DISSERTATIONES KINESIOLOGIAE UNIVERSITATIS TARTUENSIS

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PEEP PÄLL

Physical activity and motor skill development in children

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LIST OF ORIGINAL PUBLICATIONS

The dissertation is based on the following original publications which will be referred to in the text by their respective Roman numerals.

I. Raudsepp, L., Päll, P. (1999). The physical activity of Estonian primary school children. European Journal of Physical Education, 4, 65–74.

II. Raudsepp, L., Päll, P. (1998). Physical activity of children during physical education classes. Biology of Sport, 15, 265–270.

III. Raudsepp, L., Päll, P. (1998). Reproducibility and stability of physical activity in children. Pediatric Exercise Science, 10, 320–326.

IV. Raudsepp, L., Päll, P. (2006). The relationship between fundamental motor skills and outside school physical activity of elementary school children. Pediatric Exercise Science, 18, 426–435.

Paper I, II and **III,** Peep Päll coordinated and participated in data collection, made statistical analyses for data and wrote a preliminary version of the articles. **Paper IV,** Peep Päll made statistical analyses for data and wrote a preliminary version of the article.

1. INTRODUCTION

Appropriate physical activity is widely accepted as beneficial for health and fitness. Physical activity is to be encouraged among children and adolescents based largely on the assumption that the behaviour will become part of the person's life and carry into adulthood, where it will help lower the risk of several chronic diseases (Riddoch & Boreham, 1995; Davison & Lawson, 2006). However, research evidence clearly indicates that children have become less physically active in recent decades, with children today expending approximately 600 kcal day $^{-1}$ less that their counterparts 50 year ago (Durnin, 1992; Ridley & Olds, 2008). Epstein et al. (1995) reported that in the USA, children watch an average of 3.5–4.0 h of television per day. Cycling and walking to school have become unusual behaviours and playing in the street has been curtailed by safety concerns.

Although it is assumed that physical activity is beneficial to children, surprisingly, and in contrast to adults, relatively little empirical research exists to confirm this assumption. Certainly, concern has been expressed about the rising prevalence of lifestyle-related chronic diseases in developed nations (Shephard, 2008) and the well-documented decline in physical activity among adults (Caspersen et al., 2000) and children (Armstrong & Welsman, 1997; Kimm et al., 2002). However, the established causal links between health and habitual physical activity in adults are yet to be confirmed in children (Riddoch, 1998). The first main benefit is direct improvements in childhood health status; evidence is accumulating that more active children generally display healthier cardiovascular profiles, are leaner and develop higher peak bone masses than their less active counterparts (Janz et al., 2002). Secondly, there is a biological carryover effect into adulthood, whereby improved adult health status results from childhood physical activity. Thirdly, there may be a behavioural carryover into adulthood, whereby active children are more likely to become more active adults (Boreham & Riddoch, 2001). Finally, knowledge about when physical activity is the most and least stable has implications for the timing of physical activity interventions. Developmental periods during which stability of behaviour is relatively low might be easier targets of intervention programs (Raudsepp et al., 2008).

The objectives of physical education include fostering interest in physical activity (Williams, 1988) and promotion of engagement of all children in regular physical activity (Baquet et al., 2002; Fairlclough & Stratton, 2005). Physical education classes can provide children with substantial amounts of physical activity (Simons-Morton et al., 1991; Stratton, 1996; Fairclough & Stratton, 2005), which may be particularly important for those students who obtain little or no physical activity outside physical education classes (Simons-Morton et al., 1994). One measure of the quality and efficiency of physical education classes is the proportion of class time students engage in moderate-to-vigorous physical activity (MVPA), regardless of the specific activity, motor skill, or movement objective of that class (Simons-Morton et al., 1994;

Fairlclough & Stratton, 2005). Children's enjoyment of physical activity and improvement in motor skills and health-related fitness are important outcomes of the quality and success of physical education (Simons-Morton et al., 1993; Fairclough, 2003), and an important way to achieve each of these objectives is to involve students in enjoyable activity during a substantial proportion of each class (Sallis et al., 1997). However, recent review by Fairclough and Stratton (2005) indicates that students engaged in MVPA only for 27 to 47% of class time.

The main aims of the present study were threefold: (a) to measure the children's physical activity during health-related physical education classes and outside school; (b) to examine reproducibility and stability of physical activity in children; (c) to examine the associations between fundamental motor skills and various types of outside-school physical activity.

2. REVIEW OF LITERATURE

2.1. Physical activity in children

Physical activity has been defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985). It is important to note that physical activity is a behaviour that has physiological consequences such as energy expenditure and elevated levels of cardio-respiratory function. These physiological consequences may be well correlated with physical activity, but it must be emphasized that they are not synonymous with physical activity (Waring et al., 2007). Physical activity has several additional dimensions, including ground reaction forces, motor skill, form and context. Physical activity occurs in many forms and contexts, which are strongly influenced by culture. Physical activity is thus biocultural, i.e., energy expenditure or ground reaction forces are exerted (biological) in motor behaviours that occur within a cultural context. Physical activity, or its opposite extreme inactivity, thus cannot be approached from an exclusively biological or from an exclusively cultural perspective (Malina, 2001).

Observe any school playground full of 7-year-olds and you will see a study in perpetual motion. Children are invariably running, jumping, throwing and kicking in a spontaneous physical activity, untutored and unstructured. Clearly, they are doing what comes naturally and they are enjoying themselves. Contrast these images with those of children sitting passively in the car for the 'school run', watching television for up to one-third of their waking day, participating in less and less school physical education as other curriculum pressures take precedence, and mounting evidence that even our youngest children are becoming more obese (Reilly et al., 1999). Clearly, there are paradoxes in the lifestyles of children today that raise important questions. Most importantly, if our children enjoy physical activity, why are they apparently doing less of it? Part of the answer lies in the environment within which children now find themselves, an environment full of 'sedentary activities' (Epstein et al., 1995; Hinkley et al., 2008; Shephard, 2008). Sallis et al. (2000), for example, reported that access to sport facilities and programmes and time spent outdoors were positively and consistently related to children's physical activity. Time in sedentary pursuits, such as television viewing and reading, was only moderately related to children's physical activity.

Measuring habitual daily physical activity is one of the most difficult tasks for the sport scientists because activity has to be assessed in terms of type, intensity, and duration (Harro & Riddoch, 2000; Evenson et al., 2008). Obtaining this information from children is even more difficult than from adults. A problem encountered in measuring physical activity is the presence of contradictory aims. On the one hand, it is desirable to record the normal daily movements of a child, which usually means that subject must be burdened with equipment for measuring a number of body functions. On the other hand, the child's normal daily activities should not be hindered. An important factor in large-scale studies is the need for a method which is simple, low-cost, and not time-consuming so that large samples can be measured (Saris, 1986; Trost, 2001; Ridley et al., 2008;).

The assessment of physical activity in elementary school children is also complicated by the fact that children are unable to recall and/or record activity accurately. Moreover, their patterns of physical activity fluctuate more than those of adults, making activity profiling difficult (Freedson, 1989; Wickel et al., 2007). However, a recent study conducted in North West England demonstrates no significant variation in 6 to 11- year-old children's recess physical activity levels across days and seasons (Ridgers et al., 2006). Specifically, intraclass correlations for moderate-to-vigorous physical activity across 2 days ranged from 0.75 to 0.85 in summer and 0.53 to 0.81 in winter. In addition, there was a trend, albeit non-significant, for physical activity to be higher in winter than summer, contrasting previous studies which report higher physical activity levels in the summer (Hagger, et al., 1997; Loucaides et al., 2003).

2.2. Reproducibility and stability of physical activity during childhood

Many factors can influence children's physical activity behaviours and the stability they demonstrate over time (Baranowski & Moor, 2000; Tudor-Locke et al., 2005), complicating the assessment of physical activity (Sallis et al., 1995). The role of regular physical activity during childhood and adolescence on health in adulthood is not clearly understood (Malina, 1996). Until now consideration of the precursors of adult health and disease in childhood and adolescence has focused on risk factors for cardiovascular disease. However, many aspects of the lifestyle of an adult are presumably developed during childhood and adolescence, including motor abilities which are necessary for successful participation in a large variety of activities (Beunen et al., 1992; Fisher et al., 2005). Contemporary thinking in public health holds that physical activity and physical fitness may influence health during childhood and adolescence, as well as throughout life (Malina, 2001).

A characteristic "which is consistent from one point in time to another" was defined by Bloom (1964) as stable. Bloom suggested that a correlation coefficient of 0.50 or higher over a period of 1 year or more represents consistency. Over the past 60 years, the concept of tracking, or stability, has been studied by many investigators. Several indices have been proposed and numerous analytical methods have been used (Park & Schutz, 2005). Malina (1996) stated that stability of a characteristic, or tracking, refers to "the maintenance of relative rank or position within a group over time". Furthermore, Malina suggested that a correlation coefficient <0.30 reflects low stability, a correlation between 0.30 and 0.60 is moderate, while a correlation >0.60 indicates a moderately high stability. This interpretation, however, is dependent on several factors. First of all, the longer the period over which tracking is examined, and the younger the age at baseline, the lower the correlation co-efficient is likely to be. Likewise, the higher the reproducibility of the tests used to examine tracking, the higher the correlation coefficients (Malina, 1996). Other factors which influence interage correlations include short term biological variation, significant environmental change, and measurement variability (Roche & Guo, 1994).

