity of the Tritrac motion sensor in a field setting. In order to examine the convergent validity of the Tritrac-R3D test scores were compared to several measures that have been validated with children. Specifically, these measures included the Caltrac motion sensor, a seven day self-report of activity called the Physical Activity Questionnaire for Older Children (PAQ-C; Crocker et al., 1997), and a seven-day recall interview called the Physical Activity Recall interview (PAR; Sallis, Haskell et al., 1985). Several other related issues needed to be considered when validating the Tritrac, such as financial cost, compliance with wearing the instrument, response burden of participants, data contamination (e.g., instrument breakdown, tampering with motion sensors), and disruption to classes in school. Participants were asked in an interview to identify when and why they did not wear the Tritrac. Tritrac output was also examined for evidence of lack of compliance.

1.3 STATEMENT OF PURPOSE AND HYPOTHESES

The validity of the Tritrac motion sensor has yet to be determined when used for extended periods of time, such as assessing physical activity for seven consecutive days. Data for children wearing the Tritrac for extended periods does not exist, as previous studies have had participants wear the Tritrac for limited durations of time, usually for a single day, or hours within a day. Further, many settings have been controlled such as laboratories, or assessing activity during physical activity classes. Generalizing physical activity scores on short assessment periods may misrepresent the true activity patterns of a pediatric population, as children's physical activity tends not to be stable across days but rather is sporadic (Janz, 1994; Saris, 1986). It has been suggested that data should reflect an interval greater than three days to accurately assess habitual activity in children (DuRant et al., 1993; Janz, 1994).

The purpose of this research study was to assess the convergent validity and application of the Tritrac-R3D Activity Monitor in a field setting using school-aged children from grades four though eight over a seven day trial. While a laboratory setting would provide a more stringent testing of validity, the application to the field is the true test of the utility of the Tritrac monitor as a measure of physical activity in children. Convergent validity of the Tritrac-R3D will be established through moderate to strong positive correlational relationships with other measures of physical activity including a) the Caltrac Personal Activity Computer, b) the Physical Activity Questionnaire for Older Children (Crocker et al., 1997), and the Seven Day Physical Activity Recall Interview (Sallis et al., 1985). Furthermore, participant compliance with wearing the Tritrac plus instrument hardware and software problems will be assessed.

1. Primary Hypotheses

It was expected that the Tritrac would correlate highly with the Caltrac motion sensor. The two motion sensors were assumed to be assessing similar dimensions of physical activity, as well as the two motion sensors were to be worn at the same time. It was also hypothesized that the Tritrac would be moderately correlated with the two subjective measures, the PAQ-C, and the PAR interview.

1.4 ASSUMPTIONS

1. It was assumed that participants would wear the Tritrac and Caltrac motion sensors as often as possible for seven consecutive days.
2. It was assumed that participants would answer the self-report Physical Activity Questionnaire for Older children and the Seven Day Recall Interview as honestly as possible.

1.4 DELIMITATIONS

1. Generalizability of the results of this study are limited to children grades four through eight in middle class urban settings.

1.5 LIMITATIONS

1. Lack of control over compliance of participants to wear the Tritrac and Caltrac motion sensors at all possible times.
2. Participants were not randomly selected due to the voluntary nature of the study.

CHAPTER 2

2.1 METHODOLOGY

2.1.1 Participants

Seventy-nine children, in the fourth to eighth grades volunteered to participate from a Saskatoon Public School. All volunteers were required to have signed informed consent by the Saskatoon School Board, their parent/guardian and themselves (See Appendix C). Complete data sets were obtained from 44 students, twenty-four females (mean age = 11.0 years, SD = 1.5) and twenty males (mean age = 10.7 years, SD = 1.1). (See data screening; section 3.1.1).

2.1.2 Measures

2.1.2.1 Tritrac-R3D Activity Monitor (Tritrac). The Tritrac activity monitor integrates acceleration in three dimensions: horizontally, vertically, and mediolaterally (Matthews & Freedson, 1995). Data is collected in each of the three planes, as well as the composite movement score of all three directions called the "vector magnitude," in user-defined time intervals. The software driven Tritrac allows for individual data input to be entered. Since energy expenditure values from the Tritrac are not recommended for children as they have not been validated for this target population (Epstein et al., 1996; McMurray et al., 1998; Welk & Corbin, 1995), a general measure of physical activity was calculated. Participant identification, standardised measures for age (10 years); sex (female); height (60in); and weight (100lbs) were entered for all participants as a normalised movement count was of interest and not a calculation of kilocalorie expenditure. The Tritrac, approximately 2.5 x 6.75 x 10cm in size, was placed into a pouch, sealed to deter participants from tampering with the Tritrac unit, and securely fastened to a neoprene belt.

The Tritrac accelerometer has been shown to have adequate reliability and validity in assessing physical activity in children. Welk and Corbin (1995) found the Tritrac to be moderately correlated with a heart rate monitor ($r = 0.58$) and highly correlated with a Caltrac motion sensor ($r = 0.88$) in children. It has also been shown to be correlated with heart rate and self-report measures in children (Coleman et al., 1997; McMurray et al., 1998). A major limitation of previous studies is the length of assessment time has been limited to very short durations, and conducted under strictly controlled situations.

2.1.2.2 Caltrac Personal Activity Computer (Caltrac). The Caltrac Personal Activity Computer (Caltrac; Muscle Dynamics, Torrance, CA) is a motion sensor that measures quantity and intensity of vertical movement by means of a piezoelectric bender element resulting in an intensity dependant voltage output (Bray et al., 1994; Freedson & Melanson, 1996). The Caltrac can display data as a mean activity counts or as caloric expenditure, with higher scores reflecting greater amounts of physical activity. The Caltrac can also report the activity as mean movement counts by standardising all subjects data input. The Caltrac allows for the entry of age, gender, height, and weight. Standardised measurements were as follows: sex = 0; height = 60in; weight = 100lbs; age = 10 years (Kowalski et al., 1997). The activity count sum can be displayed on the Caltrac output panel. The Caltrac is limited in that only a sum of activity can be determined and not a detailed analysis of the activity during the time that the participant wore the motion sensor. The Caltrac is approximately 2.5 x 7.5 x 8.5cm and was placed into a pouch and secured to a neoprene belt. The pouch was secured with tape to deter participants from tampering with the Caltrac's external controls.

Validation and reliability have shown the Caltrac as an acceptable tool for assessing physical activity in children (Mukeshi, Gutin, Anderson, Zybert, & Basch, 1990). Sallis, Buono, and colleagues (1990) provided psychometrics of a previous version of the Caltrac, reporting inter-instrument reliability of $\underline{r} = 0.89$ in the field and $\underline{r} = 0.96$ in the laboratory setting for children when used as an activity counter. The Caltrac has also been shown to be significantly correlated with the seven day recall interview (PAR) in school-aged children (Sallis, Buono et al., 1990). The Caltrac also has been shown to have adequate validity when compared with other measures of children's physical activity. In a study of children, grades four through eight, Kowalski, Crocker, and Faulkner (1997) found the Caltrac to be moderately correlated with the PAQ-C ($\underline{r} = 0.39$), an activity rating ($\underline{r} = 0.63$), and the Leisure Time Exercise Questionnaire ($\underline{r} = 0.41$).

