STUDIES IN SPORT, PHYSICAL EDUCATION AND HEALTH
238

Arto Laukkanen

Physical Activity and Motor Competence in 4-8-Year-Old Children

Results of a Family-Based Cluster-Randomized Controlled Physical Activity Trial

JYVÄSKYLÄN YLIOPISTO

STUDIES IN SPORT, PHYSICAL EDUCATION AND HEALTH 238

Arto Laukkanen

Physical Activity and Motor Competence in 4-8-Year-Old Children

Results of a Family-Based Cluster-Randomized Controlled Physical Activity Trial

Esitetään Jyväskylän yliopiston liikuntatieteellisen tiedekunnan suostumuksella
julkisesti tarkastettavaksi yliopiston Liikunnan salissa L304
huhtikuun 15. päivänä 2016 kello 12.

Academic dissertation to be publicly discussed, by permission of
the Faculty of Sport and Health Sciences of the University of Jyväskylä,
in building Liikunta, auditorium L304 on April 15, 2016 at 12 o'clock noon.

UNIVERSITY OF JYVÄSKYLÄ

JYVÄSKYLÄ 2016

Physical Activity and Motor Competence in 4-8-Year-Old Children

Results of a Family-Based Cluster-Randomized Controlled Physical Activity Trial

STUDIES IN SPORT, PHYSICAL EDUCATION AND HEALTH 238

Arto Laukkanen

Physical Activity and Motor Competence in 4-8-Year-Old Children

Results of a Family-Based Cluster-Randomized Controlled Physical Activity Trial

UNIVERSITY OF JYVÄSKYLÄ

JYVÄSKYLÄ 2016

Editors
Jarmo Liukkonen
Faculty of Sport and Health Sciences, University of Jyväskylä
Pekka Olsbo, Ville Korkiakangas
Publishing Unit, University Library of Jyväskylä

URN:ISBN:978-951-39-6583-9
ISBN 978-951-39-6583-9 (PDF)

ISBN 978-951-39-6582-2 (nid.)
ISSN 0356-1070

Jyväskylä University Printing House, Jyväskylä 2016

ABSTRACT

Laukkanen, Arto
Physical Activity and Motor Competence in 4-8-Year-Old Children: Results of a Family-Based Cluster-Randomized Controlled Physical Activity Trial
Jyväskylä: University of Jyväskylä, 2016, 172 p.
(Studies in Sport, Physical Education and Health
ISSN 0356-1070; 238)
ISBN 978-951-39-6582-2 (nid.)
ISBN 978-951-39-6583-9 (PDF)

This thesis addresses the following research questions: 1) what are the intensities of physical activities that are typically considered to develop motor competence in children, 2) how is accelerometer-derived physical activity (PA) associated with motor competence (MC), 3) what is the effect of family-based PA counseling on children's PA and MC, and 4) does initial parental support of a child's PA moderate the counseling effect on the child's PA? Participants consisted of a total of 126 apparently typically developing children aged 4 to 8 attending childcare or primary school. PA was measured with triaxial accelerometers, MC with the Körperkoordinationstest für Kinder (KTK) test (Kiphard & Schilling 2007) and a throw-and-catch a ball test (Numminen 1995), and parental support with a self-report questionnaire (Cleland et al. 2011). Correlations were calculated and effects of intervention on study outcomes were tested by means of a linear mixed-effects model fit by REML and by a Mann-Whitney *U* test with statistical software. As a result, typical indoor physical activities were found to cover the whole spectrum of PA intensities, from sedentary to vigorous. MC correlated with moderate-to-high neuromuscular impacts and PA of vigorous metabolic intensity in 7–8-year-old girls, with high impacts in 5–6-year-old girls, and with moderate impacts and light-to-vigorous PA in 5–6-year-old boys. Associations between high neuromuscular impacts with the MC in girls requires further research, as the finding is novel and may reveal this developmentally important relationship to differ between the sexes. In general, tailored counseling was found to decrease the moderate-to-vigorous PA in the intervention children in comparison to the control children. However, children's PA in the tertile of lowest initial parental support showed a significant positive intervention effect during the 6-month counseling period, although the change was not maintained at the 12-month follow-up. Counseling during an inactive season provided a significant effect on the development of children's KTK performance during the follow-up phase. In conclusion, because physical activities that are important for motor development contain a wide range of intensities, from sedentary to vigorous PA categories, there is a need to communicate (e.g. via PA guidelines) the developmental role of PA of different intensities. Considering the two methodological approaches used in this study, there is a need for more sophisticated objective PA assessment methods to differentiate real sedentary behavior from significant PA patterns inducing low accelerations. Regarding PA counseling, screening and counseling parents who provide low support for their children's PA could offer a feasible and efficient PA enhancement strategy in 4–7-year-old children. While a focus on motor development may serve to meaningfully supplement PA enhancement in children, initiation of PA counseling during the inactive season may induce a more sustainable effect on the development of MC.

Keywords: physical activity, motor skills, children, family, home, intervention

Author's address	Arto Laukkanen, M.Sc Department of Sport Sciences Isännäntie 2 A 5 40740 Jyväskylä, Finland arto.i.laukkanen@jyu.fi
Supervisors	Docent Arja Sääkslahti, PhD Department of Sport Sciences University of Jyväskylä, Finland Professor Taija Juutinen Finni, PhD Department of Biology of Physical Activity University of Jyväskylä, Finland
Reviewers	Associate Professor David F. Stodden, PhD Department of Physical Education and Athletic Training University of South Caroline, USA Senior Research Fellow Trina Hinkley, PhD Department of School of Exercise and Nutrition Sciences University of Deakin, Australia
Opponent	Professor Matthieu Lenoir, PhD Department of Movement and Sport Sciences University of Gent, Belgium

ACKNOWLEDGEMENTS

This study is based on the InPact project, which was led by Professor Taija Juutinen Finni from the Department of Biology of Physical Activity at the University of Jyväskylä. Thanks to Professor Finni, this project combined expertise across the disciplines of sport sciences. The main work described in this thesis was carried out in the Department of Biology of Physical Activity at the University of Jyväskylä during the years 2011–2013. The writing of the fourth research paper and this thesis was carried out in the Department of Sport Sciences at the University of Jyväskylä during the years 2014–2015. I am grateful for having this unique possibility to share the doctoral thesis process with people across the disciplines of sport sciences.

I am especially thankful to all the families, parents and children who participated in this study. Without you the behavioral sciences would not be able to succeed. I want to thank my supervisors, Arja Sääkslahti and Taija Juutinen Finni, for their bottomless will to help and mentor at any time needed. Arja, your pedagogical insight is widely known and I personally feel deeply honored to be supervised by you. Taija, your ambition and talent for science are boundless, and with those characteristics you pushed me countless times to excel myself – I am extremely thankful for that. Special thanks belong to Arto Pesola, who was one of the main figures of the InPact project. Arto, your broadmindedness changed my way to look at the world. I am really pleased to have had such a great work partner. I also wish to thank Piia Haakana and Kasimir Schildt for their significant contribution to the InPact process as recruiters, event organizers, data collectors and more. Thanks also go to Martti Melin and Aarni Kimmo for helping to collect data in the first sub-study of the thesis, to Marko Havu for designing the software for raw accelerometer signal processing, and to Risto Heikkinen and Kari Nissinen for acting as statistical experts in substudies III and IV of the thesis. Also, I am thankful for the reviewers', Trina Hinkley and David Stodden, for their valuable comments which helped me in finalizing the thesis.

I want to thank my own family – my wife Suvi, and our children Oona and Aapo – for their support along the way. Suvi, in addition to greatly respecting you as a wife and the mother of our children, I value your encouraging attitude toward my research and your willingness to be involved. You have had a very influential role in my career as an active conversationalist and, in many cases, as a final reviewer of my work. I want to thank Oona for keeping me grounded during these hectic years by asking me to play outside every single day. Finally, I would like to thank my parents, Marja and Seppo, and my brothers, Anssi and Janne, for enabling me to live a happy and healthy childhood, and for encouraging me to make independent choices in life.

Jyväskylä, 7 March 2016
Arto Laukkanen

LIST OF ORIGINAL PUBLICATIONS

The present thesis is based on the following original articles, which are referred to in the text by their Roman numerals:

I Laukkanen, A., Finni, T., Pesola, A. & Sääkslahti, A. 2013. Brisk physical activity ensures the development of fundamental motor skills in children – but light is also needed! *Liikunta & Tiede* 50 (6), 47–52.

II Laukkanen, A., Pesola, A., Havu, M., Sääkslahti, A. & Finni, T. 2014. Relationship between habitual physical activity and gross motor skills is multifaceted in 5–8-year-old children. *Scandinavian Journal of Medicine & Science in Sports* 24 (2), e102–e110.

III Laukkanen, A., Pesola, A.J., Heikkinen, R., Sääkslahti, A. & Finni, T. 2015. Family-based cluster randomized controlled trial enhancing physical activity and motor competence in 4–7-year-old children. *Plos One* 10(11), e0143987.

IV Laukkanen, A., Pesola, A.J., Finni, T. & Sääkslahti, A. 20XX. Parental support and objectively measured physical activity in children: a year-long cluster-randomized controlled trial. *Research Quarterly for Exercise and Sport* (submitted for publication).

CONTENTS

ABBREVIATIONS

APM, APM-Inventory
BMI, body mass index
HH, hopping for height
JS, jumping sideways
KTK, KörperkoordinationsTest für Kinder
MS, moving sideways
MC, motor competence
MVPA, moderate-to-vigorous physical activity
PA, physical activity
SCT, social cognitive theory
SES, socioeconomic status
TCB, throwing and catching a ball
TPB, theory of planned behavior
WB, walking backwards

1 INTRODUCTION

Physical activity (PA) enhancement is a topical issue in Western cultures. Two reasons can be seen for the topicality: One reason is that there is plentiful research evidence on the beneficial effects of PA on health on people of all ages (Booth, Roberts & Laye 2012, Eaton & Eaton 2003), as well as specifically on children and adolescents (Carson et al. 2015, Strong et al. 2005, Timmons et al. 2012). Another reason is that a substantial portion of people are stated to be insufficiently active to achieve the benefits (Pate et al. 2015, Spittaels et al. 2012), and lack of PA may impede, aside from health, some aspects of growth and development in children and adolescents (Nikander et al. 2010, Pellegrini & Smith 1998, Robinson et al. 2015).

The early stages of life have been seen as a timely moment to enhance PA in a population, as experiences, attitudes and habits affecting habitual PA are formed in childhood and tend to be moderately stable over the course of life (Cleland, Dwyer & Venn 2012, Telama et al. 2014, Thompson, Humbert & Mirwald 2003). On the other hand, PA is considered to play an important instrumental role, as many developmental phases are based on physically active play behavior (Pellegrini & Smith 1998) and PA is related to many developmentally important factors, such as adjustment to school (Pellegrini et al. 2002, Pellegrini et al. 2004). Therefore, there is a great need to understand mechanisms interacting with habitual PA, as well as a need to understand how early PA habit formation could be affected. This thesis aims to contribute to the understanding of PA enhancement in children by focusing on the methodological relationship between accelerometer-derived PA and motor competence, and the effect of family-based tailored PA intervention on children's PA and motor competence, as well as parental support of children's PA.

During the last 20 years, several doctoral theses in Finland in or with a close relationship with the department of Sport Sciences at the University of Jyväskylä have studied PA enhancement and its related factors in children and adolescents. To mention just a few of the works most closely related to the current thesis's focus and age group, Sinikka Holopainen (1990) examined the development of motor skills and its association with somatotype, biological age, interests in sport, and self-concept; Pirkko Numminen (1991) investigated the role of imagery in physical education with children in childcare; Anneli Pönkkö (1999) inspected the role of parents and teachers in the self-perception of childcare-aged children and most recently, Anne Soini (2015) examined the PA of 3-year-old preschool children. These studies have greatly contributed to the understanding of factors associated with PA behavior, motor skills and self-perceptions in Finnish children. Regarding PA intervention research, Arja Sääkslahti (2005) examined the effect of family-based PA intervention on PA and motor skills and the relationship between PA and coronary heart health in children, and Susanna Iivonen (2008) studied the association between an early physical education curriculum and fundamental motor skills. These doctoral dissertations have been important for understanding the strategies of PA enhancement in daycare and home-based contexts, as there is generally a lack of knowledge regarding feasible and cost-efficient ways to affect PA behavior and its related constructs in children (Davison et al. 2013b, O'Connor, Jago & Baranowski 2009, Riethmuller, Jones & Okely 2009, van Sluijs, Kriemler & McMinn 2011).

The current thesis aims, on one hand, to respect the national and international tradition of PA enhancement research in children by utilizing the acquired knowledge of PA and its related constructs and PA intervention strategies. On the other hand, the current thesis utilizes behavioral, biological and psychological approaches to bring new knowledge and a modern perspective on PA enhancement in children. Specifically, knowledge of biosciences is utilized for gaining an understanding of objective PA measurement in relation to motor competence in children. Knowledge of behavioral sciences and psychological theories establish a scientific basis for the family-based PA intervention. The results and perspectives of the thesis are discussed in relation to the research literature conducted in the field and possibilities of implementing the research findings on a practical level.

2 REVIEW OF THE LITERATURE

In the following sections, the scientific research literature relevant for the current thesis is reviewed. As it is important to understand the continuum of human behavior and its associated constructs, the literature is reviewed, when possible, for both children and adolescents. While early PA habits predict PA later in adolescence (Hearst et al. 2012), it is important to be aware of the age-related changes and challenges that arise in PA behavior and its related constructs as a result of aging. The first section provides justification for the current thesis by reviewing the literature that studies the role of PA in growth and development in childhood and adolescence. The factors best known to interact with PA behavior in children and adolescents are reviewed in the second section, as these are understood to build a basis for PA enhancement in these age groups. The interaction between PA and motor competence as a developmental mechanism is emphasized in that section, as it is one of the main topics investigated in the current thesis. In the fourth section, the perspectives for PA enhancement is reviewed, firstly, from the point of view of theoretical frameworks and, secondly, from the findings considering past interventions.

2.1 Role of physical activity in children's growth and development

Research evidence for PA as a stimulus for favorable growth and development is relatively young, but rapidly growing. PA has been conventionally defined as "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen, Powell & Christenson 1985). Physical inactivity, on the other hand, is usually defined as not meeting recommended levels of PA, while sedentary behavior means sitting and other waking behavior causing energy consumption of less than 1.5 metabolic equivalents (METs) (Tremblay et al. 2011). Regular PA has been linked with *biological*, *motor developmental*, *psychosocial, social-affective*, and most recently *cognitive* aspects of growth and development in childhood and adolescence. It is important to keep in mind, however, that the role of PA in growth and development should be interpreted with caution, since several genetic, nutritional and environmentally driven maturational processes affect the rate and quality of development. Development should thus always be understood as a result of complex interaction between genetics, environmental factors and individual behavior. Optimally, appropriate nutrition combined with a sufficient daily level of PA during the formative years may be expected to lead young people "to display healthy patterns of physical maturation consistent with their genetic potential" (Hills, King & Armstrong 2007).

The association between PA and biological health markers is among the best-known areas in the field of PA research in general. In essence, there is an evolutionary and genetic need for daily PA to maintain appropriate metabolic function (Chakravarthy & Booth 2004, Eaton & Eaton 2003) and to prevent diseases and death (Booth, Roberts & Laye 2012, Booth, Chakravarthy & Spangenburg 2002). As energy expenditure is, according to its definition, the cost of PA (Caspersen, Powell & Christenson 1985), cross-sectional studies have shown children with a higher level of PA and lower level of sedentariness having lower adiposity (i.e. fat in adipose tissue), compared to children with low levels of PA and high sedentariness (e.g. Berkey et al. 2000). An increase of PA has been shown to result in a decrease in total body and visceral adiposity, especially in overweight children and adolescents (Gutin et al. 2002, Owens et al. 1999), as more intensive and longer periods of PA are needed to produce similar effects in normal-weight children (Barbeau et al. 2003). Although there is little research in this area, an increase in PA and decrease in sedentary time have been shown to improve elements of metabolic syndrome (abdominal obesity, triglycerides, blood pressure, fasting glucose and high-density lipoprotein cholesterol level) both in obese and non-obese youth (Cliff et al. 2013, Strong et al. 2005). There is evidence, however, suggesting that a lack of PA may not be a primary mechanism determining weight gain in children, but rather that fatness may lead to inactivity (Metcalf et al. 2010, Wilks et al. 2011). While the association between PA and cardiometabolic health has been seen as a health priority especially from a preventive perspective, PA in childhood and youth can be seen critical for bone development. This is because PA seems to significantly affect bone strength at loaded sites in children but not in adults (Nikander et al. 2010), indicating a critical time window during which the skeletal system is especially responsive to PA and bone mineral mass and strength is acquired (Timmons et al. 2012).

There is no consistent evidence showing association between habitual PA and muscular strength or endurance in children and adolescents, although longitudinal observations seem to indicate a positive effect of PA on upper body muscular endurance in adolescents (Strong et al. 2005). However, a probably not so well-known fact is that children show consistent increases in strength without significant harm observed to health when participating in strength-training programs (e.g. Fukunaga, Funato & Ikegawa 1992, Payne et al. 1997, Sewall & Micheli 1986). Nevertheless, it has been recommended that special attention be paid to program design and implementation (Faigenbaum & Myer 2010). The increase in strength has been found not to be due to muscular hypertrophy, since muscle fiber size and type typically remain unchanged regardless of significant gains in strength (e.g. Fukunaga, Funato & Ikegawa 1992, Payne et al. 1997, Ramsay et al. 1990, Sewall & Micheli 1986). Similar to female adults, changes in strength have therefore been proposed to be mostly induced by changes in motor control and coordination (Ozmun, Mikesky & Surburg 1994, Ramsay et al. 1990). Therefore, an increase in strength in children during a moderate time interval can be seen mainly as an outcome of motor learning.

While motor learning is defined as "a set of processes associated with practice or experience leading to relatively permanent changes in the capability for movement" (Schmidt & Lee 2005), regular PA plays a crucial role on the outcome of motor learning (i.e. motor competence). A term "motor competence" refers to various terminologies that have been used in literature (i.e. motor proficiency, motor performance, fundamental movement/motor skills, motor ability, and motor coordination) to describe the actual competence for goal-directed movement (Robinson et al. 2015). Therefore, the term MC refers both to general motor coordinative capacities needed in every movement (e.g. fluency, efficiency, stability), as well as to specific motor skills (e.g. running, jumping, throwing). It is assumed that children acquire fundamental motor skills (walking, running, jumping, throwing, etc.) up to school age (7 to 8 years old), after which they are refined into game- and sport-specific skills. In essence, the basics of motor skills and motor competence are gained through daily PA during childhood (Gallahue & Ozmun 2002). Motor competence has been hypothesized to have an emergent relationship with PA during childhood, which again is hypothesized to have an influence on overall health in the long term (Robinson et al. 2015, Stodden et al. 2008).