A few studies have described the variability of physical activity in children. There is substantial variability within days, and DuRant et al. (1993) found three independent components of physical activity during the day of young children. Activity levels, estimated from heart rate monitoring, were different during the morning, early afternoon, and late afternoon. Because of this variability within days, physical activity measured at one time of the day may not be readily generalizable to other times of the same day. Correlations between two full days of heart rate monitoring of children varied from r= 0.10 (Sallis et al., 1990) to r= 0.66 (DuRant et al., 1992; Pate et al., 1996) to r= 0.81 (DuRant et al., 1993), depending in part on the method of summarizing the data. Over a 3 year period beginning at 3–4 years of age, the rank order correlations for physical activity (heart rate 50% above resting heart rate between 3 and 6 p.m.) was 0.57 (Pate et al., 1996). Correlations between days of accelerometer monitoring of children varied from r= 0.25 to 0.63 (Sallis et al., 1990, 1993). Though correlations are variable between the studies, the results suggest low to moderate short term tracking of physical activity during childhood (Malina, 1996). In addition, Sallis et al. (1995) reported that less than 20% of the variation in children's physical activity can be identified as stable over time. Recently, Raudsepp et al. (2008) examined stability of physical activity and sedentary behaviours during early adolescence. The findings showed moderate stability of physical activity across a 22-month period. In addition, Ridgers et al. (2006) found no significant daily variation in children's physical activity levels during recess. Whilst numerous social and environmental factors can influence variability of behaviour, the results of the study by Ridgers and colleagues suggest that children's physical activity during recess is similar across days (Ridgers et al., 2006).

Undoubtedly, research examining the variability in physical activity will improve our ability to accurately measure habitual physical activity and thus strengthen associations with health-related outcomes (Traub, 1994; Ridley et al., 2008). However, children's habitual physical activity cannot be adequately assessed with measurements at a single point in time and activity levels are primarily influenced by transitory and dynamic variables in the biological, psychological, social, or physical environmental domains. Because of the substantial short-term variability in children's physical activity, the behaviour needs to be measured on multiple days to obtain reliable estimates of habitual physical activity (Sallis et al., 1995; Malina, 2001; Loucaides et al., 2003). Further, the advancement of statistical methods such as the Latent Growth Modeling (LGM) enables researchers to describe stability and change of health-related behaviour at the individual level in addition to the group level. This does not mean that a LGM estimates the change parameters of every person, but rather than that a LGM estimates the between-person variation as well as the mean of individual change (Park & Schutz, 2005).

Knowledge about when physical activity is the most and least stable has implications for the timing of physical activity interventions. Developmental periods during which stability of behaviour is relatively low might be easier targets of intervention programs (Raudsepp et al., 2008).

2.3. Physical activity during physical education classes

Physical education curricula have many valuable goals, such as the development of motor skills, creative and artistic expression, self-realization, moral development, and social development (Fairclough, 2003). However, 6 out of 13 principles espoused for physical education are directly related to physical fitness (Ziegler, 1994). Moreover, a number of authors have identified physical education as an important vehicle for promoting cardiorespiratory fitness (Simons-Morton et al., 1990; Sallis and McKenzie, 1991; McKenzie et al., 2006). Children's cardiorespiratory fitness will only be promoted in physical education lessons if they spend an appropriate amount of time in moderate-to-vigorous physical activity (MVPA). Moreover, for some children, the experience of MVPA may only occur during school physical education classes (Riddoch et al., 1991; McKenzie et al., 1995; Fairclough, 2003).

There are, however, conflicting views as to the role of school physical education in promoting physical activity (Waring et al., 2007). Mallam et al. (2003) suggest that the total amount of physical activity a child takes part in does not depend on the physical education lesson, as children have been shown to compensate for the lack of activity in this area by increasing activity in the home environment. In contrast, Sleap and Warburton (1996) provide evidence that the possibility of experiencing a moderate-intensity physical activity in physical education classes is substantially higher when compared to in home environment. Fairclough (2003) stated that teachers have pressure on them to meet a whole series of goals within physical education beyond just promoting physical activity and that these include the needs to develop individual skill, to foster appropriate levels of enjoyment and to deliver lessons that have educational value. This holistic position if further compounded by the minimal or lack of input within initial elementary school teacher training for physical education which now makes it doubtful whether elementary school teachers have the knowledge and understanding to deal with such a complicated agenda (Waring et al., 2007). Moreover, whilst accepting that teachers generally have positive views towards the promotion of physical activity, the majority of teachers would appear to have a limited understanding of how to increase physical activity in their own school (Cale, 2000).

Physical activity guidelines and theoretical approaches to promote health and fitness in children and adolescents have been reviewed (Sallis & Patrick, 1994; Epstein, 1998). This leads to the question, to what extent can physical education contribute toward these recommendations? Clearly, the amount of curriculum time allocated to physical education partly dictates its contribution to physical activity recommendations. Curriculum time allocated to physical education varies both between and within countries (Lee et al., 1987; Koslow, 1988; Mota, 1994; Fairclough, 2003). On the whole, the majority of schools have insufficient frequency or duration of curriculum time for physical education to achieve physical activity recommendations for the promotion of health and fitness (Mota, 1994; Stratton, 1996, 1997; Wang et al., 2005; McKenzie et al., 2006).

For over 20 years, reports have indicated that children experience insufficient MVPA during physical education lessons (Cummings et al., 1969; Li & Dunham, 1993; Stratton, 1995; Nader, 2003; Wang et al., 2005) and that the intensity of physical education lessons is too low in relation to normal daily activities (Taggart, 1985). Conversely, Verabioff (1988) postulates that children's habitual physical activity is not sufficiently vigorous to create a training effect, and that physical education lessons may be the most appropriate mode for developing and maintaining cardiorespiratory fitness in children. Optimistically, Haywood (1991) supports the premise that physical education lessons can promote cardiorespiratory fitness if the content is planned and delivered with MVPA in mind. There is some evidence to suggest that differences in MVPA in physical education classes are related to the grade/age of the students. Stratton (1997) found that MVPA increased from 9 to 10 years of age to peak at 11 to 12 years of age and then decreased in later school years. Decreased MVPA during middle school and high school may reflect youths' waning enthusiasm for physical education or a change in how physical education programs are delivered (Stratton, 1997).

One of the enduring problems in investigating physical activity is the lack of a gold standard measure of physical activity. Out of 30 different methods reported by LaPorte et al. (1979), systematic observation and heart rate have commonly been used to measure physical activity levels during physical education classes. Although systematic observation has been recommended as a criterion measure of physical activity (Baranowski et al., 1984; Waring et al., 2007), the majority of investigations have used heart rate to measure MVPA during physical education lessons (Stratton, 1996; Wang et al., 2005). Moreover, guidelines for promoting cardiorespiratory fitness generally use heart rate as the criterion measure of the intensity and duration of physical activity.

When studying heart rates, the investigators tend to select an arbitrary heart rate threshold above which the effects on fitness and health would be considered beneficial (Riddoch & Boreham, 1995). Maximum heart rate reserve (MHRR), the difference between maximal and resting rate, may be the most effective method of estimating heart rate thresholds appropriate for promoting health and fitness in school-aged children (Stratton, 1996). MHRR accounts for age and sex differences, and 75% of MHRR, plus the resting rate, is regarded as a sufficient stimulus to promote cardiorespiratory fitness (Morrow & Freedson, 1994). To calculate heart rate thresholds, resting heart rate and maximum heart rate are required. Resting heart rates vary with age and are most accurately recorded during sleep. Maximal heart rates are generally about 200 beats per minute at the end of maximal treadmill exercise, regardless of age and sex, although large individual differences are evident (Bar-Or, 1983). MHRR thresholds estimated from age-related maximum and resting heart rates are presented in Table 1.

Based on previous heart rate research, Stratton (1996) proposed guidelines that include intensity and duration criteria for first moderate and second vigorous physical activity:

1. To achieve a moderate level of physical activity, children should be moving (walking or faster) for at least 50% (or 20 minutes) of lesson time with a heart rate between 50 and 59.9% of MHRR.
2. To achieve a vigorous level of physical activity, children's heart rates should be in excess of 60% of MHRR for at least 50% (or 20 minutes) of lesson time. In fulfilling Guideline 2, Guideline 1 will also have been achieved.

Table 1. MHRR thresholds estimated from age-related maximum and resting heart rates (Stratton, 1996).

Age group (yrs)	Resting HR (bpm)		% max HR reserve					
			50		60		75	
	B	G	B	G	B	G	B	G
6–10	95	95	148	148	158	158	174	174
10–12	85	90	143	145	154	156	171	173
12–14	80	85	140	143	152	154	170	171
14–16	75	80	138	140	150	152	169	170

Note: Maximum heart rate = 200 for all age groups; HR- heart rate; B = boys; G = girls

Moderate physical activity intensities between 50 and 59.9%, and moderate-to-vigorous physical activity intensity between 60 and 74.9% of MHRR are appropriate for physical education curriculum for promoting physical activity. Vigorous physical activity intensity above 75% of MHRR may stimulate an increased cardiorespiratory fitness (Morrow & Freedson, 1995). To contribute toward physical activity goals, children should be physically active for 20 min or 50% of lessons time in physical activity that is light to moderate-to-vigorous in intensity. Physical educators should achieve this goal wherever possible and appropriate (Stratton, 1996; Baquet et al., 2002).

Improving the quantity and quality of physical education is a goal of both professional organizations and public health officials. There is general agreement on how physical education programmes can be improved. Classes need to be taught more frequently and by more qualified instructors (AAHPERD, 1994; Pate et al., 1995), students need to spend more class time being physically active (Sallis & McKenzie, 1991; Fairclough & Stratton, 2005), and more programs should promote lifetime physical activity (Pate & Hohn, 1994).

For students to acquire motor skills, increase their physical fitness, and obtain health benefits that accrue from physical activity, they must be physically active. However, when primary physical education classes are observed systematically, relatively little MVPA activity is reported (Stratton, 1996; Wang et al., 2005). A study of third-grade students in 95 American schools showed children to be engaged in MVPA only 36% of class time (McKenzie et al., 1995). Another study found an average child to be vigorously active for less than 3 min during a 30min lessons taught by physical education specialists (Simons-Morton et al., 1993). Mean heart rates in the majority of normally delivered primary lessons fall below 50 % of MHRR (Seliger et al., 1980; Parcel et al., 1987; Stratton, 1996; Fairlough & Stratton, 2005). These results clearly showed that the majority of physical education classes do not stimulate appropriate amounts of MVPA and, therefore, do not contribute significantly to physical activity guidelines for children and adolescents (Sallis et al., 1996; McKenzie et al., 2006). AS the average school physical education lesson does not achieve its goals regarding MVPA (Stratton, 1996; Wang et al., 2005), Stratton (1997) suggest that a greater effort is required when planning lessons to offset children's low levels of MVPA.