2.1.2.3 The Physical Activity Questionnaire for Older Children (PAQ-C). The PAQ-C is a self-administered seven day recall questionnaire designed to assess physical activity in children between grades 4 through 8 during the school year (Crocker et al., 1997; Kowalski, Crocker, & Faulkner, 1997; Kowalski, Crocker, Kowalski, 1997). The PAQ-C consists of ten items, nine are used in the calculation of the summary activity score, with the remaining question concerned with sickness or other events that may prevent the child in participating in their activities (See Appendix D). Question 1 consists of a list of common activities, sports, leisure activities and games. Participants indicate the number of times that they participated in these activities during the past seven days. The following six items ask the children to rate their levels of activity during physical education class, recess, lunch, after school, evenings, and weekends. Question number eight asks for an overall description of activity levels ranging from "All or most of my free time was spent doing things that involve little physical effort (e.g., watching TV, doing homework, playing computer games, Nintendo)" to "I very often (7 or more times last week) did physical things in my free time." Question 10 asks children to rate their physical activity on each day of the week from "none" to "very often" (Crocker et al., 1997; Kowalski et al., 1997). Each of the statements are scored on a five point Likert scale, with higher scores indicating increased levels of activity with scores therefore ranging from 1 to 5. The PAQ-C score is calculated by averaging the 24 activities in the checklist in question 1, and the 7 days of the week in question 10, and summing all scores.

Kowalski, Crocker and Faulkner (1997) found the PAQ-C was moderately related to other measures of physical activity in children, including a Caltrac motion sensor ($r = 0.39$), a 7-day summation of 24 hour moderate to vigorous activity recalls ($r = 0.48$), an activity rating ($r = 0.57$), Leisure Time Exercise Questionnaire ($r = 0.41$), and a seven day activity recall interview ($r = 0.46$). Crocker et al. (1997) also found the PAQ-C to have acceptable internal consistency and test-retest values.

2.1.2.4 Seven Day Physical Activity Recall Interview (PAR). The Seven Day Physical Activity Recall (PAR) is a standardized interview to aid participants in recalling activities from the previous 7 days. Participants evaluate activities as moderate, hard, and very hard. Number of hours slept for each day is also determined (Sallis et al., 1985; See Appendix E). Scores are determined from hours participating in activities or can be converted to an index of caloric expenditure. The PAR calculates the week's activities as an open-ended summary. The score is calculated based on number of hours slept (multiplied by a MET factor of 1), moderate activities (multiplied by 4), hard activities (multiplied by 6), very hard activities (multiplied by 10). Light activities (multiplied by 1.5) are determined by subtracting the above number of total hours from the sleep, moderate, hard, and very hard categories (Kowalski, Crocker, & Faulkner., 1997). The present study assessed physical activity using the PAR in two ways. The first was the calculation of the PAR Daily Average, which is determined by converting number of hours in the different categories (e.g. sleep, light, moderate, hard, etc.) into a calculation of MET's. The second score that was determined from the PAR interview was the quantification of the total number of hours that participants engaged in moderate, hard, and very hard physical activity (PAR Total Hours).

The PAR has been shown to have significant test-retest correlations with children using its kilocalorie value index for fifth graders (r = 0.47) and eighth graders (r = 0.59; Sallis, Patterson et al., 1988). Sallis and colleagues (1993) also found the PAR to have adequate test-retest validity with 11th graders (r = 0.81). The PAR has been shown to have acceptable convergent validity with the Caltrac (r = 0.49 on day 1 and r = 0.39 on day 2; Sallis et al., 1990). Kowalski, Crocker and Faulkner (1997) found similar results, reporting the PAR interview to be moderately correlated to the PAQ-C (r = 0.46).

For the present study, seven interviewers received training on the PAR and its interview procedures. PAR training followed the protocol outlined in the manual (Seven Day Physical Activity Recall Manual: Project GRAD), utilizing standardized audio samples of previously completed interviews. Prospective interviewers coded the standardized audio-tape samples and were then evaluated for accuracy of the PAR interview that was completed. Interviewer training was complete when the minimum standard of correctly coding two interviews consecutively was met.

2.1.3 Procedures

Participants were assessed during March-June, 1997, with testing completed over a total of six weeks. Volunteers were assessed in classroom groupings of 20. Each group of participants were assessed during a seven day time span that did not contain any special school events (e.g. play days, professional development days) that may cause a change in the children's normal activity patterns.

The Tritrac motion sensors were initialized using standardized age (10 years); sex (female; 0); height (60in); and weight (100lbs) the day before it was given to participants. Data could later be edited to calculate activity from the time that the unit was actually given to participants (See Appendix B). The Caltrac activity counter was reset immediately before giving the devices to participants. Children received instructions on the use and care of the Tritrac/Caltrac. These instructions included when and when not to wear the units (e.g. in water), and proper positioning of the Tritrac/Caltrac holsters. The motion sensors were then placed in pouches on a belt that was worn for seven consecutive days. Children received evening reminder calls every evening at home as well as a visit from a research assistant at school every morning to remind them to wear the motion sensors, as well as answer any questions or problems that participants may have experienced with units.

At the end of the seven day period, Tritrac and Caltrac motion sensors were collected from each participant. Each group of students completed the PAQ-C with a research assistant present to aid any students that may have difficulty with any of the particular questionnaire items. Following the administration of the PAQ-C, each student was interviewed separately using the PAR seven-day recall interview protocol. Each interviewer had received training regarding the PAR protocol. At the end the PAR interview, participants were also interviewed to determine when they were not permitted or not able to wear the Tritrac for various reasons (See Appendix E).

2.1.4 Data Analysis

Prior to any examination of statistical analyses, data were examined for participants having complete data of all physical activity assessments, including the Tritrac, Caltrac, PAQ-C, and PAR measures, as well as meeting the minimum Tritrac compliance standards (55 hours for the seven day assessment period). Fifty-five hours represented approximately 2/3 of potential hours if the Tritrac could be worn for 12 hours per day. Outliers were cases whose standard score was greater than three standard deviations above the mean on any of the physical activity measures.

Study variables were investigated to test the assumptions of correlations (e.g. normality, linearity, and homoscedasticity; Diekhoff, 1992). Distributions of the test variables were examined for normality through histograms of the physical activity measures. All physical activity measures failed to have normalized distributions, although the violations (skewness) were not severe. Linearity and homoscedasticity were determined by examining scatterplots of physical activity test measures. There were no marked violations.