Both objectively and subjectively measured PA have been shown to be positively associated with the level of motor competence in children (Fisher et al. 2005, Graf et al. 2004, Kambas et al. 2012, Sääkslahti et al. 1999, Williams et al. 2008, Wrotniak et al. 2006) and in adolescents (Jaakkola & Washington 2013), although there are some controversial findings as well (Cliff et al. 2009). Furthermore, there is some evidence suggesting that motor competence achieved in childhood may be a predictor of later PA (Barnett et al. 2008b, Jaakkola et al. 2015, Lloyd et al. 2014, Lopes et al. 2011), although some of the evidence shows only a little (Okely, Booth & Patterson 2001) or no likelihood of motor competence predicting PA (Bürgi et al. 2011, McKenzie et al. 2002). As the role of motor competence is likely multidimensional in the development of PA, motor competence has been found to mediate an increase in PA through perceived sports competence (Barnett et al. 2008a) and changes in PA and cardiorespiratory fitness in children (Cohen et al. 2015). Evidence shows consistent increases in motor competence in children and adolescents after skill- or coordination-targeted programs (Kalaja et al. 2012, Logan et al. 2011, Riethmuller, Jones & Okely 2009). Because research evidence favors a positive relationship between PA behavior and motor competence, efforts to increase PA participation and to decrease sedentary (Riethmuller, Jones & Okely 2009) behavior over the course of life have been recommended to be targeted towards children with low gross motor coordination (Smith, Fisher & Hamer 2015). This recommendation may partly be affected by a hypothesis that there is a critical threshold of motor competence above which individuals would have sufficient tools for participating in PA (Seefeldt 1980, Wrotniak et al. 2006). Yet, there is only little and indirect evidence for the assumption of a critical threshold of motor competence (Stodden et al. 2013).

Relatively recently there has arisen interest in the association of PA and psychosocial well-being. In general, psychosocial well-being has been seen as crucial for the positive development of all levels of youth (Park 2004). To date, there is very little research on young children in relation to psychosocial well-being, and evidence of the relationship is inconsistent. The paucity of evidence suggests, however, that PA is positively – and sedentary behavior inversely – associated with psychosocial well-being, namely hyperactivity or inattention and conduct problems, in young children (Hinkley et al. 2014). Interestingly, the results are inconsistent in relation to the PA measurement technique employed. The only study showing a positive dose-response relationship between PA and psychosocial factors has employed objective PA measurement techniques, while other studies showing either inverse or null associations have employed PA assessment techniques that are not objective. Only minimal differences have been found between genders in the association between PA and psychosocial well-being (Hinkley et al. 2014). An example of a successful approach for psychosocial well-being enhancement via PA is a randomized controlled trial conducted by Lobo & Winsler (2006). They found that an eight-week instructional program in creative dance and movement enhanced social competence in preschoolers from low-income families, compared to control peers. Parallel to the findings in young children, a small but significant overall effect on self-esteem and reduced depression and anxiety in relation to higher levels of PA has been summarized in reviews with older children and adolescents (from 3 to 18 years old) (Biddle & Asare 2011, Ekelund, Heian & Hagen 2005). An example of a possible mechanism of the effect of PA on mental health in older children is a study showing participation in developmentally appropriate team sports between ages 8 to 10, which has been shown to help to maintain health-related quality of life in girls especially (Vella et al. 2014). As an example of the other side of the phenomenon, in 10–15-year-old girls a small but significant negative correlation has been found between subjectively assessed free-time sedentary behavior and body image (Murdey et al. 2005). All in all, the limited body of existing evidence suggests that habitual PA, participation in sport club activities, or developmentally appropriate PA programs improve psychosocial well-being in children and adolescents, and on the other hand, excessive time spent in a sedentary way is inversely associated with psychosocial well-being in adolescents.

Regarding PA-related literature during recent years, along with more accurate and sophisticated research techniques, cognition research has offered probably one of the most influential areas of knowledge. Recent evidence suggests that PA is associated with cognition-related markers, such as executive functioning, learning and memory (Carson et al. 2015, Tomporowski, Lambourne & Okumura 2011). In addition to enhanced cognitive functioning, endurance types of exercise have been shown to accelerate hippocampal neurogenesis (i.e. new brain cell production) in rats. It has shown, however, that exercising itself does not guarantee the survival of the new brain cells (van Praag et al. 1999, van Praag 2009). Currently, a combination of exercise and mental training is proposed to be crucial, because mental challenges during exercise have been shown to increase the likelihood of the new brain cells' survival (Gould et al. 1999, Shors et al. 2012). Therefore, the optimal advantage in cognition has been hypothesized to be achieved via a combination of exercise and mental training, called the "enrichment paradigm" (Fabel et al. 2009). Interestingly, evidence reveals that complex motor skills – such as fine motor skills, a coordination of movement to rhythm, and sequenced movements – are associated with "higher-order cognitive skills" in pre-pubertal (under age 13) children (van der Fels et al. 2014). From experiments with rats, it is known that motor learning may serve as an optimal context for enhancing cognition, since endurance types of exercise combined with motor skill learning has been shown to enhance both neurogenesis and the survival of new brain cells (Curlik & Shors 2013).

A study by Hillman and his colleagues (2014) showed that a PA intervention that is very intensive in nature has the potential to result in gains in executive control and brain function in 7–9-year-old children. Before this study, similar results had been found with overweight children (Davis et al. 2011). The hypothesized mechanisms behind enhanced brain function in this kind of intensive PA intervention are increased blood flow in the brain, enhanced neurotransmitter function and increased production of new brain cells. Additionally, enhanced cognition via PA in children can also be explained by an age-related need for recess and breaks from mental demands. Furthermore, the mental engagement and challenges of typical games and play of children may serve an optimal combination of exercise and mental training for enhancing brain function. Also, PA naturally serves to provide children with many social-affective experiences and challenges, which may partly be connected to brain function. Therefore, the mechanisms of how PA enhances brain function are most likely complex and a combination of many interacting variables. As a conclusion, there is evidence for the hypothesis that regular exercise training with developmentally appropriate challenges alters both "body and mind" and, additionally, acute PA can help children to be patient and learn (Tomporowski, McCullick & Pesce 2015).

2.1.1 Sex and age differences in physical activity

Although a recent review stated child's sex to be inconsistently associated with PA in children from 2 to 6 years old (Li et al. 2015), male sex has rather consistently been found to be a consistent predictor of PA in children between 2 and 12

(Bauman et al. 2012, Hinkley et al. 2012, Sallis, Prochaska & Taylor 2000, Tucker 2008), as well as in adolescents between 13 and 18 (Sallis, Prochaska & Taylor 2000). In more depth, girls' and boys' physically active play and games have been observed to differ significantly, which may partly be associated with the PA differences between sexes. Through systematic observations, preschool-aged girls are known to have more PA of light intensity, such as nurturing or caring, and engaging in house or family types of dramatic play compared to boys, while boys tend to have PA of higher intensity, such as superhero play, pretend fighting, chase games and protect or rescue play (Storli & Sandseter 2015). Similarly, first grade aged boys are known to play more PA games than girls, especially chase and ball games, and a wider variety of PA games in general. As competence in physically active plays and games has been shown to predict boys' and girls' adjustment to first grade, there only exists evidence that it can forecast social competence in boys (Pellegrini et al. 2002). Physically active games also seem to be more popular and to become more complex among boys, compared to girls, in recesses during the first school year (Pellegrini et al. 2004). Furthermore, Seghers and his colleagues (2010) found that PA behavior and nutritional habits cluster differently in adolescent girls and boys. Approximately a quarter of 11- to 12-year-old boys were categorized into each of the clusters called "sporty media oriented mixed eaters," "academic healthy eaters," "inactive healthy eaters" and "inactive media-oriented unhealthy eaters." On the other hand, clusters of "sporty media-oriented mixed eaters" was underrepresented and "academic healthy eaters" overrepresented among adolescent girls. An explanation for the difference between the sexes in sports orientation may partly lie in the finding that girls are more likely to avoid vigorous and rough behavior, such as rough-and-tumble play behavior, already in early childhood. Socialization to boys' and girls' worlds may further reinforce these gender differences (Pellegrini & Smith 1998). Interestingly, it has been found that the level of PA changes especially in adolescent girls along with seasonal variation in Central-Northern Europe, while PA remains stable in similar aged boys (Gracia-Marco & Ortega 2013).

According to two reviews examining the correlates and determinants of children's PA, there seems to be no consistency in changes of PA along with age: several studies show an increasing trend in PA with age while others show an inverse trend and others no change at all (Hinkley et al. 2008, Li et al. 2015). Even though it is not clear whether the overall amount of PA changes with age, the quality of PA changes with growth and development. According to Pellegrini & Smith (1998), there are three developmental phases in PA during childhood: rhythmic stereotypies from the birth to 6 months of age, exercise play during preschool age, and rough-and-tumble play during the late preschool and early primary school years. Rhythmic stereotypies are characterized as movements without clear purpose or goal, exercise play as locomotor movements in the context of play, and rough-and-tumble play as vigorous behavior such as wrestling, which can seem aggressive in nature but is mostly playful and social. In sum, sex and age can be seen as important factors affecting PA behavior and how one interacts with the environment, and they should always be taken into consideration in PA research on children and adolescents.

2.1.2 Risks of physical inactivity and sedentary behavior

Even though there is a consensus on the benefits of regular PA and low levels of sedentary behavior in all ages, the risks of physical inactivity and excessive sedentary behavior for normal growth and development are not clear. Risks of inactivity and sedentariness cannot simply be seen as another side of the coin of the benefits of optimal PA for growth and development. Equal to malnutrition, extremes of PA are likely harmful for optimal growth and development (Hills, King & Armstrong 2007). However, growth and maturation generally continue regardless of limited PA (Malina 2000).

An example of the adaptability of human development is a classic study of the effect of swaddling practices upon the onset of walking among Hopi people (Dennis & Dennis 1940). It was found that even though the volitional movements of children were restrained to a minimum during the first year of life, because of a local swaddling tradition, it did not affect the onset of learning to walk (~15 months) compared to other local children with no such history of enchainment. It should be noted, however, that the babies were commonly carried by mothers during the swaddling period, and hence babies likely received versatile sensory information (e.g. visual, proprioceptic, vestibular, tactile). Scientific literature showing the effect of extremely minimal volitional physical activity on the growth and development in older children is not available. At this point it is important to note, however, that with age, changing developmental phases differ in nature, and a need for volitional PA changes dramatically with cognitive development (Piaget 1952). Essentially, PA plays a primitive instrumental role for growth and development in childhood. Physically active play (i.e. PA in children) is the main way of learning and exploring the environment during childhood. Moreover, different forms of physically active play occur at specific periods of age, serving physical, cognitive and social developmental functions. From a developmental point of view, the risk may therefore be related to neglect of physically active play typical of age and developmental level (Pellegrini & Smith 1998).

The growing body of literature shows that along with low levels of PA, metabolic and cardiovascular health risks are beginning to cluster (i.e. accumulate) already in childhood (Go et al. 2013). While being overweight and obesity are known to be a major contributor to health risks, it is especially sedentary behavior and its related habits (e.g. snacking) that seem to significantly cause weight gain in children. On the other hand, being overweight seems to lead to inactivity in youth (Hills, King & Armstrong 2007, Metcalf et al. 2010). Importantly, high levels of both PA and sedentary behavior (e.g. computer gaming, TV viewing) may coexist, complicating the separate mechanisms affecting these behaviors (Seghers & Rutten 2010). Physical inactivity and a decrease of PA may not, therefore, offer the sole explanation for an increase of excess weight and related health risks in Western people.

From a biological point of view, bone development probably offers the most compelling evidence of the crucial need for PA in childhood and adolescence. That's because childhood and adolescence are known to form a critical time window for enhancing bone mass, structure and strength, which all ultimately affect the onset of osteoporosis later in life (Nikander et al. 2010). However, even in bone research there is a lack of knowledge about the critical threshold of the minimum dose of PA sufficient for optimal bone development in childhood and adolescence (Nikander et al. 2010). The same issue concerns general PA recommendations; it is impossible to define an absolute threshold for the sufficient dose of PA for growth and development in children and adolescents (Twisk 2001). Similarly, although a low level of PA is known to be associated with lower motor competence (Lopes et al. 2011), for example, weaker academic achievement (Syväoja et al. 2013), lower psychosocial well-being (Hinkley et al. 2014), and lower adjustment to school (Pellegrini et al. 2004), evidence does not support the assumption that inactivity or excessive sedentary behavior alone would endanger growth and development in children and adolescents. As PA and sedentary behavior interact with these developmentally important factors, inactivity and excessive sedentary behavior may rather indirectly affect a clustering of risk factors threatening optimal health, growth and development.

2.2 Factors interacting with physical activity

Environmental factors strongly interact with habitual PA. Recent studies have shown that environment is especially important in childhood, since genetics may explain less of the variance in PA compared to what has been learnt from studies conducted in adults. Fisher and her colleagues (2015) collected data from twin studies in which PA was measured objectively in children, thereby avoiding the biases that might affect parent-reported PA in children. Environment was found to have a strong influence on PA in childhood (~60% of variance explained), while a smaller amount of variance was explained by genetics (~21%). In contrast, genetics have explained variance of PA from 30% to 65% in adults (Bauman et al. 2012). Interestingly, substantially higher genetic influence (~45%) was found in studies examining PA in children over the short term in a laboratory environment without parental direction (Saudino 2009, Wood et al. 2007). Taken together, these findings suggest that real life environment has a strong influence on PA in children (Fisher et al. 2015).

When it comes to the interaction between environment and PA behavior in individuals, macro-level variables (such as community-level policies) have been noted in many health-related ecological models (Sallis, Owen & Fisher 2008). Briefly, policies and environmental support have been stated, for example, to explain high levels of cycling in Germany, Denmark, and the Netherlands (Pucher & Buehler 2008). On the other hand, a substantial increase of sedentary occupations has likely contributed to total physical activity declines in most Western countries (Church et al. 2011). Interventions to change social norms via media may also have an effect on physical activity (Bauman & Chau 2009). Macro-level interventions covering large parts of the population may thus have great potential to influence individual PA, although it is difficult to show the effects in terms of scientific standards (Bauman et al. 2012).

In the following sections, the correlates and determinants of PA in children are reviewed more closely from the perspectives of physical and psychosocial environments, as these are the most researched domains of environmental effects on PA. Moreover, developmental mechanisms are known to interact with PA in children. The role of motor competence (MC) as one developmental mechanism will be specifically inspected in this relation since it is one of the main outcomes of the present thesis and MC has been suggested to significantly interact with PA, and thus affect overall health longitudinally (Robinson et al. 2015, Stodden et al. 2008).

2.2.1 Physical environment

PA correlates to physical environment can be categorized as built and natural (Bauman et al. 2012). Based on a review of 103 papers (Ding et al. 2011), significant variables of built environment in relation to PA in children consist of access or proximity to recreation facilities, land-use mix (proximity of homes and destinations such as shops), and residential density. Moreover, walkability, traffic speed and traffic volume are typically associated inversely with PA in studies examining PA behavior in children. All of the significant correlates of PA in children related to the built environment are thus somehow associated with transportation itself or transportation to recreational facilities. In the same review, only land-use mix and residential density were consistent correlates of PA in adolescents. However, it is noteworthy that the results of studies differ greatly, depending on whether PA and environmental characteristics were assessed by means of subjective or objective techniques. As a result, there is no consistent correlate of built environment with PA across all the combinations of measurement techniques in children or adolescents (Ding et al. 2011).

There is relatively consistent evidence showing that PA is associated with a built school environment (e.g. Ferreira et al. 2007, Haug, Torsheim & Samdal 2008, Martin-Diener et al. 2013), and evidence suggesting correlations with an environment with diverse play equipment compared to an environment without equipment (Brown et al. 2009, Farley et al. 2008). Interestingly, it has been suggested that having fewer children per square meter in daycare environments positively correlates with directly observed PA in children during unstructured outdoor periods (Brown et al. 2009, Nicaise, Kahan & Sallis 2011), as well as with accelerometer-derived PA during preschool PE lessons (Van Cauwenberghe et al. 2012).

An experiment of bringing natural elements to preschool environment has been found to contribute to more complex play narratives in children (Kuh, Ponte & Chau 2013). In general, children have been found to favor, when available, natural environments for free play in daycare centers (Dyment & O'Connell 2013). A quasi-experimental study with Norwegian children showed that fitness and motor proficiency improved significantly more in 5–7-year-old children who played daily in a natural environment, compared to comparable peers participating in regular outdoor activities in a childcare center (Fjortoft 2004). In addition, Fjortoft & Gundersen (2007) have stated natural environments to offer an essential context for motor practicing in children. Kyttä (2004) has suggested a theoretical model for a child-friendly environment. Accordingly, an ideal environment consists of two fundamentals: a high degree of independent mobility and a high number of actualized affordances. This kind of ideal environment is called "Bullerby," referring to a rural village with boundless freedom to move about in and an infinite number of stimuli for children to explore. It has been suggested that standardized playgrounds offer an appropriate framework for PA and skill development in children aged 2 to 5 years old, but afterwards these kinds of built environments do not provide sufficient affordances and challenges for the age and developmental level (Frost et al. 2004, Frost & Woods 2006).

Furthermore, seasonal changes and type of weather have been shown to be associated with PA in children and adolescents. Typically, extreme temperatures, either extremely hot or cold, and bad weather have been associated with lower PA rates (Carson & Spence 2010, Li et al. 2015). In terms of weather, especially precipitation has shown the largest correlation with PA in the population in general, with the exception of snow, which is linked to greater PA rates in men (Chan & Ryan 2009). The development of fitness has been shown to run parallel with the seasonal variation in PA in children (Augste & Künzell 2014). In summary, although natural environment seems to have a potential to affect habitual PA in children, generally there is a lack of high-quality studies conducted under controlled conditions to investigate the effect of natural environment on the amount and quality of PA in children.

2.2.2 Psychosocial environment

Behavioral theories have commonly assumed that family context has the greatest influence on human behavior during early childhood and that the most influential social interactions are gradually replaced by peers and friends (Bandura 1986, Buhrmester & Furman 1987). This has been assumed to also be the case regarding PA habit formation (Duncan, Duncan & Strycker 2005).

When beginning from the family context, parental support has been found to explain a substantial part of PA in children (Beets, Cardinal & Alderman 2010, Cleland et al. 2011, Edwardson & Gorely 2010, Kahn et al. 2008, Loprinzi & Trost 2010, Pugliese & Tinsley 2007, Rhodes et al. 2013, Yao & Rhodes 2015). There is also some evidence that parental support may also be a predictor of PA when moved from childhood to adolescence (Pugliese & Tinsley 2007). Parental support can be seen to consist of specific parental behaviors, such as how often the parent participates in PA with the child, how often the family does physical activities together, how often the parent provides direct or indirect support for the child's participation in PA, and how often the parent praises the child for participating in PA (Cleland et al. 2011). It is important to note that only parental encouragement for PA has alone shown a considerable effect on a child's PA, while a combination of support behaviors (as itemized above) has been shown to have a real effect on children's PA. Moreover, parental support has been found to be, irrespective of parental gender, an important indicator of PA in both boys and girls (Yao & Rhodes 2015). Finally, it is worth mentioning that a significant percentage of studies examining PA parenting have used measurements with indeterminate validity and reliability, as well as low quality of reporting study design, characteristics and results, leaving a lot of room for improvement in future investigations (Trost, McDonald & Cohen 2013, Yao & Rhodes 2015).