Recently, Hastie and Trost (2002) used a "sport education" theoretical framework to determine the extent to which special physical education curriculum can provide students with sufficient opportunities for developing MVPA. The main purpose of the "sport education" curriculum and instruction model is to provide students with authentic sport experiences. Within sport education seasons, students become affilitated with teams for the entire length of the unit (usually at least 20 lessons), and take greater responsibility for the organization and management of the sporting experience within physical education (Siedentop, 1994). The results of study by Hastie and Trost (2002) showed that a physical education setting operating under the "sport education" format can produce sufficient levels of MVPA. For the seventh-grade students, an average of 31.6 minutes of MVPA during the season, or 63.2% of lessons time was spent in MVPA levels.

Comparative studies typically show that physical education specialists provide better physical education than nonspecialists (Faucette et al., 1990; McKenzie et al., 2006). However, elementary school physical education is frequently taught by classroom teachers who are typically untrained to conduct quality lessons. In many countries, both administrators and teachers themselves have expressed interest in receiving additional training to improve physical education lessons, and various professional development programmes have been offered to meet their needs (Pate, 1995; Sallis et al., 1996).

For health benefit, physical education should promote generalization of physical activity outside of school, because physical activity recommendations cannot be met through physical education alone (Boreham & Riddoch, 2001; Barnett et al., 2006), Physical education and classroom programmes may increase physical activity throughout the day, but specific programmes to promote generalization must be developed and rigorously evaluated (Sallis et al., 1997; McKenzie et al., 2000; Baquet et al., 2002; Biddle et al., 2004). Trudeau et al. (1998) emphasized the importance of getting children accustomed to regular and intense physical activity in the school curriculum. They concluded that intense physical activity had a long-term impact on physical fitness characteristics. In addition, it must be emphasized that school is the only time when all children and adolescents must practice a compulsory physical activity or be physically active (Baquet et al., 2002).

Unfortunately, there are no objective data about physical activity levels of Estonian elementary school children during physical education classes. This information would be beneficial for both physical education teachers and health professionals for developing more effective physical education programmes and to plan different interventions to promote physical activity of children.

2.4. The relationship between fundamental motor skills and outside school physical activity of elementary school children

The acquisition of motor skills has historically been a primary goal of physical education programmes (Siedentop, 2001). It is generally believed that fundamental motor skills and habitual physical activity are related in childhood and adolescence (Fulton, et al., 2001; Ott et al., 2000; McKenzie et al., 2004). In addition, mastery of fundamental motor skills provides the foundation for the development of more sports-specific skills (Barnett et al., 2008). Little, however, is known about the development of motor skills of young children and how they are related to different types of outside school physical activities. Although more evidence is required, failure to incorporate physical activity as part of daily life and failure to master a basic set of motor skills may prove a major barrier to participation in physical activities and to achieving recommended physical activity levels for maintenance of good health (Van Beurden et al., 2003).

In fact, relatively few studies have examined the relationship between fundamental motor skills and physical activity in children (Fisher et al., 2005; Barnett et al., 2008). Cross-sectional study with 3-and 4-year-old Finnish children found that fundamental motor skills were weakly related to weekend physical activity (Sääkslahti et al., 1999). Okely et al. (2001) found a significant relationship between fundamental motor skills and self-reported participation in organized physical activity in adolescents, although only a small proportion

(3%) of participation in physical activity was explained by fundamental motor skills. Butcher and Eaton (1989) found that the daily indoor free play activities of 5-year-old children in daycare centers were related to motor skills (positively with running speed and negatively with balance and fine motor skills). Recently, Fisher et al. (2005) found a significant but weak cross-sectional relationship between objectively measured physical activity and fundamental motor skills in preschool children. Specifically, children who spent more time in moderate-to-vigorous physical activity tended to have higher fundamental motor skills. Additionally, Barnett et al. (2008) found that object control proficiency observed in elementary school predicted subsequent fitness levels in adolescence.

There is increasing evidence that children might be less physically active than expected (Jackson et al., 2003; Kelly et al., 2004; Reilly et al., 2004). There is also no consensus in the research on the methods that should be used to measure physical activity, particularly in preschool and elementary school children (Freedson & Miller, 2000; Harro & Riddoch, 2000). Many studies utilized self-report measures which, until very recently, have been considered unreliable with elementary school children (Freedson & Miller, 2000; Ridley et al., 2008). Objective measures with real-time data storage capabilities offer a distinct advantage over self-report methods in that they provide reliable information on patterns of physical activity (Trost et al., 2000). Recently, however, the question has been raised whether accelerometers are valid for the measurement of children's "free play" activities, such as jumping, throwing, skipping etc. (Harro & Riddoch, 2000; Ott et al., 2000). Because children are likely to engage in many activities that involve fundamental motor skills as part of their daily physical activity, measurement tools should be validated for use with such activities (Ott et al., 2000). Observational systems may be one solution for the accurate measurement of the children's free play activities because they quantify the behaviour of individuals, the variable of primary concern (O'Hara et al., 1989). Although direct observation is not practical for larger populations studies due to cost, it can be a useful measure for documenting patterns in activity (Daley et al., 2000; Ridley et al., 2008).

3. AIMS OF THE STUDY

The general purpose of the present investigation was to examine different patterns of physical activity (habitual, during physical education classes, stability of behaviour) and the association between outside school physical activity and fundamental motor skill development of Estonian school children aged 7 to 11 years.

Accordingly, the specific aims of the study were:

1. to examine the physical activity patterns of Estonian elementary school children (Paper 1);
2. to assess the physical activity during health-related physical education classes (Paper 2);
3. to examine the between-day reproducibility of physical activity across 1 week and determine the stability of physical activity over 2 years (Paper 3);
4. to examine the association between fundamental motor skill development and various types of outside-school physical activity (Paper 4).

4. MATERIALS AND METHODS

4.1. Subjects

A total of 194 children from 7 to 11 years of age participated in this study. Children were recruited from 3 schools in the city of Tartu and from one school in Tartu County, Estonia. Measurements were performed from 1995 to 2004 at elementary schools (Study 2, Study 4), at children's homes (Study 1, Study 3) and outside of school settings (Study 1, Study 4).

Informed consent was obtained from the parents and assent was obtained from each child. Permission to conduct the study was also obtained from the school principals. All measurements were approved by the Medical Ethics Committee of the University of Tartu.

4.2. Anthropometry

Height was measured using Martin's metal anthropometer to the nearest 0.1 cm and body mass was measured to the nearest 0.1 kg using medical scales. Sum of five skinfolds (biceps, triceps, subscapular, abdominal, medial calf) were measured with a Holtain caliper on the right side of the body (Studies 1 and 3). Three complete sets of measurements were carried out on each subject and the mean of three values were used. The sum of five skinfolds was calculated as the indicator of body fatness.

4.3. Habitual physical activity (Study 1)

Habitual physical activity was assessed by a 7-day physical activity recall questionnaire which was modified from Godin and Shephard (1986) and the Caltrac accelerometer. In the present study, the children's parents recorded how much time (hours and minutes) their child spent on various activities outside school every day for one week. The written completion of the 7-day activity recall by parents for children's daily activities took 10–15 minutes every evening. Activities were classified as low (3 METs), moderate (5 METs), or vigorous (9 METs) and added to the recall questionnaire. Activities were classified using the compendium of physical activities compiled by Ainsworth et al. (1994). This and updated compendium of physical activities (Ainsworth et al., 2000) has been developed to facilitate the coding of physical activities and to promote comparability of coding across studies. The energy costs of activities listed in the compendium were established following a review of published data. Special attention was given in the 7-day physical activity recall to MVPA, such as games and sports activities. After data collection the following measures were computed from the activity recall: total weekly physical activity (hours per week); total weekly MVPA (moderate plus vigorous activities during one week); low intensity physical activity (hours per week), and mean daily MVPA (total weekly MVPA divided by 7 expressed as minutes per day).

Caltrac accelerometers (Hemokinetics Inc., Madison, WI) were worn between the hours of 8.00 a.m. and 8.00 p.m. during one school day and one weekend day. The children's parents were instructed to put the Caltrac on at 8.00 a.m. in the morning and to record the reading and remove the Caltrac at 8.00 p.m. All monitoring occurred from Monday to Thursday (schooldays) and Saturday (weekend day). During the same week the parents reported their child's physical activities using the 7-day recall questionnaire. The accelerometers were programmed to measure only body movement without regard to age, weight or gender. The score thus reflects only the child's body movements and the intensity of that movement. It does not reflect estimated energy expenditure.

4.4. Heart rate monitoring during physical education classes (Study 2)

Heart rate of 51 first-grade children (27 boys and 24 girls, mean age 7.2±0.2 years) was measured during 3 health-related physical education classes. All classes were taught by physical education teacher with 6 years of pedagogical experience. Classes were oriented at providing maximum MVPA such as running, jogging, skipping, jumping and other activities involving large muscle groups (games, drills). The classes included health-related activities (25 minutes) and motor skill activities (10 minutes). The health-related fitness units conducted during the classes included aerobic games, fitness circuits, jump rope, and shuttle runs. The teacher was provided with general plan for each lesson. The plans contained the list of equipment needed, recommended class formations and transitions.

Heart rates were recorded with a Sport tester (Polar Electro OY, Finland) at 15 second intervals. The device consisted of a sensing transmitter unit strapped to the chest and a receiver/memory unit worn on the wrist. The data were transmitted to the computer using a special interface. The following variables of HR monitoring were used in the data analysis: resting heart rate (RHR), measured before physical education classes; mean heart rate (MHR) during physical education classes; the percentage of time exercised at the following intensities: below 50% of MHRR (up to 149 bpm), above 50% of MHRR (149–157 bpm), above 60% of MHRR (158–175 bpm), and above 75% of MHRR (over 175 bpm).