To test the primary hypothesis that the Tritrac would correlate positively and highly with the Caltrac motion sensor, and that the Tritrac would be positively and moderately correlated with the two subjective measures (the PAQ-C, and the PAR interview) a pair-wise correlational matrix was constructed. Tests for relationships between Tritrac and the other measures were examined through one-tailed Spearman rank order correlations. Spearman rank order correlation were used as physical activity measures were nonparametric (deviated from being normally distributed). A correlation matrix was produced to examine relationships among the four measures of physical activity, specifically the Tritrac and Caltrac motion sensors, the PAQ-C questionnaire and the PAR interview. Convergent validity for the Tritrac would be shown through the moderate to strong positive correlational relationships with the other physical activity measures. Levels of significance for all tests was set at $p < .05$ prior to all analyses.

CHAPTER 3

3.1 RESULTS

3.1.1 Data Screening

Seventy-nine participants originally began in the validation of the Tritrac-R3D motion sensor. Participant's data was analyzed on a case-wise basis for complete data for the Tritrac, Caltrac, PAQ-C, and PAR interview. For the Tritrac, individual data was examined for a minimum vector magnitude of 175 counts per 15 minute time interval. Based on pilot testing, a value greater than 175 was considered to be valid reflection that the participant wore the Tritrac unit for that entire time interval. Total number of acceptable time intervals were then determined to establish the total number of hours that the Tritrac unit was worn. A value of approximately two-thirds of the total time the devices were expected to be worn (7 days a week for 11-12 hours a day). A minimum criterion of 55 hours of wearing the Tritrac for the seven-day period was needed in order for participants data to remain in the final data set.

Four sets of Tritrac data were lost because of defective 9-volt and lithium batteries, and four more Tritrac unit's data was lost due to Tritrac computer software failure. Twenty-one participants data were eliminated from the Tritrac and Caltrac sample for not meeting minimum Tritrac criteria of 55 hours. Reasons for participants not wearing the Tritrac activity monitor included forgetting to wear units, being prohibited from wearing it due to league or coaches' regulations, embarrassment of physical appearance in public, discomfort, participation in aquatic type activities, and physical sickness. Two Caltrac units also experienced power failures and no data were able to be collected.

Participants data was then examined for the presence of outliers. Four participants were removed from the sample for having extreme scores on physical activity measures. Only two participants dropped out of the study during the data collection phase, and two more were absent for completing the PAQ-C and PAR interviews, but their data was never entered in the initial data set. The final data set that was examined used 44 participants that had complete data on all physical activity measures.

3.1.2 Descriptive Results

Descriptive statistics for the Tritrac-R3D Activity Monitor vector magnitude activity count, Caltrac activity count, PAQ-C total score, and the weekly total hours in moderate, hard, and very hard activity (PAR Total), as well as daily average MET scores for the PAR (PAR Daily Average) are shown in Table 3.1. The descriptive suggest that the sample had higher vector magnitude activity count scores when compared to the study by Welk & Corbin (1995) examining children's activity during an eight hour period. A similar study in design to the present was Kowalski et al. (1997). Mean values for the PAQ-C for this study (M = 3.31, SD = 0.52) was similar to the mean values reported by Kowalski (M = 3.35, SD = 0.68). Caltrac scores of the present study (M = 562.1, SD = 142.5) were slightly higher compared to Kowalski et al. scores converted for a single day average (M = 426.54, SD = 131.61). The mean value

Table 3.1

Descriptives for the Tritrac-R3D Activity Monitor, Caltrac Personal Activity Computer, Physical Activity Questionnaire for Older Children, and Seven Day Physical Activity Recall Interview

Variable	n	Mean	SD
Tritrac	44	1938725.20	477362.61
Caltrac	44	2934.70	997.26
PAQ-C	44	3.31	0.52
PAR (Total)	44	10.78	4.37
PAR (Daily Average)	44	38.24	2.98

Note.
Tritrac and Caltrac scores are activity counts.

PAR Total is the sum of moderate, hard, and very hard hours.

PAR Daily Average is the sum of sleep, light, moderate, hard, and very hard hours converted to MET's.

for the PAR Hours for this study (M = 38.24, SD = 2.98) were similar to Kowalski (M = 37.72, SD = 4.13). Mean values for the PAR Daily Average score for this study (M = 10.78, SD = 4.37) were similar to Kowalski et al. (M = 9.32, SD = 4.78).

3.1.3 Tests of Hypotheses

3.1.3.1 Primary Hypothesis

It was expected that the Tritrac would be strongly correlated with an "objective" measure of physical activity (Caltrac motion sensor), and moderately correlated with two more "subjective" measures of physical activity (PAQ-C and PAR interview). Testing of relationships between the physical activity measures were examined using Spearman rank order correlation coefficients (Table 3.2). Spearman rank order coefficients were used to assess convergence of physical activity measures as PAR Total scores and the PAR Daily Average score deviated slightly from normal distributions. Correlations among the physical activity measures support the hypothesis that the Tritrac would be strongly related to the Caltrac ($\underline{r}$ = 0.80). The hypothesis that the Tritrac would moderately correlated with the PAQ-C and the PAR interview was not supported with correlations showing no significant relationship among these physical activity measures.

3.1.3.1.1 Test of Relationship of Tritrac Planes of Orientation to Caltrac

The Tritrac assesses physical activity in three dimensions as opposed to a single plane of assessment as previous models of motion sensors did. The planes assessed are: medio-lateral (x), vertical (y), and antero-posterior (z) [Coleman et al., 1997].

Table 3.2

Spearman Rank Order Correlation Coefficients Among the Tritrac-R3D Activity Monitor, Caltrac Personal Activity Computer, Physical Activity Questionnaire for Older Children, and Seven Day Physical Activity Recall Interview

Variable	1.	2.	3.	4.	5.
1. Tritrac	-----				
2. Caltrac	.80* (44)	-----			
3. PAQ-C	.22 (44)	.16 (44)	-----		
4. PAR (Total)	.15 (44)	.11 (44)	.43* (44)	-----	
5. PAR (Daily Average)	.16 (44)	.13 (44)	.50* (44)	.85* (44)	-----

* $p < .05$ level (one-tailed significance)

Spearman rank order correlations for the Tritrac's four measures of assessment (x, y, z, and vector magnitude) against the Caltrac activity counts are shown in Table 3.3. This correlation matrix shows that the Tritrac's vertical plane of assessment (y) was significantly related to the Caltrac ($r = 0.72$).

3.1.3.1.2 Test of Relationship of PAR Activity Ratings to other Physical Activity Measures

The PAR interview is broken down into activity ratings (moderate, hard, and very hard). Spearman rank order correlations for the PAR and other measures are shown in Table 3.4. This correlation matrix shows that the moderate, hard and very hard categories reported during the PAR interview had no significant relationship to the Tritrac and Caltrac motions sensors. The hard and very hard PAR activity ratings, however, have a moderate relationship with the PAQ-C in the hard and very hard categories. This latter finding is consistent with Kowalski et al. (1997).