Interestingly, the level of parental PA has been shown to have only marginal association with the level of PA in a child. Meta-analyses conducted by Pugliese & Tinsley (2007), as well as Yao & Rhodes (2015), showed a small overall association between parental and child PA. For example, a 13-year longitudinal study with repeated measurements and multiple assessments of PA has shown no evidence of a causal relationship between mothers' and children's PA (Iannotti et al. 2005). However, there are some indications for a stronger relationship between fathers' and sons' PA (Gustafson & Rhodes 2006, Van et al. 2007, Yao & Rhodes 2015) and physically active parents tending to more often provide support for their children (Dowda et al. 2011). Besides, an intervention for decreasing overweight in fathers and increasing PA in their sons was found to be successful (Morgan et al. 2011). Regardless of the relatively weak association found in general between parents' and children's PA levels, studies have shown that sedentary behavior may be more strongly associated between family members (Jago et al. 2010), while activities performed together as a family are typically sedentary in nature (Thompson et al. 2010). Taken together, leisure-time PA, especially weekends, has been found to be the time window in which PA decreases significantly with age, so that the promotion of parental support of PA has been proposed to be a health priority (Corder et al. 2013). It is noteworthy that dog ownership may be a feasible way to promote PA in children and their parents, as cross-sectional investigations show significantly higher PA levels in families with dogs (Salmon et al. 2010).

The role of family socioeconomic status (SES) is a variable typically taken into consideration when PA behavior in children is researched. Low SES families are found to provide less PA and more sedentary behavior opportunities for children when compared to high SES families (Tandon et al. 2012). There are found also better access for organized PA and equipment in high SES families than in lower SES families (Cools et al. 2009). Even though there evidently exists some differences in family PA environments dependent to SES, systematic reviews have not shown differences in children's measured PA nor sedentary behavior in relation to the level of family SES (De Craemer et al. 2012, Hinkley et al. 2008, Tandon et al. 2012). As this is the case in high income countries, in countries with generally low and middle incomes there are found, however, systematic differences in children's measured PA regarding the level of family

SES (Bauman et al. 2012). It is important to note that the costs of PA participation tend to increase when a child becomes older and thus the role of family SES may change along the child's age (Tandon et al. 2012).

As a substantial proportion of children are enrolled in childcare in their early years (OECD family database 2010), childcare centers have been found to be a significant predictor of PA in children (Finn, Johannsen & Specker 2002). There is relatively little literature on the interaction of psychosocial childcare environments and children's PA, but there are some suggestive findings. Brown and his colleagues (2009) found that during outdoor play periods when children are most likely to be physically active, some contextual and social circumstances better predict their physical activity. They itemized sufficient open space for playing to be positively associated with PA in preschoolers, while the presence of adults was negatively associated with PA. Parallel to the latter finding, Reunamo and his colleagues (2014) found that the greater the distance between an early educator and a child, the higher the mean PA in the children attending a childcare center. Moreover, a greater proportion of time spent at high PA intensity was observed during free play outdoors when the time was spent under rule play, role play or imaginary play, and when PA was not allowed. On the other hand, early educators have rarely been found arranging activities to enhance children's PA or to encourage children's PA, and therefore the presence of adults is often not involved in children's physical activities but rather for supervision (Brown et al. 2009). The finding of relatively little encouragement for PA provided by adults in childcare centers is supported by earlier observational findings (Pate et al. 2004, Soini et al. 2014). On the other hand, when early educators have been observed to arrange physical activities and games outdoors or to prompt for PA, it has been shown to result in a relatively high proportion of time spent by children at a MVPA level (Brown et al. 2009, Soini et al. 2014). Interestingly, kindergarten teachers' prompting has been shown to be significantly more associated with children's PA during an active season, compared to prompting made during an inactive season (Jämsen et al. 2013).

Probably one of the most researched psychosocial environmental correlates for PA in children and adolescents relates to the school context (Haerens et al. 2008, Robertson-Wilson, Lévesque & Holden 2007, Sallis, Prochaska & Taylor 2000, Sallis & Owen 1999, Whitehead & Corbin 1997). Studies have shown that school teachers can enhance students' intrinsic motivation for PA and their perceived athletic competence if PA goals are supported and positive feedback is provided under a stimulating and supportive school class environment (Decorby et al. 2005, Koka & Hein 2003). Exposure to a mastery motivational climate (i.e. task-oriented climate) during physical education lessons has been found to positively affect health, fitness and skill- related outcomes, as well as affective and cognitive outcomes in children and adolescents (Braithwaite, Spray & Warburton 2011). While approximately 30% of the variance in students' learning has been estimated to be explained by teacher characteristics (Hattie 2003), there is some suggestive evidence for similar psychosocial mechanisms in physical education (Chen & Zhu 2005). Furthermore, Eather and her colleagues (2013) have shown that social support from teachers mediated PA behavior change in children around 10 years old participating in the Fit-4-Fun intervention.

While peers and friends are supposed to have an influence on PA behavior in children, and in adolescents especially, evidence for the statement is strongest from cross-sectional examinations (e.g. de la Haye et al. 2011, Duncan, Duncan & Strycker 2005, Fitzgerald, Fitzgerald & Aherne 2012, Sallis et al. 2002, Salvy et al. 2007, Van et al. 2007), while limited longitudinal evidence exists (Lopes, Gabbard & Rodrigues 2015, Lubans, Sylva & Morgan 2007). General social support of PA has more evidence for being a determinant of PA in adolescence (Craggs et al. 2011), although these findings are inconsistent (Bauman et al. 2012). Although there seems to be some evidence for an association between peer support and PA in children and adolescents, evidence for peer or friend support as a mediating factor for PA change is lacking (Dzewaltowski et al. 2009, Lubans & Sylva 2009). Moreover, Prochaska and his colleagues (2002) found that peer support was associated with subjectively assessed PA in adolescents, but not with objectively assessed PA. In the study of de la Haye et al. (2011), adolescents with a similar level of subjectively assessed PA and sedentary behavior were found to be more likely peers. Moreover, best friend dyads are found to be exhibit close association with PA levels and sedentary behavior in adolescents (Lopes, Gabbard & Rodrigues 2015). Until now, there has been a lack of randomized controlled trials aimed at enhancing PA in children and adolescents by affecting peer support-related factors.

In summary, the interaction between socio-psychological environmental factors and PA in children and adolescents has been researched mostly from the point of view of familial constructs and the most immediate social networks, as well as from the most evident institutional constructs (e.g. childcare centers and schools). Although on the whole the environment has been shown to account for over half of the variance in objectively measured PA in children (Fisher et al. 2015), relatively few physical and psychosocial environmental factors determining PA behavior in children have been found with high consistency across studies. A small number of consistent correlates and determinants in relation to PA in children underlines the complex nature of human behavior and the interaction between environments in which behavior is dynamically steered. On the other hand, this also underscores the great number of confounding variables faced by the behavioral sciences aiming to model PA behavior and PA behavior change trajectories. Lastly, authors who have conducted reviews and meta-analysis seeking to find correlates and determinants of PA behavior in youth have systematically reported a lack of quality across the studies, which has made it difficult to find consistent environmental determinants for PA behavior in these age groups.

2.2.3 Developmental mechanisms

While PA behavior is steered by a close interaction with environmental stimuli, the role of developmental mechanisms deserves considerable attention in this regard. This area is important, since childhood and adolescence have been acknowledged as periods of life marked by rapid growth and developmental changes (Malina, Bouchard & Bar-Or 2004). According to Piaget's (1952) definition, the stage of development in children aged between 2 and 7 can be characterized as "preoperational." Since the work of Piaget, the role of physically active play has been seen as crucial for this developmental stage (Pellegrini & Smith 1998). In alignment with the focus of the current thesis, the motor developmental mechanisms and mechanisms related to motor competence (MC) affecting PA behavior are detailed in the following sections.

A major constraint on the development of motor competence is ongoing neuromuscular development. Neuromuscular development refers to the "maturation of both neural and muscular systems and includes their integration." (Kellis & Hatzitaki 2012.) Neuromuscular efficiency is expressed as greater force production (strength) which, along with other domains of growth and maturation, can be seen as an essential prerequisite for motor skill acquisition (Haywood & Getchell 2009). The other way around, an increase in strength can be seen mainly as an outcome of motor learning in children (Ozmun, Mikesky & Surburg 1994, Ramsay et al. 1990). The tendency to perform activities inducing high neuromuscular impacts (i.e. forces) is assumed to significantly support the development of gross motor competence, and the lack of capacity to perform movements with high neuromuscular impacts is assumed to mediate the lack of motor competence (Payne & Isaacs 2008). On the other hand, the limited capacity to move vigorously and to perform movements with high neuromuscular impacts may be caused by the lack of motor competence. This assumption is supported by a study (Chia et al. 2010) indicating the proficiency of gross motor skills to enable one to move with more ease and for longer durations at a time because of lower perceived exertion of PA.

As neuromuscular development can be seen as crucially interacting with motor development, the level of MC can be seen to play a crucial role in the interaction with PA habit formation during the childhood. Stodden and his colleagues (2008) have presented a theoretical model of the developmental mechanisms influencing level of PA (Figure 1). According to this model, PA has an influence on the development of motor competence during early childhood, after which the level of motor competence begins to steer PA behavior during mid- and late childhood. The relationship is seen as emergent in nature; one hypothesis is that the relationship of MC and PA is strengthened during the transition from early childhood to mid- and late childhood. Based on the model, the emergent relationship between MC and PA is accompanied by an interrelationship of perceived motor competence and health-related fitness. In addition to the direct relationship between all of these four factors, perceived motor competence and health-related fitness are suspected to mediate the relationship between MC and PA. Altogether, the interaction between MC, PA, perceived motor competence and health-related fitness are hypothesized to affect the risk of being overweight and obesity, which again is hypothesized to feed back to the developmental mechanisms.

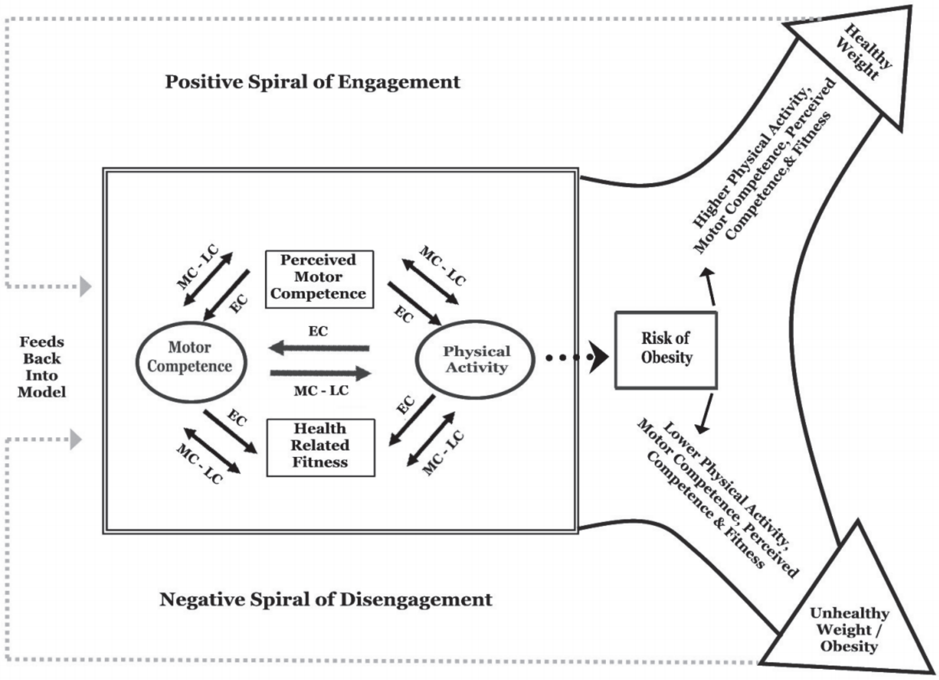


FIGURE 1 Developmental mechanisms influencing physical activity trajectories of children. Reprinted from Stodden et al. (2008, 294) with permission from Taylor & Francis LLC (http://www.tandfonline.com).

Evidence considering MC and its effect on positive developmental trajectories to health has recently been updated (Robinson et al. 2015). The current evidence supports a relatively consistent relationship between MC and PA, MC and health-related fitness, and PA and perceived competence, while the association between MC and perceived competence is stated to be variable. The mediating role of perceived competence and health-related fitness is declared to be too little investigated until now to make any conclusion of the magnitude. Additionally, there appears to be strong evidence for an inverse association between MC and weight level, which suggests that MC plays an important role in weight management during childhood and adolescence. The role of MC as a developmental mechanism is highlighted from two perspectives: competence plays a crucial psychological role for PA engagement (via social interaction and acceptance, for example) and, on the other hand, for the concrete ability to take part in physical activities typical of age and developmental level (Robinson et al. 2015).

Tracking can be seen as a kind of developmental mechanism having a close interaction with PA behavior at different ages. As the level of PA has been shown to track moderately from childhood into adulthood (Basterfield et al. 2014, Cleland, Dwyer & Venn 2012, Telama et al. 2014), the tracking of PA behavior seems to be relatively strong during childhood (Pate et al. 1996, Telama et al. 2014). To complement the phenomenon of tracking, recent evidence suggests that sedentary behavior tracks at least as strongly, or even more strongly, than PA during childhood (Hirvensalo & Lintunen 2011, Jones et al. 2013). Additionally, there is relatively strong evidence for the tracking of MC during childhood and between childhood and adolescence (Barnett et al. 2010, Vandorpe et al. 2012) and adulthood (Lloyd et al. 2014), as intervention-induced improvement in MC may be moderately maintained (Zask et al. 2012). In addition to the tracking nature of MC, preliminary evidence shows that a skill-related training background is associated with more efficient motor learning-related adaptations in the brain, possibly caused by greater neural plasticity in the task-specific areas of the motor cortex (Kumpulainen et al. 2014). It is also known that childhood PA experiences affect adult PA perceptions and behavior, while negative PA experiences (for instance, lack of support from one's immediate development environment) are associated with inactivity in adulthood (Thompson, Humbert & Mirwald 2003). Tracking of PA may be partially explained by the early formation of perceived PA self-efficacy, relating to the feeling of how confidently one perceives his or her competence for participating in PA, as self-efficacy has shown to be a consistent correlate and predictor of PA behavior in childhood and adolescence (Bauman et al. 2012).

All told, PA behavior can be seen as strongly tied with the developmental mechanisms. However, the development of MC along with the close interaction with the other related developmental mechanisms can be seen as forming a relevant framework for understanding PA behavior and its relatively strong tracking nature. More importantly, it has to be understood that developmental mechanisms interacting with PA affect tracking, but also the other way around, PA tracking affects the developmental mechanisms that interact with PA behavior. Also, developmental mechanisms are likely steered by genetics and environmental factors, as well as PA behavior itself. Developmental mechanisms should therefore be understood as inseparable part of PA behavior.

2.3 Physical activity measurement

There are several types of features and outcomes that can be measured and assessed from PA: biological, physiological, biomechanical, psychosocial, cognitive, etc. When it comes to the outcomes of PA, several characteristics differentiating children from adults make a crucial difference in PA assessment. For example, children have a limited tolerance for vigorous PA, which is shown in an intermittent nature of PA (Bailey et al. 1995, Baquet et al. 2007). Moreover, children typically show poorer economy and efficiency of movement, which results in a quicker onset of fatigue, need for frequent rest, and less interest shown in continuous PA (Welk, Corbin & Dale 2000). These characteristics may partly be explained by the developing state of motor coordination (Chia, Guelfi & Licari 2010). Children also tend to have more concrete, and less abstract, thought processes, which tends to result in a relatively brief attention span for any given task. On the other hand, children tend to have curiosity and desire for pursuing new tasks, which tends to result in interest in exploring new activities (Welk, Corbin & Dale 2000). Moreover, the nature of PA changes along with developmental changes (biological, psychosocial, cognitive) during childhood, for instance, in terms of play behavior (Dwyer, Baur & Hardy 2009).

Characteristics of PA in children set certain challenges and demands for the selection of measurement methods. PA measurement methods can be categorized as subjective and objective (e.g. Sirard & Pate 2001) or indirect versus direct measures (e.g. Adamo et al. 2009). In the following sections, the strengths and limitations of the most common PA measures used in the child population have been reviewed. However, objective PA measurement methods, especially accelerometers, are emphasized since objective PA monitoring using accelerometers is the primary method used in the original papers of this thesis.

2.3.1 Self-reporting

Self-reporting instruments (e.g. questionnaires, diaries) are traditionally used for assessing PA levels in children (Oliver, Schofield & Kolt 2007, Welk, Corbin & Dale 2000). However, several concerns have been raised about the accuracy of self-reporting assessments in children, as they have typically shown an overestimation of PA compared to direct observation and objective motion sensors or heart-rate monitors. It is also typical for PA that is intermittent in nature (including short spurts of activity) not to be recalled accurately (Adamo et al. 2009). Crucially, children may lack the cognitive skills required for recalling PA levels and intensities performed, and the issue is all the more relevant the younger the child (Durante & Answorth 1996). Therefore, responsibility for fulfilling PA questionnaires or diaries has typically fallen on a parent or teacher of a child (Oliver, Schofield & Kolt 2007). After all, no self-reporting measure has yet been developed and carefully assessed for accuracy in children. However, the strengths of the self-reporting technique are cost-effectiveness when conducted in large populations and the possibility to achieve contextual information of PA (Oliver, Schofield & Kolt 2007).

2.3.2 Direct observation techniques

Direct observation of behavior has been shown to be a highly valuable technique in studies examining the level and pattern of PA in children (Oliver, Schofield & Kolt 2007, Sirard & Pate 2001). Direct observation has also been considered as a “criterion” measurement for PA in children because it is comprehensive in nature (Sirard & Pate 2001). Typically, two trained observer(s) record PA behavior of a child by coding different kinds of activities during a set period of time. Typically PA behavior is observed for 15 seconds and coding of the PA is performed during the following 45 seconds. The total length of direct observation may vary from 30 minutes to the entire day (Pate, O'Neill & Mitchell 2010). Albeit the evident strengths of direct observation of PA behavior, drawbacks include high experimenter burden and the potential reactivity of the study participant. It can be also question whether the direct observation technique is able to capture sudden and short-term patterns of PA, which may play an important role in the study of the health outcomes of PA (Sirard & Pate 2001).

2.3.3 Heart rate and pedometer techniques

Heart rate monitoring provides an objective estimate of PA. It has been used in both adults and children for measuring energy expenditure, as it relies on the linear relationship between heart rate and oxygen consumption (VO_2) (e.g. Sirard & Pate 2001). The weaknesses of heart rate monitoring include its inaccuracy to separate energy expenditure induced by light physical activities from the changes of heart rate induced by, for instance, emotional stress, body position and digestion (McArdle, Katch & Katch 2001). Additionally, it is known that there are great individual differences in exercise responses in terms of heart rate (Tang et al. 2002). Therefore, heart rate monitoring has neither been recommended as a "criterion" measurement of PA nor as a tool for estimating the amount and intensity of PA in children (Oliver, Schofield & Kolt 2007).

Pedometers can also be seen as providing an objective measurement of PA. Pedometers use mechanical motion sensors that count steps taken during normal daily life and provide an estimate of total volume or duration of PA (Oliver et al. 2007, Sallis & Saelens 2000). Modern pedometers are small-sized, mounted on the hip, ankle, or wrist, and are also convenient to use with children. Pedometers have been recommended for general assessments of accumulated PA in children, rather than for research purposes, because there are limitations in quantifying PA that is light in nature and pedometers do not offer information about the type or intensity of PA (Oliver et al. 2007).