4.5. Reproducibility and stability of physical activity (Study 3)

The reproducibility of physical activity during 1 week and the stability of activity across the 2 years of the study were assessed by Caltrac accelerometers (Hemokinetics, Madison, WI). Prior to the days of testing all parents of the children were provided with written instructions and data collection sheets for the Caltrac. This provided a consistent recording when the unit was on, the time off, and information about activity during the day when Caltrac might have been removed. All subjects wore the Caltrac at their waist for 2 consecutive weekdays and 2 consecutive weekend days during a 1-month period. Assessment of physical activity by a Caltrac was repeated after a 2-year interval, whereas the similar recording design was used (2 consecutive weekdays and 2 weekend days). Caltrac accelerometers were worn between 8 a.m. and 8 p.m. The parents of children were instructed to attach the Caltrac in the morning and record the reading of the Caltrac in the evening. The accelerometers were programmed to measure only body movements without regard to age, weight, or gender. The score reflects only child's body movements and does not reflect estimated energy expanded by resting metabolic rate.

4.6. Observation of outside school physical activity (Study 4)

Physical activity was measured using an observational method validated by O'Hara et al. (1989) and Caltrac accelerometers (Hemokinetics, Madison, WI). Caltrac's were programmed to record activity counts rather than metabolic rates. Each child was asked to wear a Caltrac at their waist for two consecutive schooldays. Caltrac was attached to the child after the schoolday (2.00 p.m.) and they wore accelerometers until bedtime (8.00 p.m.) after which Caltrac readings were recorded by parent.

Modified Children's Physical Activity Form (MCPAF) was used to observe children's physical activity after schools (O'Hara et al., 1989). Child's activities were observed during the same period when Caltrac accelerometers were worn (2.00 p.m. –8.00 p.m. for two consecutive schooldays). In sum, the total activity scores for Caltrac and for MCPAF (6 categories) for two schooldays were used as a measures on outside school physical activity.

In addition to original four categories representing different levels of intensity of movement, two additional categories, representing throwing-related and jumping related activities, were added to observation instrument. Thus, MCPAF consisted from 6 categories: 1) stationary, no movement; 2) stationary, limb movement; 3) slow trunk movement; 4) rapid trunk movement; 5) throwing-related movement; 6) jumping-related movement. The title of each level of intensity (subscales 1–4) describes the physical activities that characterize that level. The stationary, no movement category identifies occasions during which there is no movement to another point in space and virtually no purposeful limb movement. The stationary limb movement category identifies occasions during which there is no trunk movement to another point in space, but where limb movement does occur (arm circles, arm curls). The next two movement categories identify occasions during which there is movement of the entire body from one location to another (lateral, forward, and backward or up and down movement). Activities in the slow trunk movement category are characterized by the leisurely or slow pace at which they are performed (walking, sit ups, and trunk twisters). Rapid trunk movement activities are characterized by the moderate or rapid pace at which they are performed. Fast walking and jogging are included in this category as well as running. Throwing-related movements are characterized as any movements related to one-hand throwing of the objects or games during which one-hand throwing is constantly performed. Jumping-related movements are characterized as any movements related to different forms of jumping (one-leg, two-legs, forward and backward, lateral) with and without sporting instruments (rope jumping).

Observers were trained to check each 6 categories performed by a child in each 1-minute interval. Since the type and intensity of movement can change several times in 1 minute, observers were instructed to reflect this by checking all categories of the child's activity occurring in that minute. Therefore, each 1-minute interval may have checks in several different categories, although no one category could be checked twice within the same minute.

Calculating of activity scores

An intensity of activity point score was calculated for every minute of activity. For each minute, the proportion of the minute in seconds was allocated to an activity level depending on whether that level was checked for that minute. Activity points, which are ordinal in value, were assigned to each of the ordinal levels of movement. That is, each second of stationary no movement received 1 activity point; stationary limb movement, 2 points; slow trunk movement, 3 points; rapid trunk movement, 4 points. In addition, throwing-related and jumping-related movements were scored with 3 or 4 activity points, depending whether specific skill-related activity was performed with slow trunk movement (3 points) or rapid trunk movement (4 points). A total activity points for each activity category were calculated throughout entire observation period (360 minutes).

Prior to data collection, a pilot study was conducted with 22 children to estimate inter-observer agreement. Both investigators observed children after schools (from 2.00 p.m. until 8.00 p.m.). Percentage of inter-observer agreement was 90,5% at the onset of testing. As our result show, inter-observer agreement (as index of reliability) was acceptably high using MCPAF.

4.7. Assessment of fundamental motor skills

Overhand throwing and standing long jump were performed in field conditions as an indicator of fundamental motor skill development. In throwing from a standing position each child performed three trials with a tennis ball (weight 150 g). The task was to throw the ball as far as possible. Three trials for each child were recorded with a Panasonic video camera (NV-S70) located to the left of the child. The camera objective was placed perpendicular with the throwing direction. The distance between camera and child was 20 meters. Standing long jump was also performed three times and the task was to jump as far as possible. Similar recording conditions (like in overhand throwing) were used. The qualitative evaluation of overhand throwing and jumping performance was done by visual observation of the videotapes. Two specialists of motor development served as observers. Both had previous training with the evaluation of total body developmental sequences (Haubenstricker & Seefeldt, 1986) to assess fundamental motor skills. Observers individually rated the videos. Scores for each trial could range from one to four corresponding to stages 1 through 4, i.e. immature to mature movement patterns, respectively. Prior to data collection, a pilot study was conducted with 22 children to estimate inter-observer agreement. Both investigators rated videotaped performances of children throwing and jumping. Percentage of inter-observer agreement was 93,3% at the onset of testing.

4.8. Statistical evaluation of the data

Statistical analyses were performed using Statistica 6.1. Descriptive statistics were determined for all variables. The statistical significance of the sex/group differences in measured variables was tested by Student's t- test. Associations between variables were assessed using Pearson product-moment correlation coefficients. The reproducibility of physical activity was assessed by Spearman rank order correlation coefficients. Multiple regression analyses were conducted to predict variance in fundamental motor skills scores as dependent variables with physical activity categories as independent variables (Study 4). Statistical significance was set at $p<0.05$.

5. RESULTS

5.1. Habitual physical activity

Descriptive data of body height and mass and physical activity according to intensity level across age and sex groups are presented in Table 2.

Table 2. Descriptive data and physical activity according to intensity level (7-day recall; mean ± SD).

Variables	Age group	Boys	n	Girls	n	p
Body height (cm)	7-year-olds	125.8±7.6	31	125.2±8.1	30	>0.05
	8-year- olds	131.3±7.2	27	130.4±7.8	29	>0.05
	9-year- olds	136.6±7.4	31	134.8±7.2	26	>0.05
Body mass (kg)	7-year-olds	25.5±5.2	31	24.2±4.8	30	>0.05
	8-year-olds	28.4±5.5	27	26.3±5.1	29	>0.05
	9-year-olds	31.8±5.4	31	30.3±4.9	26	>0.05
LPA (h/week)	7-year-olds	14.6±3.2	31	14.1±3.6	30	>0.05
	8-year-olds	13.7±3.1	27	14.1±3.6	29	>0.05
	9-year-olds	11.7±2.5	31	13.2±3.2	26	<0.05
TPA (h/week)	7-year-olds	26.2±3.8	31	22.7±3.4	30	<0.05
	8-year-olds	23.8±3.6	27	21.6±3.3	29	<0.05
	9-year-olds	19.9±3.1	31	19.5±3.3	26	>0.05

Note: LPA- low intensity physical activity; TPA- total weekly physical activity.

Total physical activity during one week was significantly ($p<0.05$) higher in boys than girls in the 7-and 8-year groups but not at 9-year-old. There were no significant ($p>0.05$) sex differences in body height and body mass.

The mean daily moderate-to-vigorous physical activity scores across age and sex groups obtained by the 7-day recall questionnaire are presented in Figure 1.

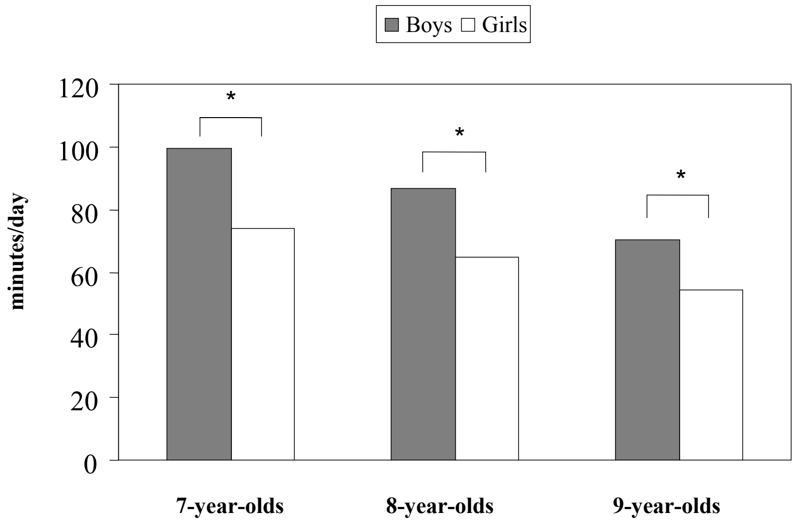

Figure 1. Daily MVPA of children (7-day recall). Values are means; * p<0.05.

Boys performed significantly more (p<0.05) minutes of daily MVPA than the girls in all age groups. The results also indicated significant (p<0.05) decreases in physical activity with age in both sex groups.

The results of the Caltrac monitoring (mean activity counts for one school day and one weekend day) across age and sex groups are shown in Figure 2. There were no significant sex differences in the activity scores of 7-year-old children. In the 8-and 9-year-old groups, boys performed significantly more (p<0.05) physical activity than girls of the same age group.

Figure 2. Physical activity of children (Caltrac). Values are means; * p<0.05.

5.2. Physical activity during physical education classes

Mean (±SD) resting heart rate of children was 68.4±4.3 beats·min^{-1} (bpm) and that during physical education classes 157.4.±8.6 beats·min^{-1} (bpm). Mean heart rate changes during health-related physical education classis presented in Figure 3. Percentages of lesson time spent above 50, 60, and 75% of MHRR are presented in Table 3. The results revealed that 60% of the class time was spent at an intensity of over 60% of MHRR, 40% of the time at the intensity above 75% of MHRR and 27% at the heart rate below 50% of MHRR. Less than 20% of the class time was spent at heart rates between 149–157 bpm or 158–179 bpm.