3.1.3.1.3 Participant Reasons for Non-Compliance with the Tritrac Motion Sensor

Participant that met minimum Tritrac criteria and had complete data for all measures reported reasons for not wearing the Tritrac during the seven-day assessment period (shown in Table 3.5). Reasons for not wearing the Tritrac units including: forgetting to wear motion sensors, disallowed to wear motion sensors due to league or coach's regulations, embarrassment related to physical appearance in public, discomfort, participating in aquatic type activities, and physical illness. These results

Table 3.3

Spearman Rank Order Correlation Coefficients Among the Tritrac-R3D Activity Monitor Planes X, Y, Z, Vector Magnitude, and the Caltrac Personal Activity Computer

Variable	1.	2.	3.	4.	5.
1. Vector Magnitude	-----				
2. X Plane	.74* (44)	-----			
3. Y Plane	.93* (44)	.70* (44)	-----		
4. Z Plane	.93* (44)	.51* (44)	.80* (44)	-----	
5. Caltrac	.80* (44)	.40* (44)	.72* (44)	.83* (44)	-----

Note.
Vector magnitude is composite score of x, y and z plane;
X plane is oriented at medio-lateral plane;
Y plane is oriented at vertical plane;
Z plane is oriented at antero-posterior plane;
Caltrac assesses activity in vertical plane.

* $p < .05$ level (one-tailed significance)

Table 3.4

Spearman Rank Order Correlation Coefficients Among the Seven Day Physical Activity Recall Interview Activity Levels (Moderate, Hard, and Very Hard) and Other Measures of Physical Activity

	PAR Activity Level		
Variable	Moderate	Hard	Very Hard
1. Tritrac	-.10 (44)	.22 (44)	.20 (44)
2. Caltrac	-.15 (44)	.22 (44)	.20 (44)
3. PAQ-C	-.04 (44)	.47* (44)	.29* (44)

* $p < .05$ level (one-tailed significance)

Table 3.5

Participant Reasons for Not Wearing the Tritrac Units for Seven Day Assessment Period For Total Sample

Rational	Occurrences	Participants	%
Forgot	21	17	39
Disallowed	31	15	34
Appearance	7	6	14
Discomfort	13	7	16
Aquatics	18	13	30
Sick	4	2	5
Total	94		

Note.
Number of incidences are number of occurrences that problem appeared during the seven day evaluation period for all possible participants.

Percentages reflect number of individuals reporting not wearing the Tritrac for a given reason.

show that children meeting minimum requirements for wearing the Tritrac still had many problems or difficulties in wearing the Tritrac at all possible times, often beyond their control. Only five of the 44 participants that were retained in the final sample did not report any reasons for not being able to comply with wearing the Tritrac at all possible times.

3.2 DISCUSSION

The present study evaluated the validity of the Tritrac by examining its convergent validity with other physical activity measures (a Caltrac motions sensor, the Physical Activity Questionnaire for Older Children, and the seven day Physical Activity Recall interview). Issues of practicality and instrument breakdown were also considered when determining the validity of the Tritrac.

Results of the present study provide only partial support for the validity of the Tritrac as a field measure of physical activity in children over extended periods. The data supported the hypothesis that the Tritrac would be strongly related to the Caltrac motion sensor. There was not, however, a significant relationship with the self-report measures of physical activity (the PAQ-C and PAR). Furthermore, due to issues of compliance and practicality, the Tritrac does not appear to be a valid field tool to assess activity over a one week period in this school-aged population.

Results of convergent validity between the Tritrac and the Caltrac motion sensor ($\underline{r} = 0.80$) are similar to previous findings of studies examining the relationship of the Tritrac in conditions assessing physical activity for shorter duration's of time. Welk and Corbin's (1995) field studies with children found the Tritrac to be strongly correlated with the Caltrac ($\underline{r} = 0.88$). The strong correlations between Caltrac and

Tritrac raises questions about the practicality of the Tritrac as a measure of physical activity due to its greater cost compared to a Caltrac motion sensor. Future research will need to determine if the unique variance not shared by the two instruments is meaningful in the prediction of health related behavior.

Validation of the Tritrac was not established through examination of the relationships to the Physical Activity Questionnaire for Older Children or the seven day Physical Activity Recall interview. The nonsignificant relationship exhibited between the Tritrac and PAQ-C ($r = 0.22$, n.s.), and that of the Tritrac to the PAR Total score (total number of hours that participant spent engaging in moderate, hard, and very hard physical activity; $r = 0.15$, n.s.) and the PAR Daily Average score (score converting hours of activity ratings to MET's; $r = 0.16$, n.s.) may question the validity of the Tritrac as a means of assessing physical activity over extended periods of time, and in situations that are not strictly controlled. If one chooses to label the Tritrac and Caltrac motion sensors as "objective" measures of physical activity, and the PAQ-C questionnaire and the PAR interview as "subjective" measures of physical activity, an interesting relationship emerges. Objective measures correlate strongly with one another, and subjective measures inter-correlate moderately with one another, but the objective and subjective measures share no relationship to one another.

Lack of convergence between measures may be attributed to different reasons. Children simply were not wearing the motion sensors as often as possible. It is evident that there were compliance problems that may have affected the results of this study (compliance rate was approximately 57%). Since the Caltrac and Tritrac were holstered together in the same belt, the two mechanical measures would have a strong relationship with one another. Second, the correlation between subjective measures may have been produced by carry-over effects. The questionnaire and interview were administered within at least one hour of each other, and reporting on the questionnaire may have influenced reporting on the interview. Problems with recalling activity may have occurred due to social influence, peer pressure, or the limitation the children have in accurately estimating the amount of time spent engaging in moderate, hard or very hard activities. Recall has always been an issue in the measurement of children's physical activity, especially when dealing with questionnaires or interview type formats. Children have more problems recalling activities to report on questionnaires or interviews, but memory may play an important factor when using motion sensors as well (Baranowski et al., 1992). Previously researchers have used the PAR and other recall type measures with children, but few recall a full week's activity. Often shorter time spans, such as three days or even hours within a single day, are assessed (e.g. Sallis et al., 1990).

The strong significant convergence between the Tritrac and Caltrac suggest the Tritrac would share similar relationships that the Caltrac would have with other measures of physical activity. Kowalski, Crocker, and Faulkner (1997) indicated a significantly moderate correlation between the Caltrac and PAQ-C (r = 0.39). It was also reported that the Caltrac significantly correlated to the PAR Daily Average (r = 0.38) and the PAR Total (r = 0.30). Kowalski, Crocker, and Kowalski reported similar results with high school students. Their findings are considerably different from the present study. Other studies, however, have also confirmed that the Caltrac and PAR have adequate convergence (Sallis et al., 1990).

A major problem in the assessment of activity with the Tritrac was that children forgot to wear the units at different points of the study. Reminder calls were placed every evening, as well as a research assistant visited participants everyday at school to answer any questions or rectify any problems children encountered with the units, as well to remind children to wear the units. Although this procedure may increase compliance, it also increases the possibility of a reactivity affect upon participants. The presence of researchers may create a situation that involuntarily or voluntarily effects the normal activity patterns of the participants. Simply reminding children to wear the motion sensors may create a demand effect upon the participants. Inactive children might increase activity in response to the daily reminder. This increase may reduce the true difference between inactive and active children.