2.3.4 Accelerometer technique

The use of accelerometers in relation to PA and children has rapidly increased during the last years. A simple Google scholar search with the keywords "physical activity" AND children AND accelerometer shows an increased proportion of publications compared to publications in relation to search results by "physical activity" AND children since 1990 (Figure 2). The increased popularity of accelerometers may lie in the objectivity of devices and possibilities for quantifying PA more precisely. Accelerometers measure movement of the human body directly and in real time, which is important when the relationship between PA and health-related outcomes is under investigation (Rowlands 2007). Importantly, the devices are small, unobtrusive and easy to use. Accelerometers are typically able to quantify PA behavior in terms of volume, duration and intensity (Freedson, Pober & Janz 2005).

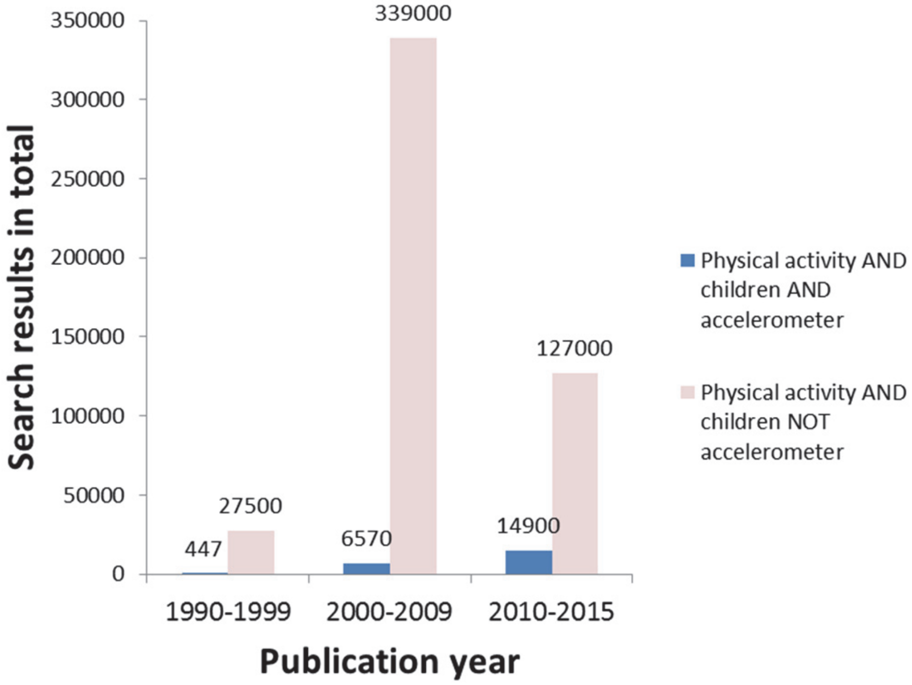


FIGURE 2 Google scholar search results by "physical activity" AND children AND accelerometer compared to search results by "physical activity" AND children and NOT accelerometer from a year 1990 to the present.

In general, there is consistent evidence showing a strong correlation between accelerometer output and PA in children (Pate, O'Neill & Mitchell 2010, Reilly et al. 2003, e.g. Rowlands 2007, Sirard et al. 2005, van Cauwenberghe et al. 2011). Moreover, accelerometers are consistently acknowledged to be feasible and reliable tools for measuring PA in children (e.g. Cliff, Reilly & Okely 2009, Pate, O'Neill & Mitchell 2010, Rowlands 2007).

There are health-, growth- and development-related interests for differentiating between sedentary, light, moderate and vigorous intensities of PA, and therefore several validation studies have been performed for defining unambiguous categories for different intensities of accelerometer-derived PA (Kim, Beets & Welk 2012). The most commonly used method for establishing intensity categories has been to create a link between typical accelerometer output, called "counts," and PA intensity. Activity counts are recorded into the internal memory of accelerometers and are based on the frequency and intensity of PA (Chen & Bassett 2005). By averaging the accumulated counts over a given time interval of PA, it is possible to define cut-off points for a different amount of counts (Kim, Beets & Welk 2012).

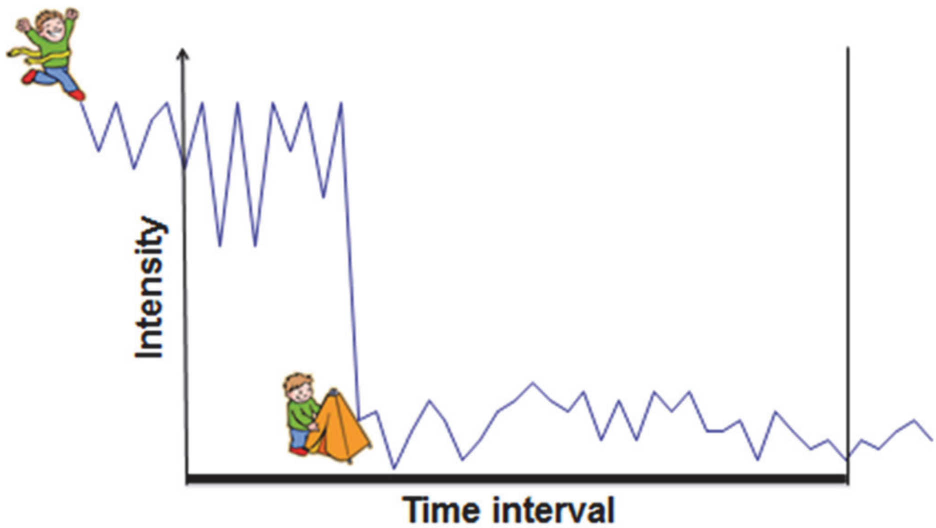


FIGURE 3 A theoretical example of accelerometer output over an undefined time interval.

Although there are fundamental advantages of using accelerometers when assessing PA objectively in children, there are several issues that can affect the way in which accumulated counts are analyzed. It is not possible to monitor certain physical activities (e.g. many devices are not suitable for monitoring water activities, in biking the accelerations do not accurately correlate to the muscle work needed in that sport, swinging and skateboarding may induce similar accelerations although those activities likely differ in physical demands) (Freedson, Pober & Janz 2005). Additionally, the selected time interval, often called "epoch time," can make a difference on the accuracy of assessment (Figure 3). As the PA in children is known to be intermittent and transitory in nature (Baquet et al. 2007) and about 95% of physical activities last less than 15 seconds (Bailey et al. 1995), averaging counts over a long time interval may disguise the variability that is natural in children's PA (Bornstein et al. 2011). In the theoretical example in Figure 3, a time interval containing vigorous, light and sedentary PA may be averaged as moderate intensity of PA. Therefore, the shorter the epoch time, the more accurate the analysis of the intensity of PA. Moreover, children tend to show some reactive behavior when using accelerometers (Dössegger et al. 2014, Foley, Beets & Cardinal 2011), though the evidence is inconsistent (Ozdoba, Corbin & Le Masurier 2004, Rowe et al. 2004). The possible reactivity of motion sensors typically means increased activity during the first day of wearing, after which being enamored with the new device begins to decline and behavior begins to normalize. Another question concerns which devices are the most reliable and valid for PA assessment in children, although to date comprehensive comparative research has not been conducted (Rowlands 2007).

Likely the most crucial challenges of accelerometer use are based on the way in which output of the device is interpreted. As such, accelerometer recordings do not have biological meaning per se and must be validated by criterion measures. Which kind of criterion measurement (e.g. direct observation, energy expenditure) is selected for validation or how the accelerometer output is interpreted and analyzed depends upon the aims or interests of the output interpretation, and they have shown great variability. For example, Van Cauwenberghe and her colleagues (2011), as well as Sirard and his colleagues (2005), used direct observation as a criterion measurement for calibrating and comparing accelerometer-derived cut-off points in different physical activities in children. In comparison, indirect calorimetry (Evenson et al. 2008) and gas respiratory analysis (Pate et al. 2006) were used elsewhere in children of relatively the same age. Regardless of the same epoch (15 seconds) used in all of these studies, the studies ended up recommending very different cut-off points. An explanation for the incoherence may lay, on one hand, behind the differences in the physical activities selected for the calibration studies, and on the other hand, the differences in criterion measurements utilized. In truth, the discrepancy between the studies reflects the sporadic nature of free-living PA in children, which makes calibration studies very challenging in this particular age group. As a result, despite several validation studies and aims to define unambiguous cut-points for accelerometer-derived PA, there is no consensus about which of those should be used (Bornstein et al. 2011). Accordingly, differences in the accumulated time spent at moderate-to-vigorous PA (MVPA) may substantially differ, depending on which cut-off points have been selected. This may cause practical discrepancies, for example, as the proportion of children meeting the commonly recommended 60 minutes of MVPA per day may dramatically differ, depending on which cut-off points are used (van Cauwenberghe et al. 2011).

All in all, there are universal and unambiguous accelerometer output interpretation methods but a lack of consensus about which ones should be used for each research purpose. In general, short epoch times for averaging counts are recommended in children (Bornstein et al. 2011) or using alternative data interpretation methods. Real-time-based raw data interpretation methods are recommended especially when the interest of research is on something other than the energy expenditure of daily living. For example, in the research of bone development, the use of raw acceleration seems a natural choice (Rowlands 2007). Recently, algorithms for recognizing sport-specific (Chambers et al. 2015) or typical daily activities (e.g. Brezmes, Gorricho & Cotrina 2009) with satisfactory accuracy have been innovated for accelerometers and other wearable microsensors. As lying down, sitting, standing, dynamic standing, cycling, walking and running have already been detected from accelerometer signals in laboratory conditions (Bonomi et al. 2009), it may be possible to objectively detect activity types and their movement patterns and intensities in children in the near future (Intille et al. 2012).

2.4 Enhancing physical activity in children

The nature of PA promotion is dependent on the age group under investigation. When PA is enhanced in children aged less than 10 years, the actions undertaken should mostly focus, aside from the underlying developmental mechanisms of a child, on the immediate learning and development environments, namely physical and psychosocial environments. Therefore, this chapter reviews theoretical frameworks. Firstly, it seeks to build an understanding of the underlying social cognitive mechanisms of behavior formation during childhood. Secondly, there is a need to understand the underlying mechanisms of behavior in adults (parents), as they are a key component in efforts aimed at increasing PA in children. Lastly, a wide spectrum of interventions focusing on PA and MC enhancement in children and adolescents are addressed. In general, early intervention has been seen as crucial, as early PA habits have been shown to be the most important predictor of PA levels later in life (Hearst et al. 2012, Kahn et al. 2008).

2.4.1 Theoretical frameworks for physical activity enhancement

Evidence suggests that theory-based PA interventions outperform those of a-theoretical strategies (Michie & Abraham 2004). It is therefore essential to understand the underlying theoretical constructs when PA in children is enhanced via the most immediate learning and development environments. The most commonly utilized theories of health psychology have focused on the cognitive aspects, and especially on the social cognitive aspects, of individual behavior (Young 2014). According to Young et al. (2014), social cognitive models or theories include the social cognitive theory (Bandura 1986), a theory of planned behavior (Ajzen 1985), the health belief model (Rosenstock 1974), the transtheoretical model (Prochaska & Velicer 1997) and protection motivation theory (Rogers 1975). As the emphasis of the current thesis is on the family-based PA promotion of children, two of these theoretical approaches are briefly discussed from the point of view of how family context impacts children's PA behavior and how changes are hypothesized to take place in PA habits. Firstly, social cognitive theory (SCT) (Bandura 1986, Bandura 2004) offers a great perspective on how the social interaction between child, parents and siblings may influence habitual PA, formation of PA habits and development of MC in children. Secondly, the theory of planned behavior (TPB) (Ajzen 1985) offers a perspective for understanding cornerstones of the behavior change process of an individual (parent). Both SCT and TPB have been widely used as theoretical frameworks in scientific behavioral research during the last decades (McEachan et al. 2011, Young et al. 2014).

2.4.1.1 Social cognitive theory

Based on Albert Bandura's (Bandura 1986, Bandura 2004) social cognitive theory (SCT), health habits are rooted in familial practices. A child is in continuous and dynamic interaction with the physical, psychological and social environment. Interaction is reciprocal in nature: an individual's action has an influence on the immediate environment and the environment has an influence on the way the individual processes feelings and thoughts.

When it comes to learning, model learning is perhaps one of the best-known constructs of SCT. A child learns by imitating and copying the behavior of other people and by making its own decisions based on these social situations. Learning or change of behavior is not necessarily seen only as behavioral but also as accumulated knowledge and as an increasing ability to adapt existing information. The child's own parents and siblings can be seen as one of the most powerful role models for a young child, because they typically form his/her core social environment.

However, the home environment should not only be seen as a source of information and behavioral models but also as an important context for testing new behavioral constructs, getting feedback, and building self-efficacy for health-related behavior (Bandura 1986). Children are continuously observing reactions of immediate social interactions and modifying cognitive representations based on this feedback information. When simplified, support and positive feedback strengthen – and lack of support and negative feedback inhibit – the behavioral patterns adopted. Ultimately, the child continuously perceives his/her efficacy for action (for example, being competent to perform the PA tasks at hand or not). Social family environment can therefore be seen to be in a key position, in this case influencing the child's PA habits formed in childhood.

In a nutshell, children form their early health habits in a close social interaction with their parents and siblings, and they test and observe the social reactions of different behavioral patterns that are carried out. Interaction with primary social environments has a strong influence on perceived self-efficacy – and, consequently, perceived self-efficacy for health-related habits – in the future. Early health habits are known to be relatively consistent, as Bandura (2004) has stated: "it is easier to prevent detrimental health habits than to try to change them after they become deeply entrenched as part of a lifestyle".

2.4.1.2 Theory of planned behavior

According to Icek Ajzen's theory of planned behavior (TPB) (Ajzen 1985, Ajzen 2002), human behavior is formed on the basis of three constructs: behavioral beliefs, normative beliefs and control beliefs. Firstly, behavioral beliefs relate to the likely outcomes of the behavior and evaluations of outcomes that together produce a favorable or unfavorable attitude toward the behavior. Secondly, normative beliefs relate to the normative expectations of others and motivation to comply with these expectations, which together result in perceived social pressure or subjective norm. Thirdly, control beliefs relate to beliefs about the presence of factors that may facilitate or impede performance of the behavior and the perceived power of these factors, which together give rise to perceived behavioral control. The model of theory of planned behavior (TPB) assumes that attitude, subjective norm, and perceived behavioral control together affect intentions of behavior or, in other words, behavioral intention. Attitude, subjective norm and perceived control are assumed to mediate with actual behavior via intention while the intention itself is assumed to be a strong correlate of the actual behavior. The key assumption of the TBP model is that the more favorable the attitude, subjective norm and perceived behavioral control, the more likely the individual's intention to perform an action. From the point of view of PA promotion, the theory of TPB offers a model for designing PA interventions aimed at changing behavior. Namely, by affecting the underlying constructs of the TPB it is assumed to be able to enhance the likelihood of the targeted behavior.

2.4.2 Physical activity interventions

Finding an intervention that works is essential for understanding human behavior (Hamer & Fisher 2012). Effective intervention strategies are called upon especially in times of low physical activity and high inactivity in all age groups (Spittaels et al. 2012). As childhood PA experiences are known to be associated with adulthood PA perceptions and PA behavior (Thompson, Humbert & Mirwald 2003), influencing PA habits at an early age has been widely recognized to be crucial, for instance, in various international policy documents (e.g. National Institute for Health and Clinical Excellence 2009).

Effective intervention strategies are ideally implemented in a variety of societal settings to promote developmentally appropriate PA and the maintenance of healthy PA levels in children, in order to prevent the decline of PA levels in school-aged children and adolescents. Importantly, at the same time there is a need to identify both effective and feasible intervention strategies that can be implemented in a real-life setting to influence the early formation of PA habits. Namely, "developing effective interventions is only the first step toward improving the health and well-being of populations" (Durlak & DuPre 2008). Therefore, at least as important as finding effective PA intervention strategies is evaluating ways in which effective intervention strategies would be practically implemented in real life (Naylor et al. 2015).

PA interventions for children are typically performed in childcare or school settings, given the high coverage of the age group and the large amount of time they spend there. As PA is known to interact with several environmental factors, interventions in other settings should also be considered. During recent years, more attention has been paid to family-based PA interventions, as family is known to be a primary context for shaping habitual behavior (Bandura 1986, Riethmuller, Jones & Okely 2009). Additionally, because PA behavior has been seen as complex in nature and challenging to influence, there is agreement that it is important to research mediative paths supporting an active lifestyle (O'Connor, Jago & Baranowski 2009). Interventions focusing on the development of MC have emerged as one major interest in this context. Recent literature on kindergarten-, school- and family-based PA interventions and interventions aimed at enhancing both PA and MC in children via these contexts are reviewed in the following sections.

2.4.2.1 Childcare and school-based physical activity interventions

In a recent literature review, over half of childcare-based PA interventions were concluded to significantly increase PA in children while PA-specific in-service teacher training seemed to offer a concrete strategy in increasing the PA intervention effect (Mehtälä et al. 2014). On the other hand, programs that have succeeded in organizing more structured activity during childcare have been more likely to result in increased PA levels in children. Furthermore, it has been stated that emphasis on intentions of increasing structured activities may threaten free play possibilities which have been stated to contribute to enjoyment of play, creativity and friendship (Council on Sport Medicine and Fitness and Council on School Health 2006). Additionally, there are very few or no childcare-based, theory-driven PA interventions of high quality, which would have significantly changed the objectively measured PA in children (Mehtälä et al. 2014). This makes it difficult to draw conclusions of effective and feasible childcare-based PA intervention strategies in general.

School-based PA interventions have generally been unsuccessful in affecting PA levels in children and adolescents (van Sluijs, Kriemler & McMinn 2011), and this has been the case especially when PA has been monitored by objective techniques (Metcalf, Henley & Wilkin 2012). The most promising evidence for school-based PA interventions comes from after-school programs (Beets et al. 2009, Heath et al. 2012, Pate & O'Neill 2009). Of the six intervention studies reporting PA outcomes included in the review of Beets and his colleagues (2009), three declared increased levels of PA. Of these three studies, only one (Weintraub et al. 2008) collected PA by an objective method, namely accelerometers. Pate and his colleagues (2009) concluded that three of the five RCT studies showed increased PA rates in children when PA was assessed objectively by accelerometers. Although after-school programs may seem to offer a relatively effective way to influence PA levels in children and youth, criticism has been directed at the narrow perspective of after-school programs on PA behavior. It may be that programs of short and intensive PA are simply replacing periods of equally intense PA (for example, time spent with peers or family during leisure time). Given the fact that school-based PA interventions in general have been unsuccessful in affecting overall, objectively measured PA (Metcalf, Henley & Wilkin 2012), and that after-school PA interventions have lacked PA monitoring during leisure time, the overall advantage of after-school PA programs on PA in children and youth remains unclear. On the other hand, after-school programs including PA components have reported improvement not only in terms of PA levels but also the fitness, body composition, and blood lipid profiles of children and young adolescents (Beets et al. 2009), which supports a real effect of after-school programs the health and well-being of children and youth. When it comes to school-based PA interventions, more knowledge is needed of how best to affect habitual PA in school-aged children, for example, by utilizing peers as PA opinion leaders (Zhang et al. 2015).