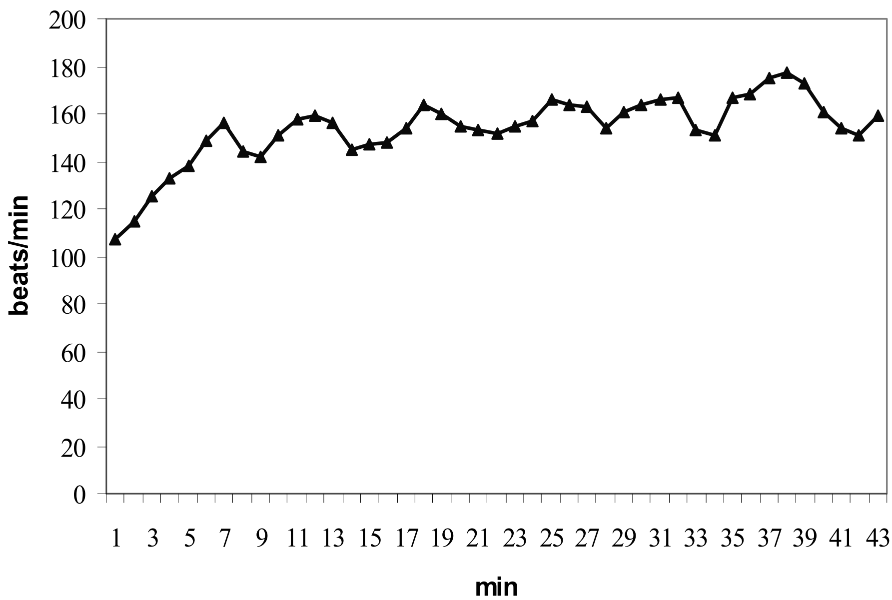

Figure 3. Heart rate changes during intensified physical education classes.

Table 3. Percentages of class time spent at various heart rate levels.

Heart rate intervals (beats·min^{-1})	% of class time
< 149	27
149–157	13
158–173	20
> 173	40
> 60% MHRR	60
> 75% MHRR	40
< 50% MHRR	27

Note: MHRR – maximum heart rate reserve

5.3. Reproducibility and stability of physical activity in children

Spearman correlation coefficients for 1 week measurements in two years are shown in Table 3. Between-day correlation coefficients ranged from 0.35 to 0.69 (May 1995) and 0.27 to 0.66 (May 1997). However, between-day reproducibility was higher separately among weekdays and weekend days. Spearman correlations between different measurements over 2 years are shown in Table 4. The correlation coefficients between mean Caltrac scores for weekdays, weekend days, and combined weekdays and weekend days were significant (p<0.05–0.01) and ranged from 0.34 to 0.57.

Table 4. Spearman correlations between different days of the week (May 1995 and May 1997).

Days	WD 1	WD 2	WED 1	WED 2	Mean of WDs	Mean of WEDs
WD 1	–	0.69**	0.42**	0.53**	0.64**	0.40**
WD 2	0.64**	–	0.37**	0.44**	0.56**	0.35**
WED 1	0.56**	0.53**	–	0.53**	0.36**	0.66**
WED 2	0.54**	0.45**	0.56**	–	0.35**	0.64**
Mean of WDs	0.66**	0.55**	0.27	0.45**	–	0.53**
Mean of WEDs	0.53**	0.34*	0.54**	0.64**	0.59**	–

Note: WD 1 – first weekday, WD 2 – second weekday, WED 1 – first weekend day, WED 2 – second weekend day.

Spearman correlations between different measurements over 2 years are shown in Table 5.

The correlation coefficients between mean Caltrac scores for weekdays, weekend days, and combined weekdays and weekend days were statistically significant (p<0.05–0.01) and ranged from 0.34 to 0.57.

Table 5. Spearman correlations between different measurements over 2 years.

Measurements	Spearman r
1 and 3	0.52**
1 and 4	0.34*
2 and 3	0.47**
2 and 4	0.57**
5 and 6	0.41*

Note: Measurements: 1 = mean of weekdays, May 1995; 2 = mean of weekend days, May 1995; 3 = mean of weekdays, May 1997; 4 = mean of weekend days, May 1997; 5 = mean of weekdays and weekend day, May 1995; and 6 = mean of weekdays and weekend days, May 1997. * p<0.05. ** p<0.01.

5.4. The relationship between fundamental motor skills and outside-school physical activity

Descriptive statistics for motor skills and outside-school physical activity across sexes are reported in Table 6.

Table 6. Means by sex for motor skills and outside-school physical activity

Variable	Boys (n = 68)	Girls (n= 65)	F value
Age (years)	7.5±0.7	7.7±0.6	ns
Throwing (stage)	3.3±0.6	2.6±0.5	4.57*
Jumping (stage)	3.5±0.7	3.1±0.6	ns
Caltrac (counts)	75.4±19.6	66.4±17.4	4.11*
C 1	141.6±25.6	162.5±27.7	5.65*
C 2	65.6±18.8	77.5±17.6	5.16*
C 3	48.6±15.6	57.3±14.3	4.42*
C 4	77.2±24.8	58.7±20.6	5.32*
C 5	21.5±12.1	10.8±8.6	6.32*
C 6	35.2±13.1	24.4±11.7	4.97*

Note: C 1 = stationary, no movement; C 2 = stationary, limb movement; C 3 = slow trunk movement; C 4 = rapid trunk movement; C 5 = throwing-related movement; C 6 = jumping-related movement, ns- not significant.

Boys had a significantly higher developmental level of overhand throwing and higher scores for Caltrac accelerometer, rapid trunk-movement physical activity, and motor skill-related physical activity, while girls showed higher scores for lower-intensity physical activities (limb movement and slow trunk movement) and physical inactivity. Correlations between fundamental motor skills and outside-school physical activity are presented in Table 7. Developmental levels of both overhand throwing and jumping were significantly correlated with the skill-specific physical activity (r= 0.44 and 0.55 for overhand throwing and jumping, respectively). Caltrac score was significantly related to throwing skill (r= 0.21).

Table 7. Correlation of motor skills and outside-school physical activity (n= 133)

Variable	**Throwing**	**Jumping**	**Caltrac**	**C 1**	**C 2**	**C 3**	**C 4**	**C 5**	**C 6**
Throwing	–								
Jumping	0.53**	–							
Caltrac	0.21*	0.15	–						
C 1	0.08	0.13	0.14	–					
C 2	-0.09	0.10	0.18	0.22*	–				
C 3	0.12	0.10	0.32***	0.11	0.25*	–			
C 4	0.23**	0.17	0.49***	0.17	0.22*	0.38***	–		
C 5	0.44***	0.29*	0.12	0.10	0.20*	0.26**	0.30**	–	
C 6	0.31**	0.55**	–0.03	0.13	0.11	0.21*	0.31**	0.33**	–

Results of multiple regression analyses to predict jumping and overhand throwing proficiency of children are presented in Table 8. The regression for overhand throwing proficiency as a dependent variable resulted in a multiple R of 0.49, accounting for 20% of the variance (adjusted R^2). For jumping, regression analysis resulted in a multiple R of 0.46, accounting for 17% of the variance (adjusted R^2).

Table 8. Results of multiple regression analysis (n= 133)

Variable	Beta	F	p
Dependent variable: throwing			
Throwing-related movement	0.19	7.17	<0.05
Jumping-related movement	0.13	4.42	<0.05
Caltrac	0.10	3.35	<0.05
Dependent variable: jumping			
Jumping-related movement	0.22	8.83	<0.05
Throwing-related movement	0.12	3.97	<0.05

Note: for throwing: multiple R = 0.49, R^2 = 0.24, adjusted R^2 = 0.20; for jumping: multiple R = 0.46, R^2 = 0.21, adjusted R^2 = 0.17.

6. DISCUSSION

6.1. Children's habitual physical activity

It is widely acknowledged that children and youth need regular physical activity for normal growth and development, and maintenance of good health and fitness (Pate et al., 1994; Malina, 2001), It is also assumed that physical activity level in childhood tend to track into adulthood (Kristensen et al., 2008), when sedentary habits have their impact (Malina, 1996). As Roberts (1996) suggested, "it may be unrealistic to expect the chauffeured children of today to become the ambulant adults of tomorrow". There is general agreement that the physical activity levels of children and youth have declined during past decades (Pate et al., 1994; Kimm et al., 2002; Nelson et al., 2006; Faulkner et al., 2009). Thus, one of the specific aims of the current investigation was to examine the physical activity patterns of Estonian primary school children as determined by 7-day parental recall and Caltrac accelerometer.

During last decade the activity levels of children have been extensively researched (Rowlands & Eston, 2005; Beighle & Pangrazi, 2006; Ridley et al., 2008; Rowlands et al., 2008). Cale and Almond (1992) concluded from a review of twenty studies that young children were not sufficiently active for the health-related benefits of that activity. Recent literature reviews of children's physical activity levels have established a number of key findings and consistent trends in activity behavior (Harris et al., 2004; Fairclough & Stratton, 2005). Harris et al. (2004) have highlighted that over 50 percent of boys and 33 percent of girls are appropriately active when compared with current physical activity guidelines. However, physical activity declines with age, with the teenage years being the time of greatest decline. There is also the sporadic and highly transitory nature of their physical activity patterns, with the majority of time being spent in low intensity activity (Waring et al., 2007).