Previous research has noted the obstacle investigators have encountered when using motion sensors to assess physical activity. Kochersberger and colleagues (1996) experienced a non-compliance rate of 20% when assessing the Tritrac motion sensor with elderly patients. Their study required forty-five participants to wear the Tritrac for a duration of three of the seven days. Nevertheless, nine participants failed to wear the Tritrac for the specified minimum duration of 10 continuous hours for a given day. Other studies using the Tritrac have encountered similar difficulties with compliance. Matthews and Freedson (1995) tested 29 university students and reported two participant's data was lost due to faulty batteries in the Tritrac units, as well as two other participants were dropped from the study due to failing to comply to minimum requirements.

Compliance issues are not restricted to just the Tritrac motion sensor, compliance issues have troubled other devices as well. Haskell, Yee, Evans, and Irby (1993) and Sallis, Buono, Roby, Carlson, Nelson (1990) lost two Caltracs data due to malfunction. Klesges and colleagues (1985) had a problem when 2 of the children refused to wear the Caltrac motion sensor. Many of these studies encountered these compliance issues despite the fact that the majority of them were conducted in very strict conditions and short time periods, often data was collected within a single day. Kowalski, Crocker, & Kowalski (1997) also reported issues of compliance. They reported only 57% of data was collected with participants ranging in age from 13 to 20 years of age. Only 48 of the 85 students had acceptable Caltrac data, mainly due to tampering with the Caltrac motion sensors. Tampering with the Caltracs were not as great with the elementary school children as it was with the older high school students. Compliance with the elementary school students resulted in 9 students not wearing the Caltrac units for a minimum of 5 days, and 9 other Caltrac units were not valid due to participant tampering. Other problems included 2 students having to stop wearing motion sensors due to a rash that developed, and 1 participant lost their Caltrac motion sensor (Kowalski, Crocker, & Faulkner, 1997).

Measurement problems are also encountered with self-report measures. The PAQ-C might have measurement problems that limit its ability to assess children's general levels of physical activity. Particular items ask for information about activity during physical education class, recess, lunch periods, evenings, and weekends (See Appendix D). However, the items assessing greater durations of time, such as evening and weekends, are equally weighted for shorter time segments, such as recess and physical education class. The PAQ-C may be assessing physical activity in a manner that is too general to show a relationship with the Tritrac and Caltrac motion sensors. Weak relationships between physical activity measures may be on account of different measures assessing distinct dimensions of activity (LaPorte, Montoye, & Caspersen, 1985; Sallis et al., 1990).

3.2.1 Practicality and Compliance Issues of the Tritrac

The utility of the Tritrac as a measure of children's physical activity was not supported in the present study due to issues of compliance and practicality. Compliance was both voluntary and involuntary. While many of the participants attempted to wear the motion sensors as often as possible, certain circumstances outside of their control limited adherence to wearing the devices. Many of the children participated in sports outside of the school setting. Strict regulations in organized sports prohibited them from wearing any item, (e.g. jewelry, watches and other extraneous articles of clothing other than team uniforms and eyeglasses). Therefore, many children were not allowed to wear the Tritrac and Caltrac during recreational sports. As well, the Tritrac is not waterproof making assessing activities that take place in water impossible. As many as 30% of the children reported participating in aquatic type activities and sports, therefore they were not able to wear the units to assess aquatic activities. The end result was that the Tritrac and Caltrac often failed to collect data during participants free-play activity, while participants continued to report these activities in the questionnaires and interviews. This was probably a major factor in producing the lack of relationship between the motion sensors and the PAQ-C and the PAR. It is unfortunate that free play activities were not being assessed adequately, as children are often most active during their free time. It has been reported that times of structured activity tend to make the levels of activity more homogenous for all participants, therefore decreasing variability in physical activity, and the possibility of restricted correlations during assessment (Welk & Corbin, 1995). Participant compliance levels were highest during school hours.

3.2.2 Limitations of the Tritrac

The Tritrac is a newly developed method of assessing physical activity, and during the course of this research project, several weaknesses were encountered. Lithium batteries in several of the units failed, subsequently losing data for some participants. The Tritrac software that initializes the Tritrac units and downloads the stored data also showed some limitations. The software is DOS-based. A more up-to-date application program may make it more user-friendly for researchers. File management, such as, moving, backing up, and converting data files into other application programs (e.g. Microsoft Excel or SPSS 8.0) are laborious and more difficult in DOS as opposed to Windows software. Computer failure also creates a hazard to data being downloaded. Four data sets were lost while downloading information due to computer failure during this study.

Other limitations of the Tritrac involve issues of its practicality and compliance. Since the Tritrac is not waterproof it is not possible to assess aquatic type activities. Some participants also reported that they did not wear the motion sensors due to the embarrassment of its physical appearance in public settings. This may have great significance when working with children. Some of the older children may be at a stage when appearance and social acceptance is important and may have considerable effects on compliance rates (Leary, 1995; Leary & Kowalski, 1995).

The Tritrac has potential to measure general levels of physical activity in controlled settings, but is not appropriate for determining energy expenditure in children since age-appropriate formulas do not existence. The conversion of physical activity to kcal may not appropriate for children, as these equations were originally designed for adult populations (Epstein et al., 1996).

One of the purported advantages of the Tritrac is its ability to assess movement in three dimensions. In comparison the Caltrac motion sensor measures physical activity in a vertical direction. The Tritrac's y plane, which is parallel to the Caltrac's measure, did not correlate highest with the vertical plane of the Caltrac ($r = 0.72$). The z plane, which was oriented at an antero-posterior orientation to the participant correlated highest ($r = 0.83$). Despite the differences between the two devices, the Tritrac seems to be assessing physical activity much the same as the Caltrac. This may suggest that the three-dimensional nature of the Tritrac does not significantly increase the assessment of physical activity in children. The strong significant correlations of the Tritrac to the Caltrac question the practicality of the Tritrac has a cost of approximately $350 (U.S.) to that of the $80 (U.S.) Caltrac.

3.2.2 Advantages of the Tritrac

The fundamental advantage of the Tritrac motion sensor over instruments like Caltrac is the researcher can determine if the unit is being worn. With a motion sensor such as the Caltrac, only a sum score of activity can be established. Data from the Tritrac can be examined in detail to ascertain if and when participants are wearing the units. Compliance may be an importance issue if habitual patterns of activity are to be assessed in children. This ability to examine data in specific segments may prove to be useful to examine specific periods of activity (Janz, 1994), such as activity during school, in recess, physical education class, or after school hours. The data is compatible with common software such as Microsoft Excel, making it more easily examined statistically and minimizing data entry time and human error.