2.4.2.2 Family-based physical activity interventions

While a majority of studies have employed multicomponent intervention methods (i.e. involvement of schools, childcares and families simultaneously), there is a lack of knowledge of how best to involve families themselves in PA interventions for children (Mehtälä et al. 2014, O'Connor, Jago & Baranowski 2009). Interventions with educational and training programs with parents have shown some evidence of effectiveness. For instance, "The Healthy Dads, Healthy Kids" (Morgan et al. 2011) educational program with eight face-to-face education sessions for dads over a three-month period was found to be effective in decreasing the fathers' weight and increasing children's PA. Elsewhere, the "Mind, Exercise, Nutrition, Do it" (MEND) intensive program with eighteen 2-hour group educational and PA lessons held twice per week followed by a 12-week free family swimming pass, was shown to effectively reduce waist circumference and BMI and increase cardiovascular fitness, PA levels and self-esteem in children between 8 and 12 years of age. Importantly, these positive changes were maintained through a six-month follow-up period (Sacher et al. 2010). Focusing on family PA planning with goal setting and perceived behavioral control (Rhodes, Naylor & McKay 2010) and having parents participate in intervention planning and implementation and in process evaluation (Davison et al. 2013a) are a few other examples of successful PA promotion in children via families. Family homework given at school and focusing, for example, on children's PA have been found to be acceptable concepts by parents, although research evidence of the effectiveness on children's PA remains unknown (Kipping, Jago & Lawlor 2012). Lastly, a very promising practically evident intervention conducted in pediatric primary care by targeting parenting practices (among other things, parental support of PA in children) did not show any effect on measured PA in children (O'Connor et al. 2013).

In general, family-based interventions utilizing the direct involvement of parents (e.g. parents' presence at education sessions, parents' attendance and participation at counseling or training sessions, or phone communication with parents) have had a greater effect on children's PA habits (O'Connor, Jago & Baranowski 2009) and nutritional intake (Hingle et al. 2010) than interventions utilizing indirect ways of contacting parents. Golley and her colleagues (2011) have proposed several characteristics that are associated with effective family-based PA and nutritional intervention strategies: parents being responsible for participation and implementation, higher degree of meaningful parental involvement, use of more behavior change techniques that span the spectrum of behavior change process, inclusion of prompt barrier identification, and prompt self-monitoring. Also, environmental restructuring was more commonly used in effective family-based PA and nutritional interventions for children. Of the behavior change techniques, a small-step principle consisting of gradually progressive goal-setting has shown potential in family-based PA and weight gain prevention programs for children (Rodearmel et al. 2006), and it may offer a potential premise for lifestyle changes, especially in families with diverse interests as well as high work and time demands (Thompson et al. 2010).

Despite these promising strategies, family-based PA interventions have had no or, at best, modest effects on children's objectively or subjectively measured PA (Metcalf, Henley & Wilkin 2012, O'Connor, Jago & Baranowski 2009, van Sluijs, Kriemler & McMinn 2011). Therefore, it seems obvious that there are serious challenges, especially in PA promotion, including those of family-based intentions. Consequently, there has been an experts-led call to build an evidence base for models that better predicts children's PA and includes parent- and child-mediating variables along with strategies that can affect changes in these variables (Davison et al. 2013b, O'Connor, Jago & Baranowski 2009).

2.4.2.3 Motor competence interventions

Because PA behavior has been seen as complex in nature and challenging to affect, it is important to research mediative pathways supporting an active lifestyle. Development of MC has emerged as one major interest in this context, as it is known to closely interact with PA behavior (e.g. Robinson et al. 2015, Stodden et al. 2008). While MC has multifaceted associations with PA, it may also predict the level of PA and fitness. It has also been shown that acquired MC itself may act as a mediator for increased PA (Cohen et al. 2015). On the other hand, low MC may be one factor exposing for physically inactive lifestyle and for accumulation of health risk factors.

There seems to be relatively strong evidence for the claim that motor competence can be enhanced at least in the short term via school- and community –based programs when delivered by physical education specialists or highly trained classroom teachers (Morgan et al. 2013). For example, Kalaja and his colleagues (2012) conducted a specific intervention program aimed at increasing students' fundamental movement skills in Finnish junior high school physical education. As a result, balance and locomotor skills were significantly enhanced, compared to controls, during one academic year, as well as self-reported PA. Interestingly, improvements in MC were found to mediate the effect of the Australian SCORES intervention on PA and cardiorespiratory fitness in 8-year-old children (Cohen et al. 2015). However, there is only one study that partially supports long-term (6-year) maintenance of the level of MC gained through school-based PA intervention (Barnett et al. 2009b). Overall, there is a lack of studies that examine the sustained effect of school-based interventions on MC in children and youth, and conclusions of the long-term effects should therefore be made with caution (Lai et al. 2013).

Similar to school-based interventions, childcare- and kindergarten-based interventions enhancing MC in children have most successfully enhanced MC in children (Logan et al. 2011, Riethmuller, Jones & Okely 2009). For instance, MC has been enhanced in preschool and first-grade children via a MC development-focused program (Matvienko & Ahrabi-Fard 2010) and an early education program, including either a component of MC development or exclusive focus on MC development (Goodway & Branta 2003, Iivonen, Sääkslahti & Nissinen 2011). A practically evident, single-blinded intervention conducted in childcare centers aimed to enhance primarily MC and secondarily weight status and PA in 2–4-year-old children (Bonvin et al. 2013). That intervention was performed by educating educators about supporting PA in children, adapting the childcare built environment, and encouraging educators to involve parents in MC promotion and daily PA. However, no changes in any of the study outcomes were observed. This result may well describe a typically seen gap between interventions implemented in research-based conditions and those in the real world. According to Bonvin and his colleagues' (2013) opinion, the finding confirms "the complexity of implementing an intervention outside a study setting."

Although behavioral theories like SCT (Bandura 1986) and some evidence consider the influence of the home environment to be important to the development of MC in children (Barnett et al. 2013, Cools et al. 2011, Iivonen & Sääkslahti 2014, Riethmuller, Jones & Okely 2009), relatively little is known about whether not only habitual PA patterns, but also the development of MC could be influenced by family-based intervention. In a study of Hamilton and her colleagues (1999), 3–5-year-old children at risk of developmental delay significantly outperformed their control peers in ball-handling skills after an eight-week (45 minutes twice a week) investigator-led and mother-assisted motor skill intervention.

More recently, home or parent components have typically been a minor intervention aspect when aiming to enhance MC in children (Cliff et al. 2011, Reilly et al. 2006), which makes it difficult to interpret the effect of family on outcomes. Cliff et al. (2011) recruited obese children to participate in structured PA sessions led by qualified PE teacher over ten weeks. Families were educated to enhance social support of PA, monitor behavior, identify barriers for PA, and set goals enhancing PA in their obese children. As a result, motor skills improved significantly compared to control peers, but objectively measured PA stayed unchanged between groups. In a study by Reilly and his colleagues (2006), MC was found to be enhanced but not sustained via a PA program in nursery plus home-based health education aimed at increasing PA and reducing sedentary behavior. Family involvement has therefore shown some potential to be a worthy component to include when seeking to enhance the development of MC in children.

In sum, affecting PA in children has proven challenging. The most researched ways of affecting PA in children relate to childcare- or school-based intervention strategies. PA-specific teacher training may be the most efficient way to enhance PA in early education settings (Mehtälä et al. 2014) and after-school programs have shown the best potential to increase PA in school-aged youth (Beets et al. 2009, Heath et al. 2012, Pate & O'Neill 2009). At the same time, there is relatively little research aimed at affecting PA practices via family context itself, since the family component has often been a minor intervention tool included in multicomponent studies (O'Connor, Jago & Baranowski 2009). All in all, as MC enhancement may provide an influential mediative way to affect PA in children (Cohen et al. 2015, Robinson et al. 2015, Stodden et al. 2008), more knowledge of effective and feasible intervention strategies aimed at enhancing MC in children is needed.

3 AIMS OF THE STUDY

This study was conducted as part of an InPact study, a year-long cluster-randomized controlled trial entitled “A family-based tailored counselling to increase non-exercise physical activity in adults with a sedentary job and physical activity in their young children” (ISRCTN28668090, Finni et al. 2011). The counseling process, intervention outcomes regarding PA and MC in children, and parental support of children’s PA are detailed in this thesis.

Previously it has been known that parents face conflicting interests in time management when it comes to their work, daily housework, hobbies, time spent with their children, etc. (Thompson et al. 2010). However, children whose parents have spent time providing support of their PA (for instance, spent time playing with them and encouraged them to do physical activities) are known to more likely be physically active at present (Beets, Cardinal & Alderman 2010, Cleland et al. 2011, Edwardson & Gorely 2010, Loprinzi & Trost 2010, Rhodes et al. 2013) and in the future (Davison & Jago 2009). On the other hand, there is a lack of controlled family-based PA enhancement trials and there has been a call to build an evidence base for models that better predict children’s PA and include parent- and child-mediating variables along with strategies that can affect changes in these variables (Davison et al. 2013b, O'Connor, Jago & Baranowski 2009).

Therefore, the aim of the present study was to examine whether individually tailored counseling given to parents is effective in increasing PA, MC and parental support in children aged 4 to 7 when taking interaction of theory-based variables into account. The counseling process was intended to be of moderate intensity, so that the intervention tools utilized would be realistic and it would be feasible to implement them in real-life circumstances. The goal was to use objective observation methods to examine behavioral changes taking place due to the intervention.

It was hypothesized that the InPact study, which sought to enhance children’s daily PA through family-based intervention, may have reflections on the development of children’s MC. This was based on the relatively consistent association found in earlier studies between objectively measured PA and MC in children (Barnett et al. 2009a, Holfelder & Schott 2014, Lopes et al. 2011, Wrotniak et al. 2006) and on earlier PA intervention studies found to benefit motor competence in children (Cliff et al. 2011, Reilly et al. 2006, Sääkslahti 2005). Although there are several advantages of utilizing objective techniques to assess changes in children's physical activity, there is generally a lack of consensus of how to interpret the accelerometry output (e.g. Bornstein et al. 2011, Kim, Beets & Welk 2012, Oliver, Schofield & Kolt 2007). Also, there is a lack of knowledge of how the accelerometry output should be interpreted from the motor developmental perspective. Reflections of PA intervention on the development of MC would therefore be hidden and remain unknown because of the methodological shortcomings in terms of accelerometry signal interpretation. Consequently, this study examined the association between MC and PA so that accelerometer-derived PA could be interpreted from the perspective that was appropriate for motor development. For this purpose, a specific technique for examining the neuromuscular loading of PA was utilized. The knowledge gathered from the associative studies was aimed to contribute, firstly, to a theoretical understanding of the developmentally important interaction between PA and MC, and, secondly, to gain understanding of the PA intervention's reflections on the development of MC in children.

The specific research questions considering the association between accelerometer-derived PA and MC are as follows:

1. What are the intensities of physical activities typically seen to develop motor competence in children? (paper I)
2. How are the different PA intensities, as analyzed using metabolic (typical count-based analysis) and neuromuscular (g-force) -based parameters, associated with MC in children? (paper II)

Considering the effects of InPact intervention, this thesis aimed to examine whether individually tailored PA counseling for parents influenced objectively measured PA and MC in their 4–7-year-old children.

The specific research questions considering the effects of intervention are as follows:

3. What is the effect of family-based physical activity counseling on children's physical activity and motor competence? (paper III)
4. What is the effect of family-based physical activity counseling on children's physical activity in the lowest and highest initial parental support tertiles? (paper IV)

As the present study was conducted in a northern country with great seasonal variation that possibly influences PA behavior and development of physical fitness (Augste & Künzell 2014, Carson & Spence 2010, Li et al. 2015), the interaction between counseling effects and season regarding PA and MC were additionally examined (paper III). On the other hand, as parental support has been shown to be associated with children's PA, the initial level of parental support was hypothesized to influence the effect of intervention on parental support and children's PA. Consequently, the effect of intervention on parental support and on children's objectively measured PA was examined in tertiles of lowest and highest initial parental support (paper IV).

4 RESEARCH METHODS

4.1 Ethical considerations

During the participant recruitment, data collection, analysis and publication of the study results, the researchers followed good scientific practice and confidentiality. Especially in PA and MC measurements, the aim was not to pressure children to perform against their own will. During the PA counseling, the parents' own will was respected and the voluntariness of any actions taken was emphasized. ID codes were used for handling participant information and identifiable information was not published or publicly discussed. All participant information remained confidential and was used only for the purposes of the study.

The Ethics Committee of the Central Finland Health Care District conferred ethical approval for the InPact project on March 25, 2011 (Dnro 6U/2011). Written informed consent was received from all of the parents for their own and their children's involvement in the study.

4.2 Study design

The design of the InPact study was twofold in terms of tailored counseling delivered to parents. Firstly, a goal was to enhance non-exercise PA in parents. Secondly, there was a goal to enhance PA in children via PA counseling delivered to the parents. The effect of intervention was examined by means of several measurements, both in adults and in children. The overall timeline and measurements of the InPact study are illustrated in Figure 4.

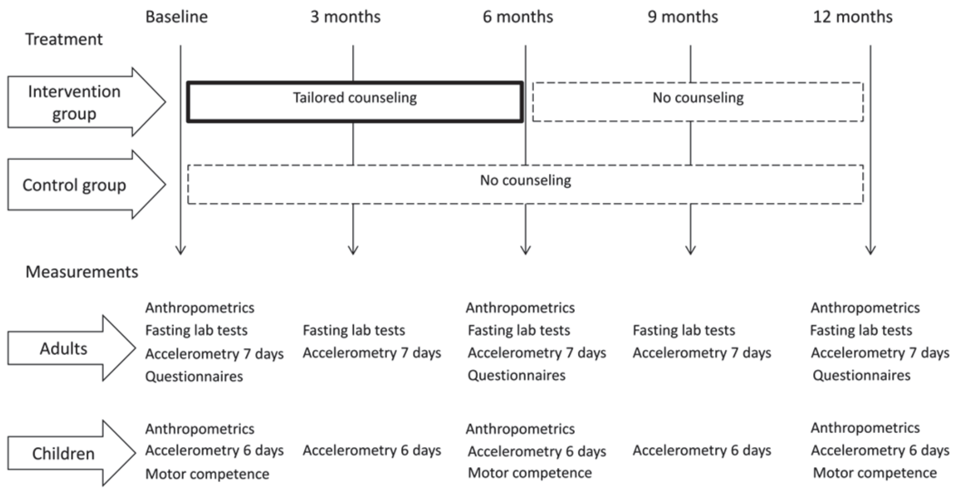


FIGURE 4 InPact study timeline and measurements.

4.3 Recruitment and randomization

Recruitment for the first methodological examination (paper I) was performed in one combined childcare center and primary school situated in the Jyväskylä area; it did not take part in the intervention arm of the study. The nature of this experiment was cross-sectional. Altogether 30 recruitment letters were sent to parents of children attending preschool and 12 attending primary school on January 2013. Acceptance for study participation was received from the parent(s) of 20 children attending preschool and 12 children attending primary school in February, 2013. Altogether 3 children were absent on the day the experiment took place (February 13, 2013).

The intervention study was performed in Jyväskylä, Central Finland, with approximately 133,000 inhabitants living in a relatively small city center and topographically and socioeconomically varied suburbs. Balanced regions in the city (henceforth referred to as "clusters") were matched in terms of population, daycare centers and school facilities, socioeconomic characteristics (education) and outdoor PA possibilities, as these characteristics have been shown to be associated with PA behavior and the importance of their cluster randomization is understood. Seven balanced counterpart clusters were formed (from one to four daycare centers or schools in each cluster) and randomization into either intervention or control clusters was done by researchers (AL, TF) for each of these counterparts. As a result, there were seven intervention clusters and seven control clusters. Recruitment of families for the intervention group was then performed from the intervention clusters and families for the control group from the control clusters. The allocation ratio was around 10%, as 1055 recruitment letters were sent to parents via children attending 21 kindergartens and 8 primary schools. Altogether 103 children were allocated to the study. The researchers performed randomization, enrolled participants, and assigned participants to the intervention. The flow of participants through the cluster-randomized controlled trial is illustrated in Figure 5. Children attending day-care less than 10 days a month, children with a developmental disorder or other disorders delaying motor development, children whose parents sat less than 50% of their work time or had a chronic disease, and children with a pregnant parent were excluded. At least one parent and a child were required for the family to be included in the study. The recruitment of participants was performed between the 1st of April, 2011 and the 30th of April, 2012. The baseline measurements took place between the 2nd of May, 2011 and the 2nd of May, 2012 in balanced waves including both intervention and control group families. All parents were given the possibility to receive PA counseling: intervention families after the baseline measurements and control families after the final measurements. A written informed consent to take part in the study was received from the parent(s) of children participating to any of the sub-studies (papers I-IV) of the present thesis (Appendix 1).

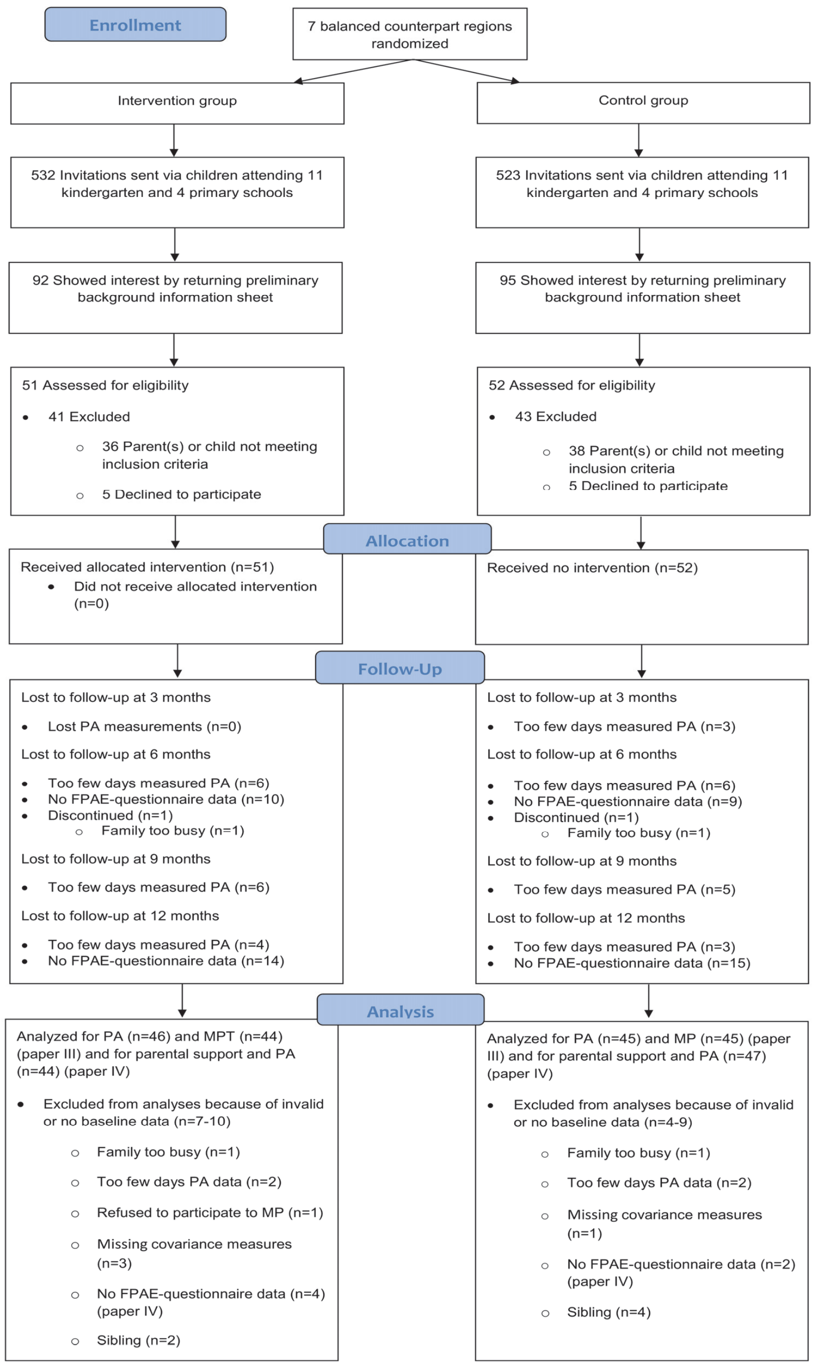


FIGURE 5 Flow chart of the cluster randomized controlled trial.