General guidelines are used to describe the amount of physical activity related to health benefits in children and youth (Sallis & Patrick, 1994; Corbin & Pangrazi, 1998; Cavill et al., 2001). Those general guidelines stress the importance of participation in MVPA, at least 60 minutes per day. The 54.2 to 99.4 minutes (third-grade girls and boys, respectively) of daily MVPA reported by the parents of elementary school children in this study is generally consistent with previous surveys (Simons-Morton, 1997; Cavill et al., 2001). The mean values met or exceeded the guidelines for physical activity proposed by the consensus conference (Sallis et al., 1994). These provide an amount of physical activity that is adequate for health maintenance for adolescents. Although these guidelines have been developed specifically for adolescents, it is interesting to analyze whether the primary school children's activity met established recommendations. In considering the more stringent guideline of the International Consensus Conference (Guideline 2), which states that adolescents should engage in three or more sessions per week of activities that last 20 min or more at a time and that require MVPA, it appears that the primary school children participating in the present study meet this guideline. The rational provided for this guideline is the evidence that regular participation in MVPA enhances physiological health, increases HDL cholesterol and increases cardiorespiratory fitness (Sallis & Patrick, 1994). Furthermore, the amount of daily MVPA reported in this study is higher than the amount typically reported in other studies which have assessed children's physical activity by other methods such as heart-rate monitoring (Armstrong & Bray, 1991; DuRant et al., 1992), direct observation (Strand & Reeder, 1993; Sleap & Warburton, 1996; Waring et al., 2007) and accelerometry (Wang et al., 2005; Evenson et al., 2008). Sleap and Warburton (1996), for example, investigated the physical activity levels of 5-to 11-year-old children in England which showed that children engaged in MVPA for an average of 117 minutes or 8% of a 24 hour day. Nevertheless, despite almost two hours of MVPA daily, the authors stated that although some preadolescent children appear to be quite active, the overall picture shows that most children engage in very little sustained, playful activity. Recently, Waring et al. (2007) found that children spent 11,8% of the available time in at least moderate activity which, when set in minutes, evidences that an average of 15 minutes of the school day was spent in appropriate activity to promote health.

The descriptive data of sex differences in physical activity in this study were consistent with previous research findings (Eaton & Enns, 1986; Sallis, 1993; Wedderkopp et al., 2004). The results from the activity recall indicated that boys spent 16–25 more minutes per day on MVPA than the girls. Although boys are generally more active than girls, little is known about the possible reasons for this. It has been suggested however that boys seem to spend more time in activity-enhancing environments than girls (Baranowski et al., 1993; Biddle et al., 1998). In addition, boys and girls have also been found to engage in different types of activities (Faucette et al., 1995). It is also well documented that boys sepnd more time than girls in higher-intensity activities (Aaron et al., 1993; Waring et al., 2007). Aaron et al. (1993) found that males reported 22.5 hours per week of leisure time physical activity compared to 6,6 hours for females. Waring et al. (2007) reported that boys spent in at least moderate level physical activities for 13 percent of total observation time compared to 10 percent for girls.

Research focusing on the gender differences in physical activity and sport participation in children has shifted from a focus on biological to social and psychological factors (Fox et al., 1994; Allender et al., 2006; Barnett, et al., 2006). MacPhail et al. (2003) found that providing children with many different types of physical activity and sport encouraged participation. Previous investigations involving children have also identified parental support, enjoyment of physical activity, and time spent outdoors as factors associated with physical activity participation (Sallis et al., 2000; Dishman et al., 2005; Raudsepp, 2006).

Several theories in developmental psychology have emphasized the importance of the environment in facilitating and/or limiting behaviour (Morris, 1988) and increased attention has been focused on the environmental correlates of physical activity (Sallis et al., 2000; Faulkner et al., 2009). However, relatively little is known about the differences in physical activity levels between children living in different locations (Baranowski et al., 1993; Sallis & Owen, 1997). The results of current investigation showed that rural children were more active than urban schoolchildren. Possible explanations for these differences include the different socioeconomic conditions of rural and urban families (relatively high unemployment of rural families in Estonia), physical environments (distance of schools from homes), and possibly different attitudes of rural and urban children towards physical activity. There are many opportunities for children from urban families of a higher socioeconomic status to develop sedentary lifestyles. For example, Robinson et al. (1993) found that the time children spend watching TV or playing video games has increased dramatically in recent years. In the absence of computers in many Estonian rural families, rural schoolchildren have little opportunity to spend their free time playing computer games. Therefore, it can be assumed that they have more free time for outdoor activities including participation in games and exercises. Previous studies have found that the single strongest correlate of physical activity in young children in time spent outdoors (Sallis et al., 1993; 2000; Davison & Lawson, 2006).

Another explanation for the higher levels of physical activity of rural schoolchildren compared with urban children may stem from ecological models (Sallis et al., 1997). Ecological models posit that there are multiple levels of influence on physical activity, including intra-personal, social and physical environmental factors (Sallis & Owen, 1999). The physical environment has come to the forefront of research in the past 5 years, leading to a surge of research on environmental attributes and their associations with physical activity behaviour (McMillan, 2005; Krahnstoever et al., 2006). Clearly, it is important to understand the possible effects of physical environment on children's physical activity, because environments have the capacity to facilitate or hinder physical activity (Sallis & Owen, 1997). It could be assumed that for rural schoolchildren, physical environments are richer in resources relevant for physical activity (e.g. parks, playgrounds, sidewalks). On the other hand, urban schoolchildren often lack relevant conditions for participation in leisure-time physical activities which may be one reason for their lower activity levels. Therefore, additional studies with young children are needed to identify which psychosocial and environmental factors affect children's physical activity behaviour (Sallis et al., 1997; Brodersen et al., 2005). Future studies that simultaneously investigate multiple variables across multiple physical activity domains may assist in the identification of potential mediating, moderating, of confounding influences on children's physical activity. The use of larger samples may allow for the detection of small yet significant associations previously concealed. The collection of physical activity data a range of times, locations, and contexts, using methods validated in the children population, is imperative to obtain a full picture of children's physical activity behaviour (Hinkley et al., 2008).

6.2. Reproducibility and stability of physical activity

Although physical activity in children and youth is an area of growing interest, relatively few studies have described the reproducibility and stability of physical activity (Roche & Guo, 1994; Kristensen et al., 2008). One aim of the present study was to examine the reproducibility of physical activity during one week and the stability of physical activity over 2 years. The results of the current investigation provide relatively strong evidence that physical activity is stable over two years during late childhood and yearly adolescence. In addition, our results indicate that the reproducibility of children's physical activity depends, at least partly, from the day of the week (weekday and weekend day). Thus, our results confirm an assumption that physical activity habits developed by childhood continue through adolescence into adulthood (Livingstone, 1994; Malina, 1995, 2001).

Measurement of physical activity in children is complicated by the variability of the behaviour. Physical activity was not expected to be highly stable over time. It is argued that numerous biological, psychological, social, cultural, and physical environmental factors are associated with physical activity levels in children, and many of these factors change over time (Sallis et al., 1992, 1995, 2000). For example, children's physical activity habits may change when children enter school, when they are changing living location, or when their motivation and attitudes toward physical activity changes in some reasons (Biddle, 1995). However, the health benefits of physical activity in children and adults are most likely to be due to habitual patterns that sustained over time (Sallis et al., 1995). In addition, habits of and attitudes towards physical activity developed during childhood are assumed to continue through childhood into adulthood (Livingstone, 1994; Malina, 1995; Kristensen et al., 2008).

The Spearman's rank-order correlations reflecting the reproducibility of physical activity found in the present study during 1-week measurement period were generally consistent with previous studies where reproducibility and short-term variability of physical activity in children were examined (DuRandt et al., 1992, 1993; Sallis et al., 1990; 1995). DuRandt et al. (1992, 1993) studied within-day and between-day reproducibility of heart-rate indicators in 3–7-year-old children. The results indicated that between-day correlations for heart-rate indicators ranged from 0.65 to 0.81. Consistently lower physical activity correlations in a study of young children were found by Sallis et al. (1995). For the shortest interval in the study, 1 week, the correlations between single days were 0.29 for home and 0.38 for recess. Sallis et al. (1995) argued that the key finding of the study was that the variance in the children's physical activity in two settings (at home and at recess) was accounted for by the short-term influences. Therefore, children's physical activity levels are primarily influenced by transitory and dynamic variables in the biological, psychological, social, and physical environmental domains (Sallis et al., 2000).

Some important features concerning the results of present investigation need to be considered. Firstly, between-day reproducibility was calculated on the basis of the Caltrac scores of two weekdays and weekend days with an interval of 2 years. It was hypothesized that the habitual level of children's physical activity depends, at least to some extent, on the differences in children's daily activity patterns associated with the different schedules of weekdays and weekend days. Our results indicated that physical activity correlations between different weekdays as well as different weekend days during two measurements periods were consistently higher than correlations between "mixed" days. Spearman correlations between weekdays of Caltrac scores varied from 0.64 to 0.69 and between weekend days from 0.53 to 0.56. The between-day reproducibility for weekdays and weekend days of the accelerometer scores were consistently lower, ranging from 0.37 to 0.56. Higher correlations among weekdays than between weekend days were also found in a study of adult men (Gretebeck & Montoye, 1992). One possible explanation for the higher between-day reproducibility of children's physical activity among workdays could be attributed to the fact that some children's physical activity patterns are relatively stable during weekdays (schooldays). Conversely, during weekend days, children probably have more "free" or unstructered leisure time and their activities are more variable compared with schooldays. Reproducibility of physical activity over a week's period could also be attributed to similarities in weather, the child's health status, consistency of playmates, and other factors (Sallis et al., 1995).

Stability of a chracteristic (e.g. physical activity) over longer periods of time can be conceptualized as tracking, or tendency of people to retain their relative ranking on a variable over time (Malina, 1996; Sallis et al., 1995). Tracking of different physiological risk indicators has been well described (Clarke & Lauer, 1993; Fortier et al., 2001) but tracking of physical activity during childhood and adolescence has been seldom studied (Sallis et al., 1995; Malina, 2001; Raudsepp et al., 2008). However, the need for objective estimates of stability of physical activity in children and adolescents has been clearly recognized in the literature (Malina, 2001). In accordance with previous studies, Spearman correlation coefficients were used to assess the short-time tracking of physical activity. Moderate correlation coefficients over 2 years in children (r= 0.34 to 0.57) and adolescents (r= 0.48 to 0.53) found in the present study are in agreement with several previous studies (Sallis et al., 1995; Pate et al., 1996; Janz et al., 2000; Falk et al., 2001). Pate et al. (1996) reported Spearman correlations for PAHR-50 index (time during which heart rate was 50% or above individual resting heart rate) over a 3-year period ranging from 0.57 to 0.66. Sallis et al. (1995) reported the highest correlations between physical activity scores in young children over 1 year, 0.36 (at home) and 0.09 (at recess) and over 2 years, 0.27 (at home) and 0.12 (at recess). Malina (2001) concluded on the basis of earlier studies that the results are generally consistent in indicating low to moderate short-term tracking of physical activity in the transition from early to middle childhood and during adolescence. Recently, Kristensen et al. (2008) concluded that physical activity behaviour tracks moderately from childhood to adolescence with stability coefficients of approximately 0.50

independent of gender. The implication of our results is that physical activity habits established in childhood tend to follow the individual into later stages of life (at least into early adolescence) and, as a consequence, childhood physical activity should be recognized as a possible target for intervention strategies.