CHAPTER 4

4.1 SUMMARY AND CONCLUSIONS

Research in adults has found a positive relationship between regular physical activity and health status (Bar-Or, 1994; Malina, 1994). While the strength of the relationship has been established in adults, it has been studied less often in children. The clinical endpoints of chronic diseases including coronary heart disease, hypertension, and osteoporosis usually reveal themselves during the adult years, but there is new information suggests that many of these chronic diseases may have their roots in early as childhood or adolescence (Bar-Or, 1994). However, due to the infancy of physical activity research, specifically applied to pediatric populations, the true nature of regular physical activity and its effects on health status have yet to be fully determined (Malina, 1994). Accurate physical activity assessment to determine the true physical activity-health relationship may help in prevention earlier in life to many of these chronic diseases, and may be of immense significance to the general health of all. The role of physical activity researchers can then help aid in the development and implementation of educational services to children and adolescents on the benefits of regular physical activity. Developing the skills and enjoyment of an active lifestyle early, we then help to establish a lifetime of physical activity and the benefits associated with it.

This research project assessed the validity of the Tritrac-R3D Activity Monitor in field settings over seven days with children. The Tritrac was compared to three other measures of physical activity, a Caltrac motion sensor, the Physical Activity Questionnaire for Older Children (PAQ-C), and the seven day recall interview (PAR). Issues of compliance and practicality were also examined when determining the validity of the Tritrac a means of assessing physical activity in children. Seventy-nine elementary school students, grades four through eight, were monitored over seven consecutive days using the Tritrac and Caltrac motion sensors to assess levels of physical activity. Upon retrieval of the motion sensors, the PAQ-C was completed followed by the PAR interview to assess convergent validity for the Tritrac. It was hypothesized that the Tritrac would be moderately positively correlated with the PAQ-C, the PAR, and strongly positively correlated with the Caltrac. Convergent validity was only partially established with strong positive correlations to the Caltrac ($r = 0.80$). Convergence was not established with the PAQ-C ($r = 0.22$, n.s.), nor with the PAR Total ($r = 0.15$, n.s.) score or the PAR Daily Average score ($r = 0.16$, n.s.). Further validation of the Tritrac is not supported when accounting for issues of practicality and compliance. Mechanical, technical and software problems contributed to the lack of validation for the Tritrac as valid field assessment tool to measure children's physical activity.

The results of the study indicate that the Tritrac needs further assessment concerning its convergent validity against other children's measures of physical activity in a field setting. Lack of convergent validity with other measures of physical activity can be attributed to compliance issues. Interview reports indicated that participants did not wear the motion sensors for various reasons, including forgetting to wear units and not being permitted to wear them during particular organized sport situations. Additionally, situations of social acceptance and peer expectations may have involuntarily limited participants from wearing the Tritrac. Situations of organized sporting regulations prohibited children from wearing the Tritrac during extra-curricular physical activity and activities taking place in an aquatic environment could not be measured due to the Tritrac not being water-resistant. Mechanical and technical problems may have contributed to the lack of validity of the Tritrac. Several incidences of Tritrac units permanently losing participant data due to failed batteries (both 9-volt and lithium back-up) and technical failure with Tritrac computer software.

The cost of the Tritrac motion sensor may not be warranted (about $350 U.S. compared to $80 U.S. of the Caltrac) if it highly correlated with the Caltrac motion sensor ($\underline{r}$ = 0.80) when an estimate of total activity is required. However, the Tritrac does offer the ability to examine specific time segments of participants which may be great benefit for other research examining specific time periods of physical activity. This may be useful when examining physical activity during physical education classes or during larger time segments such as activity within the day during recess, lunch or after school.

The Tritrac may be an effective measurement tool for quantifying physical activity patterns in children in a controlled situation, but problems with compliance may be a problem in activities that happen in an unstructured or free-activity environment (e.g. outside of school). The participants must wear the device for it to accurately record data. Discrepancy between measures in the present study may be due to participants simply not wearing the devices. Further study of the Tritrac is needed to fully evaluate the motion sensor's validity in a field setting and its use as an objective measure of physical activity in children.

4.2 RECOMMENDATIONS FOR FUTURE RESEARCH

There has been considerable interest in the general public as well as the scientific community regarding children and their levels of physical activity and fitness (Blair, 1995). Many conclusions that have been drawn have been speculative and anecdotal. Due to problems of measurement validity the true relationship between physical activity and health in children may yet be fully determined. Two major dilemmas that need to be resolved in pediatric physical activity research is when, and if at all, during childhood or adolescence, does habitual physical activity have positive effects on health status. Second, is habitual childhood physical activity a significant part of adult health status (Bar-Or & Malina, 1995). Methodological constraints, including the lack of a valid assessment techniques for quantifying physical activity, have left many questions unanswered.

Although the current study failed to demonstrate convergent validity of the Tritrac-R3D Activity Monitor in a field setting, it is recommended that future research continue to examine its validity as a means to assess children's physical activity levels. The limited past research has shown the Tritrac to be a valid measure of adult physical activity. The limitations of many of these studies was that they took place in restricted environments (e.g. lab settings or short assessment durations).

Validity of the Tritrac as a measure of physical activity in children may have to be examined in steps to determine its worth as a measure. Beginning with multiple single-day assessment periods, reliability of the Tritrac could be determined. Although Welk et al (1995) used multiple single-day assessments, they never determined the reliability of the averaged assessment. Researchers can use generalizability theory to determine the number of assessments required to obtain a reliable averaged measure (Crocker et al., 1997). After reliability has been determined, convergent validity using other measures of physical activity may be examined with short assessment periods as well.

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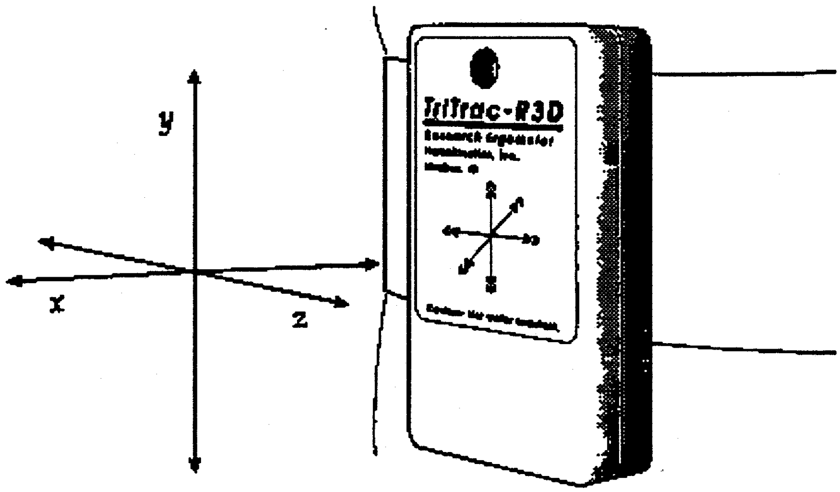
Appendix A

Tritrac Vector Directions

Tritrac-R3D Activity Monitor Vector Directions:

Tritrac Vector Magnitude ($[x^2 + y^2 + z^2]^{0.5}$)