4.4 Participants

Altogether 126 children aged from 4 to 8 participated in one or more study areas of the thesis. For cross-sectional analysis of the relationship between PA and MC (papers I and II), the background characteristics of the study participants are given in Table 1. Background characteristics are represented separately for children of different sexes and also separately for children attending childcare or a primary school. There was nearly an equal number of girls and boys in both of the examinations, and no significant differences were found between the sexes in terms of background variables.

TABLE 1 Means and standard deviations (maximum and minimum) of background characteristics of the study subjects for methodological examinations.

Participants	Variable	Paper I	Paper II
Children (*N*)		29	84
Childcare center children (*n*)		18	53
Girls (*n*)		11	28
	Age	6.26 ± 0.64 (5.31-7.03)	5.95 ± 0.47 (5.01-6.92)
	Height	115.33 ± 6.52 (108.0-126.0)	115.41 ± 6.09 (101.50-129.60)
	Weight	21.64 ± 2.20 (19.40-26.0)	20.70 ± 2.72 (16.0-26.40)
	BMI	16.27 ± 0.94 (14.17-17.02)	15.49 ± 1.04 (13.37-17.66)
Boys (*n*)		7	25
	Age	6.22 ± 0.54 (5.35-6.81)	5.92 ± 0.45 (4.96-6.59)
	Height	119.64 ± 7.96 (109.0-132.80)	117.40 ± 4.97 (109.10-126.90)
	Weight	23.23 ± 3.91 (18.20-28.60)	21.69 ± 2.42 (17.80-26.60)
	BMI	16.12 ± 1.11 (14.13-17.43)	15.70 ± 0.89 (14.46-18.32)
Primary-school children (*n*)		11	31
Girls (*n*)		3	18
	Age	7.75 ± 0.29 (7.44-8.01)	8.06 ± 0.51 (7.79-8.35)
	Height	122.77 ± 3.96 (120.0-127.30)	128.25 ± 5.85 (112.80-138.10)
	Weight	24.40 ± 1.64 (23.0-26.20)	25.49 ± 4.23 (19.60-32.0)
	BMI	16.23 ± 1.56 (14.81-17.89)	15.47 ± 2.14 (10.70-19.0)
Boys (*n*)		8	13
	Age	7.48 ± 0.24 (7.18-7.92)	7.93 ± 0.34 (7.38-8.42)
	Height	126.50 ± 5.33 (116.60-131.0)	127.83 ± 4.18 (119.90-136.0)
	Weight	28.91 ± 4.32 (22.0-34.60)	26.70 ± 3.56 (22.40-32.60)
	BMI	18.0 ± 1.86 (15.97-20.79)	16.28 ± 1.45 (14.98-19.59)

The background characteristics for the participants included in the analyses of the intervention effects on PA and MC in children (papers III) are shown in Table 2. There was nearly an equal number of girls and boys represented in the intervention and control groups, and no significant differences were found in background variables between the sexes nor between children in the intervention and control groups. However, the parents of the control group were significantly older than the parents of the intervention group (t = 3.37, p = .001).

TABLE 2 Means and standard deviations (minimum and maximum) of background characteristics of the study participants for analysis of intervention effects on children's physical activity and motor competence (paper III).

Characteristics	Intervention	Control
Children (*N*)	46	45
Girls (*n*)	25	24
Age (years)	6.22 ± 1.14 (4.49-7.80)	6.47 ± 1.11 (4.59-7.87)
Height (cm)	121.11 ± 8.81 (101.50-135.70)	120.76 ± 8.59 (108.40-138.10)
Weight (kg)	23.28 ± 3.93 (17.0-32.0)	22.64 ± 4.05 (16.0-32.0)
BMI	15.80 ± 1.36 (13.03-18.93)	15.47 ± 1.72 (10.70-19.00)
Boys (*n*)	21	21
Age (years)	6.02 ± 1.16 (4.26-7.91)	5.89 ± 1.09 (4.32-7.92)
Height (cm)	121.48 ± 5.97 (109.10-131.40)	119.52 ± 6.93 (110.20-136.0)
Weight (kg)	23.48 ± 2.98 (19.6-31.60)	22.66 ± 4.19 (17.80-32.60)
BMI	15.86 ± 1.02 (14.69-18.30)	15.72 ± 1.20 (14.46-19.59)
Season of baseline measurements		
Spring (*n*)	18	13
Autumn (*n*)	17	22
Winter (*n*)	11	10
Parents involved in the study (*N*)	64	58
Age	36.34 ± 4.88 (25)**	39.48 ± 5.40 (22)
Females (n)	40	30
Higher level education (%)	67.04 (%)	67.78 (%)
Household income ≥ 60 000€ (%)	62.79 (%)	58.14 (%)
Single parent (%)	2.22 (%)	4.65 (%)

Data are presented as mean ± SD and range (in parentheses) from baseline measurements, except height, weight and BMI (kg/m2) for children, which are presented from midline measurements. Season, season in which participant started in this study. Significant difference between intervention and control groups, p < 0.01 (**).

Background characteristics for the participants included in the analyses of the intervention effects on the overall level of PA in children in tertiles of initial parental support level (papers III) are shown in Table 3. There was nearly an equal number of girls and boys represented in the intervention and control groups, and no significant differences were found in background variables between the sexes nor between children in the intervention and control groups. However, mothers of the intervention group were significantly younger than mothers of the control group ($t = 2.94$, $p < 0.01$).

TABLE 3 Background characteristics of the study participants for analysis of the intervention effects on parental support and children's physical activity in initial parental support tertiles (paper IV).

	All		Lowest parental support tertile		Highest parental support tertile	
	Intervention	Control	Intervention	Control	Intervention	Control
Children (*N*)	44	47	15	16	16	14
Girls (*n*)	**21**	**26**	**8**	**10**	**8**	**7**
Age (years)	6.27 ± 1.15 (4.49-7.80)	6.38 ± 1.11 (4.59-7.87)	7.03 ± 0.90 (5.59-7.80)	6.61 ± 1.06 (4.92-7.65)	5.61 ± 1.0 (4.49-7.79)	6.75 ± 1.17 (5.13-7.87)
Height (cm)	121.29 ± 9.08 (101.50-135.70)	120.10 ± 8.58 (108.40-138.10)	126.68 ± 6.63 (117.0-135.70)	121.80 ± 7.53 (109.20-131.20)	117.31 ± 8.70 (101.5-129.20)	121.30 ± 9.25 (110.70-135.50)
Weight (kg)	23.37 ± 4.03 (17.0-32.0)	22.28 ± 4.09 (16.0-32.0)	25.43 ± 4.91 (19.80-32.0)	23.70 ± 4.75 (16.80-32.0)	21.73 ± 2.98 (17.0-26.40)	23.77 ± 3.40 (19.60-27.40)
BMI	15.82 ± 1.42 (13.03-18.93)	15.38 ± 1.69 (10.70-19.0)	15.72 ± 1.79 (13.86-18.93)	15.83 ± 1.74 (14.09-19.0)	15.79 ± 1.46 (13.03-18.16)	16.12 ± 1.12 (14.81-17.66)
Boys (*n*)	**23**	**21**	**7**	**6**	**8**	**7**
Age (years)	5.92 ± 1.17 (4.20-7.91)	5.80 ± 1.04 (4.44-7.92)	5.94 ± 1.40 (4.26-7.85)	5.92 ± 1.36 (4.44-7.92)	6.16 ± 1.34 (4.84-7.91)	5.53 ± 0.87 (4.45-7.18)
Height (cm)	120.97 ± 6.06 (109.10-131.40)	118.38 ± 6.69 (110.2-136.0)	122.09 ± 7.75 (114.80-131.40)	116.98 ± 7.51 (110.20-128.20)	119.55 ± 6.10 (109.10-127.10)	117.60 ± 8.42 (112.20-136.0)
Weight (kg)	23.40 ± 3.06 (19.0-31.60)	21.80 ± 3.49 (17.80-32.20)	23.91 ± 4.53 (19.80-31.60)	20.96 ± 3.34 (17.80-25.60)	22.73 ± 1.90 (19.60-25.20)	21.54 ± 4.90 (18.40-32.20)
BMI	15.94 ± 1.11 (14.69-18.32)	15.45 ± 0.76 (14.46-17.41)	15.90 ± 1.18 (14.84-18.30)	15.22 ± 0.56 (14.66-16.0)	15.92 ± 1.05 (14.98-17.65)	15.39 ± 1.05 (14.46-17.41)

…to be continued in the next page…

Parents (*N*)	61	63	19	21	23	17
Mothers (*n*)	38	33	13	12	15	8
Age	34.89 ± 4.11 (28.21-48.43)**	38.82 ± 5.61 (29.70-48.56)	35.77 ± 5.56 (28.45-48.92)	39.92 ± 5.52 (29.56-48.10)	33.67 ± 2.42 (29.11-38.34)	39.5 ± 5.76 (31.47-48.80)
HL (%)	82	72	80	81.3	75	57.1
Single parent (*n*)	1	3	0	1	1	1
Fathers (*n*)	23	30	6	9	8	9
Age	37.22 ± 5.16 (30.33-53.65)	39.64 ± 5.36 (31.21-51.49)	39.84 ± 7.63 (32.36-53.69)	41.23 ± 4.28 (33.45-48.78)	35.63 ± 4.41 (30.12-41.39)	41.45 ± 6.31 (35.56-51.23)
HL (%)	55	66	33.3	62.5	56.3	57.1
Single parent (*n*)	0	0	0	0	0	0

Data are presented as mean ± SD and range (in parentheses) from baseline measurements, except height, weight and BMI (kg/m2) for children, which are presented from midline measurements. CPM, mean accelerometer counts per minute on leisure time. Scale for parental support of PA is 1 to 6. HL, higher level education.
Significant difference between intervention and control groups, $p < 0.05$ (*), $p < 0.01$ (**) and between sexes, $p < 0.05$ (#), $p < 0.01$ (##).

Apparently typically developing children were included in all of the study parts (papers I–IV), and children with a developmental disorder or other disorders delaying motor development were excluded. Based on the international, age-standardized, cut-off points for body mass indexes (BMI) for being overweight and obesity, children in the present study (papers I–IV) generally represented a normal-weighted part of the age group (Cole et al. 2000). Each of the 17 children (~13.5%) categorized as overweight only slightly exceeded the international age-standardized BMI threshold of being overweight and none of these children were even close to the threshold of being obese. The parents of the children included in intervention effect analyses were more often highly educated (i.e. more often had a university or polytechnic degree) than other local (Jyväskylä region) adults (71–84% / 35%) and were less often single parents than other local (Jyväskylä region) parents (4% / 27%).

4.5 Tailored counseling as intervention

Tailored counselling supporting parents to change behavior to enhance PA in their children (papers III and IV) was based on social cognitive theory (SCT) (Bandura 1986) and the theory of planned behavior (TPB) (Ajzen 1985). The TPB was added to the study design after trial commencement for complementing the theoretical framework of the tailored counseling process. Behavior change techniques used in this study were based on nine items conducted in one or several parts of the counselling process: 1) a lecture (~20 minutes) (Appendix 2) and 2) individual face-to-face counselling and goal setting (~30–45 minutes), and 3) phone counselling (~30 minutes, 2 times) (Table 4). The lecture and individual discussions were led by researchers (AL, AP, TF) who had all undergone an orientation in good practices in behavior change counselling before the present intervention. The phone counselling sessions were held by two researchers (AL, AP). In the lecture, parents were instructed that outside the kindergarten or school context, one hour of moderate-to-vigorous PA (MVPA) during weekdays and two hours of MVPA during weekend days was the target level of PA (Table 4: item 1). This general target was justified by the gap between national PA guidelines and preliminary research findings about the current level of PA in children (Soini et al. 2014), as well as by the assumed consequences of (not) achieving the recommended PA (Strong 2005). Specifically, the close relationship between PA and health, the development of MC (Stodden et al. 2008), and school readiness (Tomporowski et al. 2008, Tomporowski, Lambourne & Okumura 2011) were conveyed to parents (Table 4: item 2).

Scientifically based, concrete strategies for enhancing PA were discussed. The key message was to enable PA that is natural to children (e.g. running around, climbing trees and not restricting them unnecessarily), and also to offer possibilities for PA in non-built environments, such as heaths, forests and hills, as time spent outdoors has been shown to be associated with PA and PA in natural environments may contribute the development of MC (Fjortoft 2004, Sallis, Prochaska & Taylor 2000). Seasonal variation, and especially the decline of PA in late-autumn and winter, was emphasized as a key challenge for PA in children (Carson & Spence 2010) (Table 4: item 1). The parental support and role of parents as an important model for their children's PA behavior in everyday life, not only regarding exercise habits, was emphasized (e.g. Yao & Rhodes 2015). Parents were encouraged to engage in PA-friendly role-modeling (Table 4: item 3). Typical restrictions to PA in children's everyday life were discussed between parents and researchers during the counselling session (Table 4: item 5).

Following a fidelity checklist (Appendix 3) of the individual face-to-face discussion, parents were first asked to describe leisure-time PA habits in the family and then encouraged to consider and set small goals for increasing children's PA to reach the target levels. Physical activities common to the entire family were also encouraged (Table 4: items 4 and 6). The goals that parents set were scaled from 1 to 4, depending on frequency of intended implementation (1: randomly, 2: once or twice a week, 3: three to four times a week, 4: daily) (Table 4: item 7). The goals set by the parent him/herself were written into an agreement document that was signed by the subject and the researcher (Appendix 4).

To promote compliance with goal implementation, phone discussions were held two and five months after the counseling and goal setting. During the phone calls, compliance with the set goals, possible modifications to the goals and perceived barriers for implementation of goals were discussed (Table 4: item 8). Additionally, the parents were asked to self-evaluate the implementation of goals by answering the question “Did you do your best to achieve the goal?” on a scale of 1 to 5 (1: not at all, 2: a little, 3: moderately, 4: relatively well, 5: fully) (Table 1: item 9). Parental implementation was supported by monthly e-mails which contained seasonable tips and illustrative videos about how to increase PA and develop MP in their children. Feedback about the progress of MC in children was given to parents shortly after measurement at six months (Appendix 5). The feedback form also included practical advice for improving MC (e.g. moving on varied terrain enhances the development of balance and coordination). The last six months of the study were the same for the intervention and control groups, containing only assessments at 9 and 12 months, but no other contact with the researchers.

TABLE 4 Description of the counselling techniques used in the family-based intervention discussion between parents and counsellors.

Technique items (theoretical framework)	Counselling	Description	Example of implementation
1 Provide instruction (SCT)	Lecture, face-to-face, phone counselling	Providing scientifically based ways to increase PA in children	"Outdoor PA, PA with peers, PA with parents, active ways of commuting"
2 Provide information on consequences (SCT, TPB)	Lecture (Appendix 2)	Information about how physical activity enhances health, development of gross and fine motor coordination, and therefore academic readiness	"PA is associated with lower cardiometabolic risk factors in children, and lack of gross motor coordination may hamper development of fine motor coordination."
3 Prompt identification as a role model (SCT)	Lecture (Appendix 2)	Information of concrete situations parents act as physically active role models for their children	"Consider if you could choose lift instead of stairs and walking instead of taking a car."
4 Provide general encouragement (SCT)	Lecture, face-to-face, phone counseling (Appendices 2 and 3)	Justifying concrete benefits from the intended behavior change	"Adequate PA during the day helps children to go to sleep"
5 Provide information about others approval (TPB).	Lecture (Appendix 2)	Information about other parents' and authorities' opinions/rules about restricting PA natural to children	Discussion of typical restrictions with other parents (e.g. restricting children from running upstairs, playing ball outdoors in rainy weather and climbing on trees)
6 Prompt intention formation (SCT, TPB)	Face-to-face (Appendices 2 and 3)	Encouragement for enabling behavior change	"Consider if prohibiting children from jumping indoors would be unnecessary."
7 Progressive goal setting (SCT)	Face-to-face, phone counselling (Appendices 2 and 3)	Encouragement to set target frequency for goal implementation, prompt for considering progressive increase of the target frequency	"I aim to provide my children weekly opportunities for outdoor play on leisure time."

…to be continued in the next page…

8 Prompt barrier identification (SCT)	Phone counselling	Prompting parents to identify barriers of PA in children and implementing the goals set in the counselling session	"What are the reasons your child was not able to play outdoors on the weekend?"
9 Self-evaluation	Phone counseling	Parents were asked to self-evaluate the implementation of goals set	"On a scale of 1–5, how well did you achieve the set goal?"

PA = physical activity; SCT = Social Cognitive Theory; TPB = Theory of Planned Behavior; Face-to-face = face-to-face physical activity counseling

4.6 Measurements

4.6.1 Physical activity

PA was measured with triaxial X6-1a accelerometers with a dynamic range of ±6 g (Gulf Coast Data Concepts Inc., Waveland, MS, USA). This accelerometer was selected for the relatively large g-force range the device is able to record, and for the possibility to also analyze raw data (which is not possible in some other commercial accelerometers).

Following the manufacturer's recommendation, a "tumble test" was performed to estimate the offsets and scaling factors (multipliers) of each axis for device calibration in order to fine-tune the linear relationship between sensor output and acceleration in units of g-force (Gulf Coast Data Concepts, calibration instructions, http://www.gcdataconcepts.com/calibration.html). The non-standard devices used in this thesis (Gulf Coast Data Concepts) were piloted, as recommended (Intille 2012), simultaneously with standardized ActiGraph GT3X (Actigraph LLC, Pensacola, FL) devices in three children during normal daily living so that validity and reliability were confirmed. In practice, the device used in the present study was worn simultaneously with standardized ActiGraph devices for few typical days. Outputs were then compared and a scaling factor was used to obtain values equal to ActiGraph accelerometers.

Regarding the measurements of children, the device was carried on the anterior waistline in a firmly worn adjustable elastic belt (Appendix 6) during waking hours, with the exception of water-based activities and bathing. A resultant vector $(x^2+y^2+z^2)^{0.5}$ of the 3D accelerometer signal was composed, band-pass filtered (0.25 Hz to 11 Hz), and values below $0.05 \cdot g$ were threshold filtered (Figure 6). All these phases of analysis are similar to standard ActiGraph accelerometer analysis. Non-wearing time was defined as a 20-minute or longer continuous zero signal and was not included in the data. In addition, mid-day nap-time was not included in further analysis of children attending childcare. Nap-times were marked into a diary by the childcare staff. Post-processing of the accelerometer measurements was performed with visual MATLAB software

(MathWorks, Natick, MA, USA). Basically, therefore, all PA measurements were visually checked for proper device functioning and possible malfunctions (Figure 6).