6.3. Physical activity during physical education classes

Physical education classes are intended to help all children experience regular MVPA. Moreover, for some children, the experience of MPVA may only occur during school physical education classes (Riddoch et al., 1991; McKenzie et al., 1996; Fairclough & Stratton, 2005). Previous studies, however, showed that mean heart rates in the majority of normally delivered physical education classes fall below 150 beats per minute, whereas none achieved 175 beats per minute (Callesen et al., 1983; Klausen et al., 1986; Li & Dunham, 1993; Mota, 1994; Wang et al., 2005). Only mean heart rates during intensified physical education (15- year-olds males) classes exceeded 175 beats per minute (Seliger at al., 1980; Baquet et al., 2002).

The present study also examined the physical activity of elementary schoolchildren during intensified or health- related physical education classes using heart rate monitoring. The results of our investigation showed that mean heart rate measured during intensified physical education classes (157. 4 bpm) was higher when compared to mean heart rates of the normally delivered classes (Klausen et al., 1986; Li & Dunham, 1993; Mota, 1994; Wang et al., 2005). The early results of Seliger et al. (1980) study showed that mean heart rates during intensified physical education classes in 15-year-old males exceeded 75% of MHRR (approximately 170- 175 bpm). No other physical education classes exceeded this threshold, and none was intense enough to increase cardio respiratory fitness of children (Stratton, 1996). Morrow and Freedson (1994) reported, that heart rate above 75% of MHRR is regarded as a sufficient stimulus to promote cardiorespiratory fitness of adolescents. Baquet et al. (2002) found that students' mean heart rate during high-intensity running and high-intensity jumping classes was significantly higher when compared with students of control class. However, several important questions have to be addressed concerning the present investigation. First of all, the physical education classes during which children' s heart rates participating in the present study were measured, were not aimed at promoting only cardio respiratory fitness. Health related physical education is also aimed to provide children with activities related to other components of health- related fitness (flexibility, functional strength and body composition). Although a majority of classes' time was devoted to promote the cardio respiratory fitness of children, several units of classes were also aimed to develop flexibility and strength of children. In addition, it is well recognized that physical activity recommendations developed to promote the cardio respiratory fitness of adults or even adolescence, are not very strictly modified for young children (Riddoch & Boreham, 1995). Therefore, concerning the mean heart rate measured during health related physical education classes in present study, it is complicated to say that our classes did not promote cardiorespiratory fitness of elementary schoolchildren. Furthermore, the mean heart rate during physical education classes in not the best indicator of children's activity level (Stratton, 1996; Fairclough & Stratton, 2005).

Heart rate time curves are more useful than mean heart rate as they also provide information about the quality of the physical activity. Continuous measurement of heart rate throughout classes enable investigators to report time or percentage of lesson time spent at predetermined heart rate thresholds (Stratton, 1996). However, a particular problem encountered with heart rate studies is the tendency of investigators to select an arbitrary heart rate thresholds above which they consider activity to be beneficial to health (Riddoch & Boreham, 1995). In the present study, we used MHRR, or the difference between maximal and resting heart rate, as an objective indicator of estimating heart thresholds (Stratton, 1996). For the 6–10-year-old children, following MHRR thresholds estimated from age- related maximum and resting heart rate, are suggested: resting heart rate- 95 bpm; 50% of MHRR- 148bpm; 60% of MHRR- 158bpm; and 75% of MHRR- 174bpm (Bar- Or, 1983; Stratton, 1996).

The results of the present study showed that 60% of health related classes' time (24 minutes) was spent with heart rate above 60% of MHRR (158bpm). Stratton (1996) proposed that the appropriateness of each physical education lesson should be assessed against the following guidelines:

1. To achieve a moderate level of physical activity, children should be moving (walking or faster) for at least 50% (or 20 min) of lesson time with heart rate between 50 and 59.9% of MHRR.
2. To achieve a vigorous level of physical activity, children's heart rates should be in excess of 60% of MHRR for at least 50% (or 20 min) of lesson time. In fulfilling Guideline 2, Guideline1 will be achieved.

Concerning our finding, that 60% of classes' time was spent with heart rate above 60% of MHRR, it was revealed that the activity level of elementary schoolchildren of present study met proposed activity guidelines. Therefore, it can be concluded from heart rate data that health related physical activity program implemented in present investigation was efficient for the promotion of health-related fitness of elementary schoolchildren. However, according to more stringent requirement developed for the promotion of cardio respiratory fitness of adolescents, only physical activity intensity above 75% of MHRR may stimulate an increased cardio respiratory fitness (Morrow & Freedson, 1994). Our results showed that 40.2% of lesson time (approximately 16 min) was spent with heart rate above 75% of MHRR. Therefore, the physical activity of elementary schoolchildren during health related physical education classes was appropriate to promote also a cardiorespiratory component of health-related physical fitness. When comparing our data with other heart rate threshold studies (Callesen et al., 1983; Klausen et al., 1986; Li & Dunham, 1993; Mota, 1994; Baquet et al., 2002; Wang et al., 2005), it becomes apparent that physical activity of elementary schoolchildren participating in the present study was higher. For example, Klausen et al. (1986) reported that children spent between 15 to 35% of class time in heart rates in excess of 50% of MHRR. Mota (1994) found that boys spent 60.2% and girls 46.5% in heart rates greater than 140 beats per minute. Stratton (1993) reported that 8% (gymnastics) to 59% (volleyball) of class time was spent with heart rate above 50% of MHRR. Recently, Wang et al. (2005) found that on average, 14.4 minutes of physical education classes had been spent in MVPA with children's heart rates above 139bpm and only 6.7 minutes had been spent in vigorous physical activity with children's heart rates above 159bpm. Waring et al. (2007) reported that in English schools, boys spent only 6.8 minutes in MVPA and girls spent 6.0 minutes in MVPA during physical education classes. However, it needs to be taken into account, that heart rates in these studies were measured during normally delivered physical education classes. In the present study, although the classes were also normally delivered, however, we used health-related physical education programme for elementary schoolchildren. Seliger et al. (1980) also measured heart rates of children during intensified physical education classes. However, only mean heart rates during classes, but not percentage of classes time above selected heart rate thresholds, was reported.

There are, however, conflicting views as to the role of physical education in promoting children's physical activity (Waring et al., 2007). Mallam et al. (2003) suggest that the total amount of physical activity a child pates part in does not depend on the physical education lesson, as children have been shown to compensate for a lack of activity in this area by increasing activity in the home environment. In contrast, Sleap and Warburton (1996) provide evidence that children are almost twice as likely to engage in at least a moderate activity in a physical education lesson as they are in the home environment. Fairclough (2003) argued that teachers have pressure on them to meet a whole series of goals within school physical education beyond just the promotion of physical activity and these include the needs to develop individual skill, to foster appropriate levels of enjoyment and to deliver lessons that have educational value.

In summary, the results of the present study indicated that health- related physical education programm was effective to promote physical activity of elementary schoolchildren. In addition, physical activity of children, as estimated by heart rate, was sufficient to promote cardio respiratory fitness during physical education classes. School physical education remains a critical place for promoting health-related physical activity. It is the only setting in which some students can accrue vigorous physical activity and learn important physical skills.

6.4. The relationships between fundamental motor skills and outside school physical activity

This study examined the relationship between two fundamental motor skills (overhand throwing and jumping) and outside school physical activity in elementary school children. Findings generally supported our hypothesis that developmental level of fundamental motor skills would be related with skill-specific outside school physical activity but not with general level of physical activity of elementary school children.

The development of motor skills has been a primary goal of physical education programs (Siedentop, 2001; Fairclough, 2003), and skilled children would presumably be more involved in different physical activities (Butcher & Eaton, 1989; Barnett et al., 2008). Relatively little, however, is known about the motor skills of elementary school children and how they are related to different types of outside school physical activities. The main reason why current study focused on outside school physical activity is related to the rather limited possibilities of children to participate in physical activities during ordinary school days. Although McKenzie et al. (1998) suggest schools share more of the responsibility for increasing children's physical activity, previous research showed that during physical education lessons children do not participate enough moderate-to-vigorous physical activity for promoting their health-related physical fitness (Simons-Mortin et al., 1997). Curtner-Smith et al. (1996), for example, found that much of physical education lesson time is spent standing (65,8%) and sitting (13,4%) and pupils experience limited opportunity to engage in moderate to vigorous physical activity (13,4%). Simons-Morton et al. (1999) study conducted in American schools showed that student participation in physical education classes declined from 3,6 days to 3 days per week. In addition, many schools allow children to spend recess periods indoors where school computers are available for homework and games (Dale et al., 2000). If children are exposed to school days of predominantly indoor activities, with relatively little time for physical activity, there is a strong need to compensate this inactivity after school days.

Previous research focused on children's motor skill development and outside school physical activity of different types is very limited. Butcher and Eaton (1989) reported that free play behaviour and physical activity were significantly related to motor proficiency. Specifically, children who participated in high active, gross motor activities with high activity level were more likely to have good running skills, while children who participated in low active, fine motor activities with low activity levels were more likely to have good visual motor control and balance. Sääkslahti et al. (1999) found fundamental motor skills to be weakly related to weekend physical activity in 3-and 4-year-old Finnish children. The results of the present study suppported the hypothesis that fundamental motor skills would be related with skill-specific physical activity but not with general outside school physical activity. Despite the fact that zero-order correlations between throwing and jumping-related physical activities and qualitative development of those motor skills were rather medium, skill-related activities predicted 17–20 % of the variance in jumping and throwing skills in children. At the same time, the overall physical activity of children during two schooldays was not related with overhand throwing and jumping proficiency. Although more evidence is required, failure to incorporate physical activity as a part of daily life and failure to master a basic set of motor skills may prove a major barrier to participation in physical activities and to achieve recommended physical activity levels for maintenance of good health (Van Beurden et al., 2003) and fitness (Pate, 1983; Barnett et al., 2008).