Appendix B

Tritrac Download Sample

ID	1				
Name	LAST NAME,		FIRST NAME		
Time	Stamp	06-May-97	14:38		
Age	10				
Gender	F				
Height	**(in)**	60			
Weight	**(lb)**	100			
Minutes	**per**	**Interval**	15		
Standard	**Measures**	**for**	**This**	**Study**	
Comment	**2**				
Initial	**Battery**	**Reading**	**145**	**9+**	**Volts**
Current	**Battery**	**Reading**	**144**	**9+**	**Volts**
Initial	**Lithium**	**Reading**	**166**	**3+**	**Volts**
Current	**Lithium**	**Reading**	**168**	**3+**	**Volts**
	Error	**Flag**	**N**		
	Power	**Fail**	**N**		
	PDU	**Serial**	**Number**	**793**	
	PDU	**Version**	**Number**	**3**	

Number	**of**	**points:**	756	
Metabolic	**Calories**	**per**	**interval:**	15.08
Total	**Metabolic**	**Calories:**	11400.48	

Date/Time	**RawCntX**	**RawCntY**	**RawCntZ**	**Vec.Mag**	**Act.Cals**	**Tot.Cals**
06-May-97 14:38	1233	799	541	1565	2.63	17.71
06-May-97 14:53	8	4	15	17	0.01	15.09
06-May-97 15:08	79	43	95	130	0.21	15.29
06-May-97 15:23	21	6	15	26	0.03	15.11
06-May-97 15:38	17	33	18	41	0.06	15.14
06-May-97 15:53	1604	891	944	2063	3.48	18.56
06-May-97 16:08	1927	450	431	2025	3.41	18.49
14-May-97 10:23	135	221	177	313	0.52	15.6
14-May-97 10:38	0	0	0	0	0	15.08
14-May-97 10:53	0	0	0	0	0	15.08
14-May-97 11:08	2734	1575	4310	5341	9.02	24.1
14-May-97 11:23	672	442	1023	1301	2.19	17.27
Totals	**871257**	**854323**	**966685**	**1592130**	**2685.75**	**14086.23**

Appendix C

Subject Volunteer Consent Form

Physical Activity Study

Dear Parent

We are conducting a study on physical activity levels in older children. Physical activity has been identified by the Canadian Heart and Stroke Foundation as important for the health of all Canadians of all ages. The present research, funded by the Canadian Heart and Stroke Foundation, will investigate physical activity in children grades four through eight using different measurement instruments

We would like you to approve the participation of you child in this research. The study involves being interviewed about activity levels (about 15 minutes long), completing a short questionnaire in activity (10-15 minutes) and wearing an activity monitor which accurately records all physical movement for 7 days. The monitor is contained in a harness that attaches to the child's hip. The testing will occur at their school. A research assistant will phone each night (around supper) as a reminder about wearing the motion sensor. The study does not involve any physical or psychological danger to your child. He or she will be asked to engage in his or her normal activity patterns.

The purpose of the study will be clearly explained to your child. All information your child provides will remain confidential. That is, no person outside of the research team will be able to identify your child's data. The findings of this project will be made available to you at your request upon the completion of the project.

The consent of your child for her/his participation is also necessary before she/he can participate in the study. He or she may withdraw from the study at any time. There will be absolutely no penalty for withdrawing. Thank-you for your co-operation. If you have any questions at any time please do not hesitate to contact me at my office or home.

Your Respectfully,

Peter R.E. Crocker, PhD.
966-6510 (Office)
477-1864 (Home)

CONSENT FORM

My signature on this sheet indicates I will allow my child, ________________, to participate in a study by Dr. Peter Crocker on **Validation of the Physical Activity Questionnaire of Older Children**.

It indicated that I understand the following:

1. My child is a volunteer and can withdraw at any time from the study without fear of penalty.

2. I have received explanations about the nature of the study, its purpose, and procedures.

3. I will be told of any changes in the study that may effect my child's participation in the study.

4. There is no risk of physical or psychological harm.

5. As part of this study my child will require to wear a motion sensor for seven days (to be removed at night and during bathing/swimming). My child will not be responsible for any damage to this sensor.

6. The individual data my child provides will remain private from sources outside of the study. The group findings will be submitted to a journal for publication. Also a final report will be submitted to the Heart and Stroke Foundation. However, in either case, individual data or my child's identity will remain confidential.

7. I will receive a summary of this project, upon request, following the completion of the project.

8. I have received the name and phone numbers of the researcher (Dr. Crocker) who I or my child can contact if I have any questions.

PARENT'S SIGNATURE________________________________

CHILD'S SIGNATURE________________________________

DATE________________

Appendix D

The Physical Activity Questionnaire for Older Children

Physical Activity Questionnaire for Older Children
May-June, 1997

Name:________________________________ Age:______________

Sex: M______ F______ Grade:____________

Teacher:____________________________________

We are trying to find out about your level of physical activity from **the last 7 days** (in the last week). This includes sports or dance that make you sweat or make your legs feel tired, or games that make you breathe hard, like tag, skipping, running, climbing and other.

Remember:

A. There are no right or wrong answers- this is not a test.

B. Please answer all the questions as honestly and accurately as you can-this is very important.

---

1. PHYSICAL ACTIVITY IN YOUR SPARE TIME

Have you done any of the following activities in the past 7 days (last week)? If yes, how many times?

Tick Only One Circle Per Row

	No	1-2	3-4	5-6	7 or more
Skipping	O	O	O	O	O
Rowing/Canoeing	O	O	O	O	O
Roller blading	O	O	O	O	O
Tag	O	O	O	O	O
Walking for exercise	O	O	O	O	O
Bicycling	O	O	O	O	O
Jogging or running	O	O	O	O	O
Aerobics	O	O	O	O	O
Swimming	O	O	O	O	O
Baseball/softball	O	O	O	O	O
Dance	O	O	O	O	O
Football	O	O	O	O	O
Badminton	O	O	O	O	O
Skateboarding	O	O	O	O	O
Soccer	O	O	O	O	O
Street hockey	O	O	O	O	O
Volleyball	O	O	O	O	O
Floor hockey	O	O	O	O	O
Basketball	O	O	O	O	O
Ice skating	O	O	O	O	O
Cross-country skiing	O	O	O	O	O
Ice hockey/Ringette	O	O	O	O	O
Other: ____________________	O	O	O	O	O

________________ O . O . O . O . O

2. In the last 7 days, during your physical education (PE) classes, how often were you very activity (Playing hard, running, jumping, throwing)?

I don't do PE	. . . . . .	O
Hardly ever	. . . . . .	O check
Sometimes	. . . . . .	O one
Quite often	. . . . . .	O only
Always	. . . . . .	O

3. In the last 7 days what did you do most of the time at RECESS?

Sat down (talking, reading, doing school work)	. .	O
Stood around or walked around	. .	O check
Ran around or walked around	. .	O one
Ran around and played quite a bit	. .	O only
Ran and played all of the time	. .	O

4. In the last 7 days, what did you normally do AT LUNCH (besides eating lunch)?

Sat down (talking, reading, doing school work)	. . .	O
Stood around or walked around	. . .	O check
Ran around or walked around	. . .	O one
Ran around and played quite a bit	. . .	O only
Ran and played hard most of the time	. . .	O

5. In the last 7 days, on how many days RIGHT AFTER SCHOOL, did you do sports, danced, or played games in which you were very active?