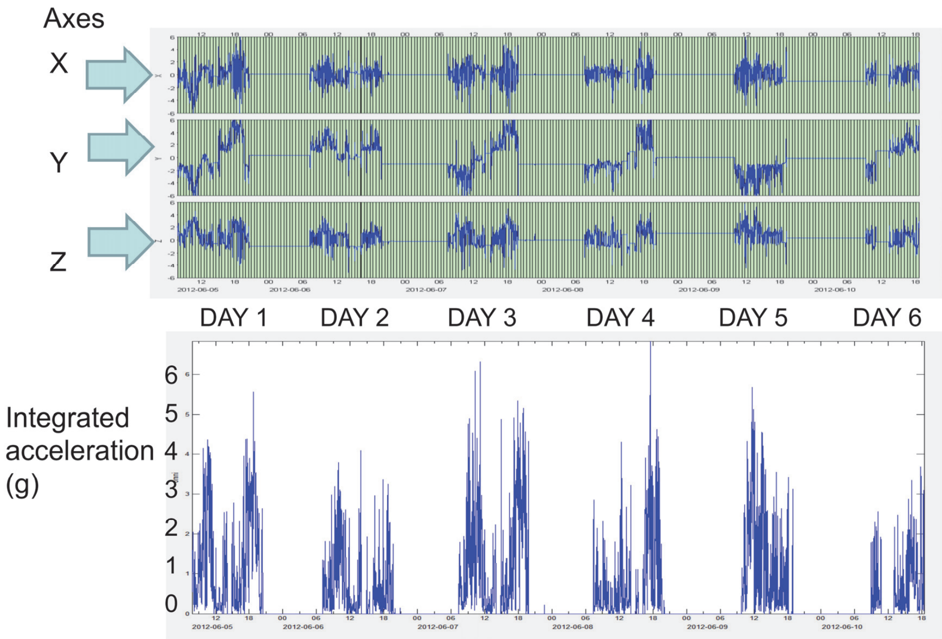


FIGURE 6 Example of a procedure used for filtering and integrating a three-axial accelerometer signal for a vector signal in MATLAB software.

For assessing the metabolic-based intensity of PA (papers I-III), PA counts were calculated by summing over 15-second epochs and multiplying by a device-specific factor that was derived from simultaneous recordings with the X6-1a and ActiGraph GT3X (Actigraph LLC, Pensacola, FL) in three children during normal daily living. The time spent at intensity categories was analyzed by means of cut-off points: sedentary—under 373, light—373 to 585, moderate—585 to 881, and vigorous—over 881 (Van Cauwenberghe et al. 2011). While Van Cauwenberghe et al. used an uniaxial accelerometer and in the present study a triaxial device was used, there is sufficient agreement between uniaxial and triaxial accelerometers to classify PA into intensity categories in children (Robusto & Trost 2012).

There are a few reasons why these cut-off points were selected. Firstly, in the study of Van Cauwenberghe et al. (2011) the physical activities used for defining accelerometer-derived intensity categories were natural; for instance, children were not obliged to sit silently when assessing the cut-off point for the category of sedentary behavior. Evidence states consistently that children's behavior is intermittent in nature (e.g. Bailey 1995), which is probably also the case with sedentary behavior. Secondly, the cut-off points defined in that calibration study were the same for all of the children aged 5.8 ± 0.4. By using the cut-off points that covered relatively well the age scale represented in the present study, it was possible to analyze PA with the same criteria in all PA measurements of the thesis. It would be problematic if a categorization system were changed during the longitudinal follow-up after children have gotten older. Using the same cut-off points made it easier to compare the different studies conducted and included in this thesis. Thirdly, Van Cauwenberghe and her colleagues (2011) used direct observation as a criterion. This method can be seen as an appropriate foundation for the present thesis, as the focus is on behavioral and developmental changes rather than energy expenditure alone.

The neuromuscular intensity or loading of PA can be examined via real-time assessment of acceleration forces caused by bodily movements. The use of a real-time-based accelerometer raw signal has been previously recommended for bone studies in children (Rowlands 2007), and it was also considered in this study to supplement the typical metabolic-based analysis of habitual PA regarding the relations between PA and MC in children. This is especially important because habitual PA in children is known to be transitory in nature (Baquet et al. 2007), and about 95% of physical activities last less than 15 seconds (Bailey et al. 1995). Consequently, in both of the methodological examinations (papers I and II), the neuromuscular loading of PA was assessed via real-time g-force impacts, which were recorded as high as 6 ·g. Accelerometry signal integration and typical accelerometer raw signals are illustrated in Figures 6 and 7. The percentage of measurement time at different g-force impact categories was analyzed in the intervals as follows: 0 ·g to 0.05 ·g, 0.05 ·g to 0.2 ·g, 0.2 ·g to 0.4 ·g, …, 5.6 ·g to 5.8 ·g and 5.8 ·g to 6.0 ·g (Figure 8). Gravity on the Earth is constantly 1 ·g, and the accumulated time spent at the g-force categories used in this study are to be understood in addition to constant gravity as accelerations caused by bodily movements. Because all children did not display accelerations up to 6 g, associative analyses were performed only up to the g-force category in which every subject within a given group had data. Consequently, the upper limit for g-forces was set to 5.6 g in preschool girls (highest g-force performed among preschool girls), 5.4 g in preschool boys (highest g-force performed among preschool boys), and 6 g in primary schoolers (paper II).

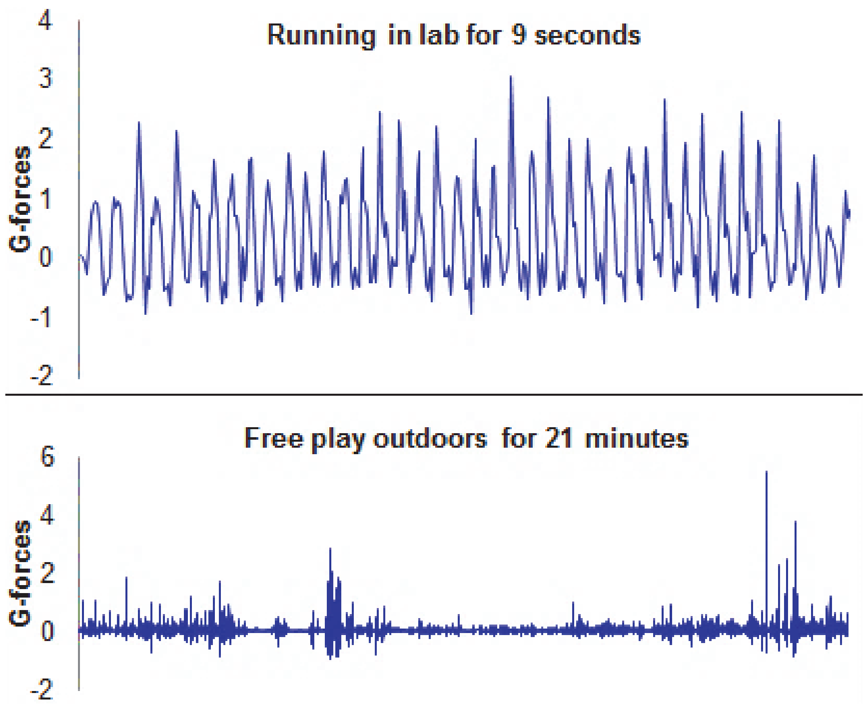


FIGURE 7 Examples of accelerometer raw signals from running and free play in the same child.

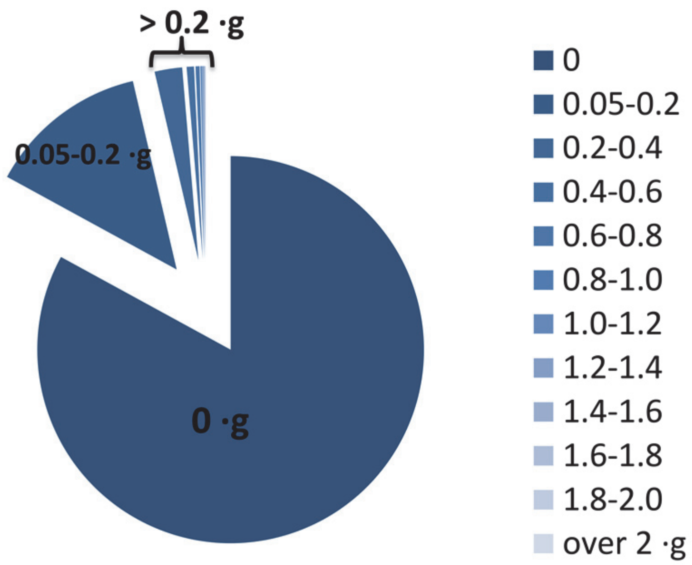


FIGURE 8 Example of the proportion of measurement time spent at different g-force impact categories over a typical day.

In the first methodological examination (paper I), PA was measured only on one day, on which the measurements took place. In the second methodological examination, subjects with recordings longer than 500 minutes on at least three days (2 weekdays and 1 weekend day) were accepted for analysis (Penpraze et al. 2006).

Considering the subjects participating in the intervention examination (papers III and IV), PA was measured at the baseline and at three, six, nine and 12 months for six consecutive days at a time (Figure 3). Verbal and written instructions for accelerometry measurement in children were given individually to parents and teachers at the kindergarten. Recordings longer than 7 hours (420 minutes) on at least 3 days (2 weekdays and 1 weekend day) (Penpraze 2006; Rich 2013) were accepted for analysis. Proportional values of time spent at different PA intensities of sedentary, light and MVPA (van Cauwenberghe et al. 2011) were calculated in relation to the total measurement time and by weighting weekdays by 5/7 and weekend days by 2/7 (paper III). Missing PA values were imputed by using a predictive model on the condition that the subject had successfully performed the baseline and at least one other measurement point. Variation in school timetables, teacher support of PA, etc. may cause bias on the intervention effects, and therefore PA during school time, imputed when needed, was used as a covariate when explaining the change in MC due to intervention. The imputed PA was not used as a dependent variable itself but only as a predictive covariate. The time spent at school was captured on the basis of diaries filled by parents.

When the intervention effect on parental support and on children's PA in the lowest and highest parental support tertiles was examined, the mean counts per minute on leisure time was used as an indicator of children's overall PA in family time (paper IV). The leisure time was defined as time spent elsewhere than at kindergarten or school and engaged in extra-curricular activities (afternoon clubs at school). Leisure time was captured on the basis of diaries filled by parents.

4.6.2 Intensity of physical activities

A panel of specialists in physical education and kinesiology chose individual and cooperative physical activity tasks that are generally seen to develop different aspects (e.g. stability, locomotion, manipulative skills) of motor competence in children. The aim was to find tasks in which the intensity of movement would be able to be measured with reasonable inter-individual variance. Tasks were therefore intended to be relatively simple and easy to administer, in order that task planning and attentional abilities, for example, would not comprise a large proportion of the performance (Wolf 2007). Additionally, PA tasks were chosen so that they would all be suitable for children aged from 5 to 8. Based on these validity criteria, the following indoor PA tasks were included in the study:

1. Tag. A game of "banana-tag" was played in groups of 6 similarly aged children (area size 10.9 m × 6.1 m). Each child had a responsibility to try to tag other players for a 30-second-long period of time.

Other players were encouraged to save the players who had been tagged as quickly as possible. The overall length of the game was 3 minutes, plus the time spent for changing the tagger-player and informing everybody of the change. If all of the players were tagged before the 30-second time limit, the game was restarted right away with the same tagger-player until the 30-second time expired.

2. Ball game. A ball game called "clear your own side" was played (area size 10.9 m × 6.1 m) with two teams of 3 similarly aged children. The aim of the game was to throw bean bags from one's own half of the area to the opposite team's half of the area. It was allowed to carry and throw only one bean bag at a time. The game was played for one minute at a time, and the team with less bean bags on their half of the area at the end of the time was the winner. The game was played altogether three times.
3. Crawl. A gymnastics mat (length 12.3 m, width 90 cm, thickness 4 cm) was laid out across the indoor hall. On the mat was marked a zigzag course. The aim of the task was to crawl through the course without any breaks. There was no instruction on the speed of crawling; children were free to crawl at the speed they felt suitable.
4. Stair walking. The task of the stair walking was to carry five bean bags, one at a time, from the downstairs to the upstairs (each stair was 5.9 cm high, and the stairs altogether were 3.5 m high). It was prohibited to run on the stairs, but moving style was otherwise free. Taking support from a handrail was allowed.
5. Climbing on stall bars. A climbing route was marked on the four stall bars set on the wall of the indoor hall (height 2.5 m, combined width 3.04 m). The task of the climbing was biphasic, but it was performed consequently without a break. Firstly, children had to climb up each of the four stall bars and drop a plain bean bag that was hanging on top of each. Secondly, children were to move sideways from left to right on the stall bars and drop a striped bean bag hanging on top of each of the four bars. A short period of practice was provided prior to the trials and the style of climbing was free and not instructed.
6. Balance beam walking. The task was to walk once back and forth on three separate balance beams (length 2.4 m, width 9 cm, height 35 cm, combined length 14.4 m) set back-to-back on the floor. There were empty gaps of 50 cm between the balance beams, and it was allowed to either take a long step over them or take a step on the floor between the beams.

In cooperative PA tasks, the size of the group was always 6 children and the individual tasks were performed by one child at a time. In each case, a trained researcher was instructing and observing the intended performance of the given task. Pictures of the PA task performance conditions are represented in Appendix 7.

4.6.3 Motor competence

MC was tested by the KörperkoordinationsTest für Kinder (KTK) (Kiphard & Schilling 1974, Kiphard & Schilling 2007). KTK is a product-oriented assessment tool, and it is appropriate for children with a typical developmental pattern as well as for children with brain damage, behavioral problems or learning difficulty. KTK is a suitable tool for identifying motor problems and impairments in children aged 5–14 years. The test battery is also not learned quickly, so it can be utilized for evaluating developmental trajectories over a relatively long period in, for example, interventions and longitudinal follow-up studies (Cools et al. 2009). KTK assesses gross body control and coordination, mainly dynamic balance (Cools et al. 2009, Vandorpe et al. 2011) instead of single movement skills. In addition, KTK has been used for the criterion validity studies of other assessment tools, such as M-ABC (Henderson & Sugden 1992, Smits-Engelsman & Henderson 1998).

From the KTK–test battery, the children performed the following four subitems:

1. Walking backwards (WB) on balance beams (length 3 m, height 5 cm) with different widths of 6.0 cm, 4.5 cm and 3.0 cm, starting from the widest one. The maximum test score possible was 72 steps, based on 3 trials per each beam and a maximum of 8 successful steps for each trial.
2. Hopping for height (HH), one foot at a time, over an increasing pile of soft mattresses (width 60 cm; depth 20 cm; height 5 cm each). The first, second or third trial of each height was awarded by three, two or one point(s), respectively. The maximum test score was 39 points (ground level + 12 mattresses) for each leg, resulting in a maximum of 78 points with both legs.
3. Jumping sideways (JS) from side to side over a thin wooden lath (60 cm × 4 cm × 2 cm) on a jumping base (100 cm × 60 cm). Two trials of 15 seconds were performed and the total of successful jumps was summed.
4. Moving sideways (MS). The children had two identical wooden plates (size 25 cm × 25 cm, height 5.7 cm) and after stepping to one, they had to transfer another one sideways for the next transition. The total of transitions was summed over two 20-second trials. Transitions were performed in the same direction on both trials.

The reliability of the KTK has been shown to be high (Kiphard & Schilling 2007) and robust for maturity, at least in 10-year-old boys (Rouvali 2015). The total score of KTK has been shown to moderately correlate with Movement ABC total score (r = 0.62–0.65) (Henderson & Sugden 1992) and the BOT-2 short form total score (r = 0.61–0.64) (Fransen et al. 2014, Smits-Engelsman & Henderson 1998). Both Movement ABC and BOT-2 are widely used protocols for testing

MC in children (Cools et al. 2009). The KTK protocol has shown moderate to high reliability based on test-retest correlation (r = 0.60–0.99) (Camacho-Araya, Woodburn & Boschini 1990, Freitas et al. 2015, Lopes et al. 2011, Lopes et al. 2012a, Lopes et al. 2012b, Martins et al. 2010), and high reliability based on inter-rater correlation (r = .90–.99). In addition, Cronbach's alpha between the four items has shown high internal consistency (0.95) (Camacho-Araya, Woodburn & Boschini 1990).

The raw test scores of the KTK test items were transformed into gender- and age-standardized values and into a measure indicating the overall result of the test protocol (KTK), according to the KTK manual (paper II). The KTK is categorized as follows: 'not possible' (values under 56), 'severe motor disorder' (values 56–70), 'moderate motor disorder' (values 71–85), 'normal' (86–115), 'good' (116–130) and 'high' (131–145). A mean of KTK sub-items was calculated and used for statistical analyses in paper III. This was due to the possibility of taking age and sex as covariates in the models testing changes in KTK performance.

In addition, manipulative skills' domain of MC was measured by an underarm throw-and-catch a ball (TCB) test of an APM-inventory (Numminen 1995). The APM-inventory has been validated in 1800 Finnish children of 1–7 years of age and shown to be highly reliable (Numminen 1995). In the TCB test for preschoolers, a soft ball (circumference 65.4 cm, weight 228 g) was thrown underarm ten times to a target (10-cm-wide piece of distinguishable tape) at 1.30 m high on the wall from a distance of 2 meters and caught after a bounce on the floor. The TCB test was modified for primary schoolers so that it was performed in two separate parts with a higher degree of difficulty. In the first part, the ball was thrown 10 times from a distance of 3 meters and caught after a bounce on the floor. Additionally, hits that rose over the marked upper limit 2 meters high on the wall were counted as fails. In the second part, the ball was thrown 10 times from a distance of 3 meters and caught without a bounce on the floor. No marked upper limit on the wall existed in the second part. The number of catches was summed for preschoolers, and for primary schoolers the average number of catches in the two parts was calculated (maximum of 10 points in each age group). In relation to paper II, the raw scores of the TCB test were additionally transformed into age-standardized TCB values by the averaged sum scores of the age groups (5–, 6–, and 7–8 years old). Performing the KTK and the TCB test took approximately 20 to 30 minutes per child. The MC measurement form and equipment are presented in Appendices 8 and 9.

The tests of MC were performed in kindergarten or at primary school, depending on which suited the children and their parents the best. In each case, the testing circumstances were set as similar as possible in regards to distractions, floor material, space and equipment needed in the measurement. Children were tested alone or in small groups of two or three, and the tasks were performed one child at a time. Oral instruction and a model performance were given for every task, and the tasks were performed in the same order for every child. The same trained researcher (AL) assessed all of the tests. A pilot study for testing MC by this protocol was conducted in preschoolers (*n* = 7), separate from this study group. In the pilot, the testing sessions were videotaped and analyzed afterwards by two senior researchers in the field for appropriate arrangement and assessment practices.