Acquisition of fundamental motor skills has been considered a key objective of elementary physical education programmes (Siedentop, 2001), as evidence suggests that a developmental sequence exists in motor skill behavior, with mastery of fundamental motor skills prerequisite to the successful introduction of specific sports and games (Gallahue & Ozmin, 1998). In addition, it is important that children learn fundamental motor skills early in life, because they are prerequisites to successful participation in health-related physical activities during childhood and even during adulthood (McKenzie et al., 2004). In addition to school physical education programmes, outside school physical activity (organized as well as volitional) seems to offer a perfect possibilities for the acquisition of fundamental motor skills in children. Current findings clearly indicate (Van Beurden et al., 2003) that when acquisition of fundamental motor skills is the primary goal, specific skill-related motor activities should be integral part of those programmes. Although many games and activities performed by elementary school children in free-play conditions contain skill-related activities, the learning effect of those nonorganized activities is still unclear. Thus, teachers and instructors involved in outside-school programmes have to be given additional support and resources so that they can deliver a comprehensive sport and exercise programme outside of formal physical education lessons (Daley, 2002). The new developments in this direction, such as school sport co-ordinator programme (Flintoff, 2003), which aims to develop opportunities for youth sport and physical activity through co-ordinated links between PE and both within and outside of the formal curriculum, are also required to maximize the quality of outside school programmes. Furthermore, one alternative solution might be to provide additional qualified coaches to assist PE teachers with the planning and delivery of extra-curricular activities. This might also help to alleviate the time and staffing constraints that operate for many PE teachers (Daley, 2002).

There were several limitations to this study. Firstly, the cross-sectional design of the study does not allow to draw causal relations between outside school physical activity and development of fundamental motor skills. Clearly, longitudinal studies are needed to examine the influence of outside school physical activity on motor skill development during childhood. Secondly, a limited number of elementary schoolchildren from only two schools participated in the study. And finally, the two measured skills represented only a subset of relevant fundamental motor skills for this age group.

In conclusion, the present findings add to the body of knowledge on the relationship between outside school physical activity and fundamental motor skills in elementary school children. Our results clearly showed that the developmental level of two fundamental motor skills (overhand throwing and jumping) of elementary school children was related with skill-specific outside school physical activity. These findings need to be replicated in more diverse samples (i.e., in children over a wider age range), using different contexts in which children may be restricted to indoor activities (i.e., television, reading, computer playing) and conducting longitudinal and experimental studies to examine the causal relations between motor skill development and outside school physical activity.

CONCLUSIONS

1. According to the parental recall, the moderate-to-vigorous physical activity levels of the boys were significantly higher than that of the girls in all age groups.
2. Accelerometer monitoring indicated that there were no gender differences in the activity counts of 7-year children. In 8-and 9-year groups boys were more active than girls.
3. Moderate-to-vigorous physical activity of rural schoolchildren was higher compared with urban children.
4. Health-related physical education classes were effective in promoting children's physical activity during lessons. The mean heart rate during intensified elementary school classes was 157.4 beats per minute.
5. The between-day reproducibility of accelerometer monitoring was higher between similar days of the week (weekdays or weekend days).
6. Short-term stability of physical activity during late childhood was moderate.
7. Developmental level of fundamental motor skills was related with skill-specific outside-school physical activity but not with general level of physical activity.

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SUMMARY IN ESTONIAN

Kehaline aktiivsus ja liigutusvilumuste väljakujunemine 7–11-aastastel lastel

Sissejuhatus

Laste ja noorukite kehaline aktiivsus on oluliseks teguriks tervisliku eluviisi ja harjumuste omandamisel ning säilitamisel täiskasvanueas. Kehaline aktiivsus on väga mitmekomponendiline, sisaldades nii igapäevast liikumist kui ka sihipärast sportlikku treeningut. Istuva iseloomuga vaba-aja veetmise tegevuste jõuline pealetung on aga viinud selleni, et laste ja eriti noorukite kehalise aktiivsuse tase on langemas (Kimm jt., 2002). Sellest tulenevad omakorda laste nõrk kehaline vormisolek, ülekaaluliste laste üha suurem osakaal ning terviseprobleemid. Lisaks kanduvad kehaliselt inaktiivsete tegevuste harjumused sageli lapseeast noorukiikka ning sealt edasi täiskasvanuikka (Malina, 2001). Käesolevas uuringus on laste kehalise aktiivsuse temaatikale lähenetud kompleksselt. Empiirilisi andmeid 7-11-aastaste laste kohta on kogutud nii vaba aja kontekstis kui ka kooli kehalise kasvatuse tundide raames. Lisaks on uuringus hinnatud laste kehalise aktiivsuse stabiilsust ning kehalise aktiivsuse seost põhiliigutusvilumuste omandamisega.

Uuringu eesmärk ja ülesanded

Käesoleva uuringu eesmärgiks oli hinnata laste kehalist aktiivsust vaba ajal ning kehalise kasvatuse tundides ning välja selgitada kehalise aktiivsuse lühiajaline stabiilsus ja seos põhiliigutusvilumuste omandamisega.
Uuringus püstitati järgmised ülesanded:

1. Hinnata algklasside õpilaste vaba-aja kehalist aktiivsust.
2. Hinnata kehalist aktiivsust tervisele-suunatud (intensiivistatud) kehalise kasvatuse tundides.
3. Hinnata kehalise aktiivsuse korratavust 1 nädala jooksul ning lühiajalist stabiilsust 2 aasta kestel.
4. Selgitada välja põhiliigutusvilumuste ja koolivälise kehalise aktiivsuse seosed.

Vaatlusalused ja metoodika

Uuringus osales kokku 194 7-11-aastast kooliõpilast kolmest Tartu linna ja ühest Tartumaa üldhariduskoolist. Mõõtmised viidi läbi ajavahemikus 1995-2004.a. Antropomeetrilistest parameetritest registreeriti keha pikkus ja keha mass ning 5 nahavoldi (biceps, triceps, subscapular, abdominal, säär) paksused.

I uuringus hinnati vaatlusaluste igapäevast kehalist aktiivsust vanemate 7 päeva raporti (Godin ja Shephard, 1986) ja Caltraci liikumissensori abil. Vanemad raporteerisid kirjalikult lapse kehalise aktiivsuse ühe nädala jooksul ning Caltraci abil registreeriti laste aktiivsus ühel nädalapäeval ja ühel nädalavahetuse päeval.

II uuringus registreeriti 51 algklassiõpilase südame löögisagedus pulsitestriga (Polar Electro OY) intensiivistatud kehalise kasvatuse tundides. Lisaks tunnieelsele südame löögisagedusele arvutati välja laste südame löögisagedus protsendina südame maksimaalsest löögisageduse reservist (alla 50%, üle 50%, üle 60% ja üle 75% südame maksimaalsest löögisageduse reservist).

III uuringus hinnati laste kehalist aktiivsust 2 nädalapäeva ning 2 nädalavahetuse päeva jooksul ja 2-aastase intervalliga. Laste kehalist aktiivsust registreeriti ajavahemikus 8.00-20.00.

IV uuringus kasutati laste kehalise aktiivsuse hindamiseks süstemaatilist vaatlust (O'Hara jt., 1989 metoodika modifikatsioon) ja Caltraci liikumissensorit. Põhiliigutusvilumuste arengut hinnati visuaalselt paigalt kaugushüppes ja hoota palliviskes, kasutades 4-arengustaadiumi skaalat (Haubenstricker ja Seefeldt, 1986).

Järeldused

1. Keskmise ja kõrge intensiivsusega kehaline aktiivsus (hinnatuna vanemate 7-päeva raporti alusel) on 7-9-aastastel poistel kõrgem kui tütarlastel.
2. Liikumissensori andmed näitavad, et soolisi erinevusi ei esine 7-aastaste laste grupis; küll aga on 8-9-aastased poisid kehaliselt aktiivsemad samaealistest tütarlastest.
3. Maapiirkondades elavate laste keskmise ja kõrge intensiivsusega kehaline aktiivsus on suurem võrreldes linnalastega.
4. Tervise edendamisele suunatud (intensiivistatud) kehalise kasvatuse tunnid kindlustavad algklasside õpilaste kõrge kehalise aktiivsuse tunnis, hinnatuna südame löögisageduse alusel. Õpilaste keskmine südame löögisagedus tundides on 157,4 lööki minutis.
5. Laste kehalise aktiivsuse korratavus on suurem sarnase iseloomuga nädalapäevadel (koolipäevadel ja nädalavahetuse päevadel).
6. Laste kehaline aktiivsus omab keskmist stabiilsust 2 aasta jooksul.
7. Põhiliigutusvilumuste omandamise tase on seotud vilumuste spetsiifilise mitte aga üldise laste kehalise aktiivsusega.

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- Jaak Raie, for help in collecting data

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Physical education, children physical activity and motor skill development

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2007 Rahvusvaheline kehalise kasvatuse õpetajate suvekursus, august, Haapsalu, Eesti

Peamised uurimisvaldkonnad

Kooli kehaline kasvatus, õpilaste kehaline aktiivsus ja põhiliigutusvilumuste areng

Kokkuvõte publikatsioonidest

Ilmunud on 4 artiklit rahvusvahelistes refereeritavates ajakirjades

DISSERTATIONES KINESIOLOGIAE UNIVERSITATIS TARTUENSIS

1. **Lennart Raudsepp.** Physical activity, somatic characteristics, fitness and motor skill development in prepubertal children. Tartu, 1996, 138 p.
2. **Vello Hein.** Joint mobility in trunk forward flexion: methods and evaluation. Tartu, 1998, 107 p.
3. **Leila Oja.** Physical development and school readiness of children in transition from preschool to school. Tartu, 2002, 147 p.
4. **Helena Gapeyeva.** Knee extensor muscle function after arthroscopic partial meniscectomy. Tartu, 2002, 113 p.
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