None	. . . . .	O
1 time last week	. . . . .	O check
2 or 3 times last week	. . . . .	O one
4 times last week	. . . . .	O only
5 times last week	. . . . .	O

6. In the last 7 days, on how many EVENINGS did you do sports, danced, or played games in which you were very active?

None	. . . . .	O
1 time last week	. . . . .	O check
2 or 3 times last week	. . . . .	O one
4 times last week	. . . . .	O only
6 or 7 times last week	. . . . .	O

7. ON THE LAST WEEKEND, how many times did you do sports, danced, or played games in which you were very active?

None	. . . . . .	O
1 time	. . . . . .	O check
2 or 3 times	. . . . . .	O one
4 times	. . . . . .	O only
6 or 7 times	. . . . . .	O

8. Which ONE of the following describes you best for the last 7 days?
****Read ALL FIVE statements before deciding on the one answer that describes you****

A) All or most of my free time was spent doing things that involve little physical effort . . O

B) I sometimes (1-2 times last week) did physical things in my free time (e.g. played sports, went running, swimming, bike riding, did aerobics) . . O

C) I often (3-4 times last week) did physical things in my free time . . O

D) I quite often (5-6 times last week) did physical things in my free time . . O

E) I very often (7 or more times last week) did physical things in my free time . . O

9. Were you sick last week, or did anything prevent you from doing your normal physical activities?

Yes	. . . .	O check
No	. . . .	O one

If Yes, What Prevented you?

____
____
____
____
____
____

10. Mark how often you did physical activity (like playing sports, games, doing dance or any other physical activities) for each day last week.

	None	Little Bit	Medium	Often	Very Often
A) Monday . .	O	O	O	O	O
B) Tuesday . .	O	O	O	O	O
C) Wednesday . .	O	O	O	O	O
D) Thursday . .	O	O	O	O	O
E) Friday . .	O	O	O	O	O
F) Saturday . .	O	O	O	O	O
G) Sunday . .	O	O	O	O	O

Appendix E

Seven Day Physical Activity Recall Interview

PHYSICAL ACTIVITY RECALL (PAR) INTERVIEW SCRIPT

Now we would like to know about your physical activity during the past 7 days.

1. On the average, how many hours did you sleep each night during the last five weekday nights (Sunday-Thursday)? ______hours. On the average, how many hours did you sleep each night last Friday and Saturday nights? _____ hours

2. Now I am going to ask you about your physical activity during the past 7 days, that is, the last 5 weekdays, and last weekend, Saturday and Sunday. We are not going to talk about light activities such as slow walking, light housework, or unstrenuous sports such as bowling, archery, or softball. Please look at this list which shows some examples of what we consider moderate, hard, and very hard activities. People engage in many other types of activities, and if you are not sure where one of your activities fits, please ask me about it.

3. First, let's consider moderate activities. What activities did you do and how many total hours did you spend during the last five weekdays doing these moderate activities or others like them? Please tell me to the nearest half hour _____ hours

4. Last Saturday and Sunday, how many hours did you spend on moderate activities and what did you do? (Probe: Can you think of any other sports, job, or household I activities that would fit into this category?)_____ hours

5. Now, let's look at hard activities. What activities did you do and how many total hours did you spend during the last five weekdays doing these hard activities or others like them? Please tell me to the nearest half hour _____ hours

6. Last Saturday and Sunday, how many hours did you spend on hard activities and what did you do? (Probe: Can you think of any other sports, job, or household activities that would fit into this category?)_____hours

7. Now, let's look at very hard activities. What activities did you do and how many total hours did you spend during the last 5 weekdays doing these very hard activities or others like them? Please tell me to the nearest half hour.

8. Last Saturday and Sunday, how many hours did you spend on very hard activities and what did you do? (Probe: Can you think of any other sports, job, or household activities that could fit into this category")_____hours

9. Compared with your physical activity over the past 3 months, was last week's physical activity more, less, or about the same?

1. More
2. Less
3. About the same

Interviewer: Please list below any activities reported by the subject which you don't know how to classify. Flag this record for review and completion.

Activity (brief description)	Hours: workday	Hours: weekend day
____________________	____________	______________
____________________	____________	______________
____________________	____________	______________

EXAMPLES OF ACTIVITIES IN EACH CATEGORY

Moderate activity

Occupational tasks: 1) delivering mail or patrolling on foot; 2) house painting; and truck driving (making deliveries, lifting and carrying light objects).

Household activities: 1) raking the lawn; 2) sweeping and mopping; 3) mowing the lawn with a power mower; and 4) cleaning windows.

Sports activities (actual playing time): 1) volleyball; 2) Ping-Pong; 3) brisk walking pleasure or to work (4.83 km/hour (3 miles/hour) or 20 minutes/km (mile)); 4) golf walking and pulling or carrying clubs; and 5) calisthenics exercises.

Hard activity

Occupational tasks: 1) heavy carpentry; and 2) construction work, doing physical labor.

Household tasks: 1) scrubbing floors.

Sports activities (actual playing time): 1) tennis doubles; and 2) disco, square, or folk dancing.

Very hard activity

Occupational tasks: 1) very hard physical labor, digging or chopping with heavy tools and 2) carrying heavy loads such as bricks or lumber.

PAR
7-DAY PHYSICAL ACTIVITY RECALL INTERVIEW

Subject Name: ______________________ **Subject ID:** ______________________
Date of Interview: ______________________ **Interviewed By:** ______________________

1. Were you employed in the last 7 days?
   Yes   If No, skip to worksheet

2. How many days of the last 7 did you work? ________

3. How many hours in total did you work in the last 7 days? ________

WORKSHEET FOR PHYSICAL ACTIVITY RECALL

									Totals	
	Days	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Weekday**	**Weekend**
	Sleep									
Morning	**Moderate**									
	Hard									
	Very Hard									
Afternoon	**Moderate**									
	Hard									
	Very Hard									
Evening	**Moderate**									
	Hard									
	Very Hard									

Comments on the interview: ____

Tritrac Summary Sheet

Name___________________________ Grade__________

Please indicate if participant wore the Tritrac activity monitor at all possible times for each day of the week.

Was the Tritrac worn at all possible times on Monday?
Yes_____
No _____
If No, indicate reason: ____

Was the Tritrac worn at all possible times on Tuesday?
Yes_____
No _____
If No, indicate reason: ____

Was the Tritrac worn at all possible times on Wednesday?
Yes_____
No _____
If No, indicate reason: ____

Was the Tritrac worn at all possible times on Thursday?
Yes_____
No _____
If No, indicate reason: ____

Was the Tritrac worn at all possible times on Friday?
Yes_____
No _____
If No, indicate reason: ____

Was the Tritrac worn at all possible times on Saturday?
Yes_____
No _____
If No, indicate reason: ____

Was the Tritrac worn at all possible times on Sunday?
Yes_____
No _____
If No, indicate reason: ____

(On back, please indicate if participants encountered any other problems worth noting).