4.6.4 Anthropometrics

In the laboratory, school or kindergarten, height (wall-attached measuring tape) and body weight (Soehnle Digital personal scale, Soehnle, Germany) were measured by research personnel. All children were asked to wear only light clothes and take off their shoes and hats during the measurements. Body mass index (BMI, kg/m^2) was mathematically calculated for each subject.

4.6.5 Socioeconomic status

Socioeconomic status was assessed by asking the highest educational level of the parents / guardians of the child participating to the study. The highest educational level was assessed on the scale from zero to four (0 = elementary school, 1 = secondary school, 2 = high school, 3 = vocational / intermediate degree, 4 = polytechnic or university degree). A mean of the highest education level of parents / guardians was calculated for each subject.

4.6.6 Parental support

Parental support of children's PA was assessed by using the Family Physical Activity Environment (FPAE) questionnaire, which has been validated by Cleland et al. (2011). It has been found to be a reliable tool for assessing parental support in Australian children aged 5 to 12 years (test-retest ICC = .65–.90). The FPAE was translated into the mother tongue of the study participants by an informed translator and by an uninformed one (Beaton, Bombardier, Guillemin & Ferraz 2000). In the second phase of the translation process, the two independent translations were synthesized. In the third phase, the translated questionnaire was pre-tested for its clarity of language and suitability for the local culture by five experts in different fields (physical education, exercise physiology, kinesiology, and health science). The translated FPAE was not back translated to English. Based on the aims of the tailored counseling of the present study, three sections consisting of a total of seven items from the FPAE were chosen to represent the rate of parental support of children's PA (Table 5). The same parent or guardian of a child participating to the study was asked to fulfill the questionnaire in each measurement point if possible. Each section consisted of two separate items, considering the parental support that the father and the mother provided to the child. The first section, family participation in PA, was assessed by the following items: "Evaluate how often *father/mother* participates in physical activity with your child, such as moving and playing games." Moreover, the first section included a third item: "Evaluate how often you do physical activity, such as cycling, walking, playing outdoors or indoors, hiking, playing games, together as a family." The second section, direct support of child's PA, was assessed as follows: "Evaluate how often *father/mother* provides support for your child's participation in physical activity, such as taking him/her to PA hobby or training, providing money for participation, buying sports clothing/equipment." The third section, reinforcement for PA, was assessed by the following items: "Evaluate how often *father/mother* praises your child for participating in PA, such as saying positive things to him/her for being physically active." The original form of the parental support questionnaire is represented in Appendix 10.

TABLE 5 Questionnaire used for assessing parental support of children's physical activity.

Section	Question
a) Family participation in PA with a child	
	Evaluate how often
a1)	father participates in physical activity with your child, such as moving and playing games.
a2)	mother participates in physical activity with your child, such as moving and playing games.
a3)	you do physical activity, such as cycling, walking, playing outdoors or indoors, hiking, playing games, together as a family.
b) Direct support of child's PA	
	Evaluate how often
b1)	father provides support for your child's participation in physical activity, such as taking him/her to PA hobby or training, providing money for participation, buying sports clothing/equipment.
b2)	mother provides support for your child's participation in physical activity, such as taking him/her to PA hobby or training, providing money for participation, buying sports clothing/equipment.
c) Reinforcement for PA	
	Evaluate how often
c1)	father praises your child for participating in PA, such as saying positive things to him/her for being physically active.
c2)	mother praises your child for participating in PA, such as saying positive things to him/her for being physically active.

PA = physical activity.

In addition to parental support, sibling co-participation in PA was assessed with the following statement: "Think about which of your children is most often physically active with the child participating in this study. Evaluate how often he/she is physically active with the child taking part in this study, such as moving and playing games together." Parents evaluated the frequency of support on a six-point scale for each item (1 = never, 2 = less than once per week, 3

= 1–2 times per week, 4 = 3–4 times per week, 5 = 5–6 times per week, 6 = daily). At the baseline, 6 months, and 12 months, the same parent of the child participating in the study was asked to answer the selected FPAE items each time.

4.7 Statistical analysis

Statistical analyses were performed with Statistical Package for the Social Sciences (SPSS) statistics software (IBM SPSS Statistics versions 20-22, SPSS Finland, Espoo, Finland) (papers I, II and IV) and in statistical programming language R (R 3.0.1, NLME package, the R foundation for Statistical Computing) (paper III). The level of significance was set to $p < .05$ in all analyses.

4.7.1 Descriptives

Descriptives for the variables of interest included means, standard deviations, and ranges, together with minimum-maximum ranges of background information variables (papers I–IV). Sex and group differences were tested by *t* test, the Mann-Whitney *U* test, and chi-square (X^2) tests. Normality of variable distributions was assessed by a Shapiro-Wilk test. Skewed distributions were logarithmically transformed for further statistical inspections when needed. (Papers II, III and IV.)

4.7.2 Associations

Partial correlation coefficients were determined between the time spent at g-force impact categories and MC, and between the time spent at counts intensity categories and MC (paper II). The effect of age and BMI was controlled in all associative analyses. The skewed distributions of proportional time spent at g-force impact categories in preschool girls and boys and in primary school boys were logarithmically transformed.

4.7.3 Overall intervention effects

The effect of PA counseling on children's PA and MC was determined with a linear mixed-effects model fit by restricted maximum likelihood (REML). An autoregressive covariance model (AR1) was also used in the analyses considering changes in the KTK. Initially, modelling of the intervention effect was based on a three-level hierarchy where children (n = 97) were nested within families (n = 91) and families were nested within randomized clusters (n = 14). Out of 47 intervention and 43 control families, there were two intervention and three control families with more than one child participating in the study. These children represented four out of 48 and seven out of 49 subjects in the intervention and control groups, respectively. The children, families and clustered samples were considered in the models as random grouping effects. However, because of the high number of families in comparison to the total number of children, the models were inestimable. Therefore, in five cases where more than one child per family was participating to this study, only one child from the family was randomly included to the final analyses. Consequently, the final counseling effect analysis based on a two-level hierarchy where children (*n* = 91) were nested within randomized clusters.

The Group × Time interaction formed a base model for examining the effects of intervention on changes of the proportional time spent at different PA intensities, KTK between the baseline and the 12 month follow-up. Based on this interaction, the mean change from the baseline to 6 months and the baseline to 12 months, and the mean difference between groups in these time intervals, were calculated. In the second phase, the interaction of sex was added to the base model and three-way interaction of Group × Time × Sex was tested with the likelihood ratio test. The models with and without the three-way interaction term were compared. The same procedure was applied for the three-way interaction of Group × Time × Season for examining the influence of seasonal variation on the intervention effect. Subjects were divided into three groups based on the season in which they were tested at the baseline: spring (n = 30) (March, April, May and June), autumn (n = 42) (August, September, October and November) and winter (n = 22) (December, January and February). The categorization of these three seasons was done on the basis of average monthly temperatures observed between 1981 and 2010 in Finland (see Appendix 11). No measurements were conducted for July because of national summer vacation when schools and childcare centers are commonly closed. The influence of seasonal variation was illustrated by plotting the proportion of time spent in MVPA at baseline, three, six, nine and 12 months, and the mean of KTK and the TCB test at baseline, six and 12 months among intervention and control groups, starting in spring, autumn and winter. All valid subjects with acceptable baseline data from outcome measures and covariances were included in analyses of intervention effect.

With PA as a dependent variable, mixed models were adjusted for theory-based confounding variables (in order of statistical importance): average temperature of the month, participation in extracurricular PA, sex, age and season at baseline measurement. Similarly, with KTK as a dependent variable, models were adjusted for age, BMI, proportion of time spent in MVPA during school time, participation in extracurricular PA, and testing environment. Average temperatures were retrieved from climate statistics published by the Finnish Meteorological Institute. The effect of clustered samples was tested as a random grouping effect, but it was found to be non-significant. Sedentary time was LOGIT-transformed and light PA and MVPA LOG-transformed due to skewed distributions. Furthermore, distribution of the TCB test was not normal at the baseline because of a few zero point performances (n = 13) in the youngest participants. Therefore, a non-parametric Mann-Whitney U test was used to test differences between the groups in the changes of the TCB test, first in all children, and secondly, in girls and boys separately. Additionally, a related samples Wilcoxon signed rank test (*W*) was used to examine the development of TCB by time in general. A logistic regression analysis was performed in order to reveal possible systematic explanations (e.g. parents' education level) for dropping out of the study.

4.7.4 Parental support questionnaire

Internal consistency for all seven of the FPAE questionnaire items was tested by Cronbach's alpha (paper IV). Cronbach's alpha for the items was found acceptable at the baseline (0.83), 6 months (0.79), and 12 months (0.83). Pairwise correlations were found to be consistently moderate-to-high between all seven items at different measurement points (baseline, 6 months, and 12 months) ($0.334 < r < 0.718$), and removal of any of the items would not have increased the consistency of the questionnaire. Therefore, a sum factor of all seven selected FPAE items was calculated and used as a parental support factor for further analysis.

4.7.5 Intervention effects in tertiles of initial parental support

The statistical protocol for examining intervention effects in parental support and children's PA in tertiles of lowest and highest parental support (paper IV) was mainly similar to the statistical protocol for examining the overall intervention effect (paper III). In order to include parental support as a predictor of intervention effect on changes of parental support and children's PA, children and their parents were divided into tertiles of low and high initial parental support. These tertiles were identified by selecting the lowest and highest thirds of the intervention and control families based on parental support at the baseline. For the intervention effect analysis, an equal mean of the parental support between the tertiles of the intervention and control groups was prioritized. Consequently, the proportion of children belonging to the lowest and highest parental support tertiles was adjusted as close as possible to 33% of the study sample. The initial parental support was therefore comparable between the children in the lowest tertiles of intervention (n = 15, mean 2.77 ± 0.33, min. 2.14, max. 3.14, range 1) and control (n = 16, mean 2.74 ± 0.37, min. 1.86, max. 3.14, range 1.29), and between the children in the highest tertiles of intervention (n = 16, mean 4.51 ± 0.46, min. 4.0, max. 5.71, range 1.71) and control (n = 14, mean 4.42 ± 0.55, min. 3.57, max. 5.14, range 1.57). As a result, the effect of intervention on changes in parental support and PA were tested using the whole sample (all) and when children were stratified into tertiles of lowest and highest parental support.

Variables having significant interactions with the unadjusted model were entered into the mixed effect models. Consequently, Model 1, which examined the intervention effect on parental support, was adjusted (in the order of statistical significance) for child's age, PA in leisure time, and average temperature of the measurement month. Correspondingly, when examining the intervention effect on children's PA, Model 1 was adjusted for temperature of the measurement month, the child's sex, and the sex of the parent answering the parental support questionnaire. Additionally, the child's participation in organized PA was found to be a nearly significant confounding variable when examining the intervention effect on parental support and a significant variable when examining the effect on PA. However, interpretation of the interaction between participation in organized PA and the intervention effect on PA can be complex. Therefore, Model 2 was applied when examining the intervention effect on parental support and on PA by adjusting apart from other covariates for participation in organized PA. Finally, a three-way interaction of Group × Time × Sex was performed in unadjusted and adjusted models with the whole sample and separately considering the tertiles of parental support for examining whether the intervention effect on parental support or PA differed between the sexes of the children. In addition, sibling co-participation in PA was used as a theory-based covariate in mixed models when the intervention effect on PA in children was examined. Counts per minute, the outcome of children's overall PA, was logarithmically transformed due to skewed distributions. A logistic regression was used to identify significant predictors for dropping out of the study. Level of significance was set to $p < 0.05$ in all analyses.

5 RESULTS

The main findings of the thesis are presented in this chapter. The original papers (I–IV) should be consulted for additional details.

5.1 Intensity of physical activities typically seen to develop motor competence in 5–7-year-old children

Under controlled circumstances, children performed a total of six physical activities typically seen to develop MC in children. The aim of the study (paper I) was to determine the intensity of these typical physical activities with accelerometers. Preschool-aged children (5–6 years old) spent on average more time than first-grade-aged children (7–8 years old) performing the individual tasks (Table 6). Also, standard deviations of the performing times for individual tasks were larger among preschoolers than first-graders. As expected, time spent in group activities was stable because the performance time was set by the research personnel.

TABLE 6 Means and standard deviations of time (seconds) spent in group activities and individual tasks

Task	Preschoolers (*n* = 18)	Primary schoolers (*n* = 11)
Tag	179.8 ± 0.8	179.9 ± 0.4
Ball game	180.0 ± 1.6	180.0 ± 0.5
Crawling	23.0 ± 5.6	18.8 ± 2.8
Climbing	116.1 ± 40.5	64.7 ± 14.0
Stair walking	154.9 ± 53.5	119.2 ± 14.6
Balance walking	62.9 ± 18.7	50.6 ± 10.2

Both preschool and first-grade-aged children spent most of the time in tag, the ball game and crawling at a vigorous metabolic-based intensity level (min-max 65.2 - 100%) (Figures 8 and 9).

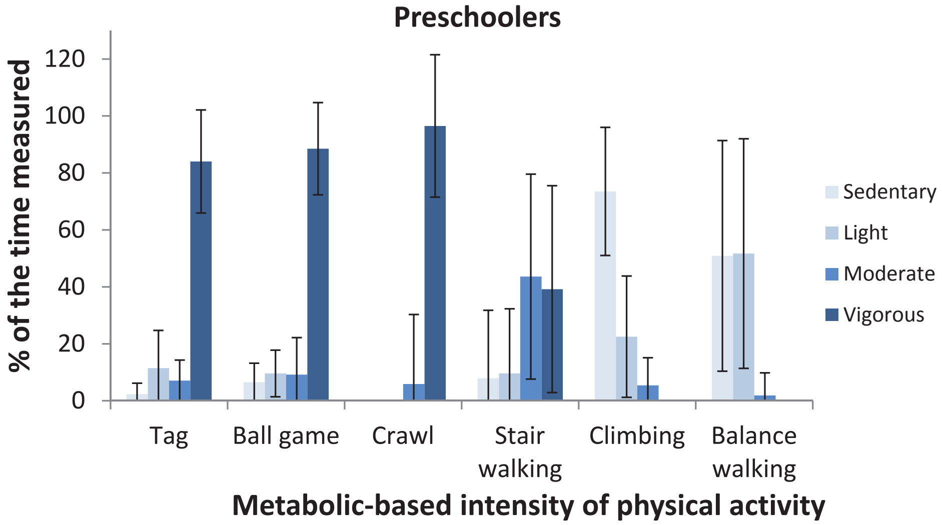


FIGURE 9 Means and standard deviations of proportional time spent at metabolic-based intensities of physical activities typically seen to develop motor competence in 5–6-year-old children.

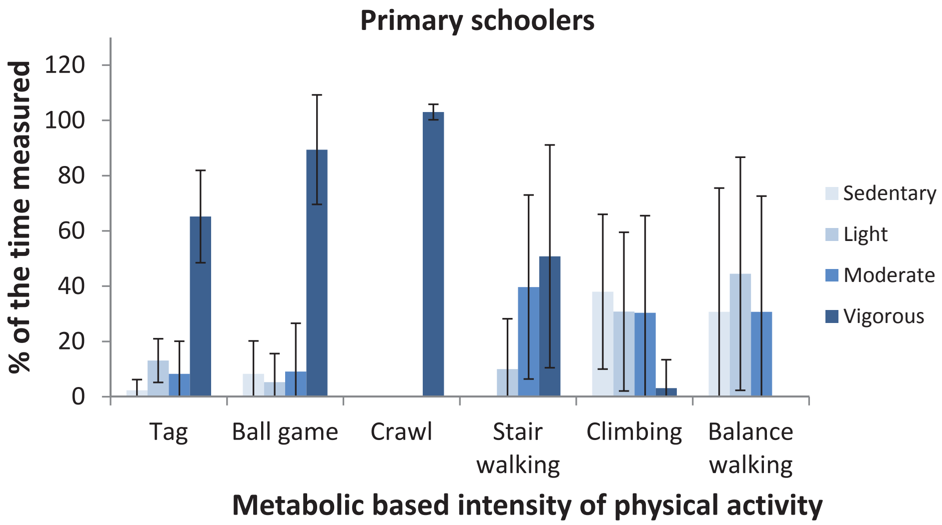


FIGURE 10 Means and standard deviations of proportional time spent at metabolic-based intensities of physical activities typically seen to develop motor competence in 7–8-year-old children.

Moreover, time spent in stair walking was categorized mostly as vigorous (50.8%) and moderate PA (43.6%) in primary schoolers and preschoolers, respectively. In both age groups, crawling induced the greatest proportion of performance time of higher (over 1·g) g-force impacts (Tables 7 and 8). The next highest g-force impacts induced were monitored in tag, ball game and stair walking in both age groups. Contrary to other physical activities, climbing was categorized mostly as sedentary (73.5%) and balance beam walking as light (51.7%) intensity of physical activity in preschool-aged children (Figure 9). Parallel to preschoolers, climbing consisted mostly as time spent in sedentary (38%) and balance beam walking in light (44.5%) intensity categories in first graders (Figure 10). The low intensity of these physical activities was confirmed by the great proportion of time spent in low g-force impact categories, and on the other hand, by the low proportion of time spent at higher g-force impact categories in both age groups (Tables 7 and 8).

TABLE 7 Means and standard deviations of time spent at neuromuscular-based intensities of typical physical activities developing motor competence in preschool-aged children. Bolded values signify the category that time was spent the most at after the 0 ·g category.

Impact category	Tag	Ball game	Crawl	Stair walking	Climbing	Balance walking
0 ·g	65.7 ± 3.3	62.4 ± 2.4	61.4 ± 4,2	66.1 ± 3.5	72.5 ± 4.1	69.8 ± 3.0
0.05–0.2 ·g	**9.8 ± 1.4**	**10.9 ± 1.8**	6.7 ± 2.2	**12.3 ± 2.4**	**20.4 ± 1.7**	**19.1 ± 2.7**
0.2–0.4 ·g	6.6 ± 1.1	9.3 ± 1.2	6.5 ± 2.1	8.7 ± 1.6	4.7 ± 2.0	6.9 ± 1.8
0.4–0.6 ·g	4.6 ± 1.1	5.9 ± 1.0	5.1 ± 1.3	4.8 ± 1.1	1.1 ± 0.7	2.3 ± 1.3
0.6–0.8 ·g	3.3 ± 0.8	3.7 ± 0.7	4.0 ± 1.2	2.8 ± 1.0	0.5 ± 0.3	0.8 ± 0.6
0.8–1 ·g	2.5 ± 0.6	2.4 ± 0.6	3.6 ± 1.1	1.6 ± 0.7	0.3 ± 0.2	0,4 ± 0,3
sum of 1–2 ·g	6.0 ± 1.6	4.4 ± 1.4	**10.2 ± 3.4**	2.9 ± 1.6	0.4 ± 0.4	0.5 ± 0.3
sum of 2–3 ·g	1.3 ± 0.8	0.7 ± 0.6	2.3 ± 1.5	0.6 ± 0.7	0.1 ± 0.1	0.1 ± 0.1
sum of 3–4 ·g	0.2 ± 0.2	0.1 ± 0.2	0.3 ± 0.4	0.1 ± 0.3	0.0 ± 0.0	0.0 ± 0.1
sum of 4–5 ·g	0.0 ± 0.1	0.1 ± 0.2	0.0 ± 0.1	0.0 ± 0.1	0.0 ± 0.0	0.0 ± 0.0
sum of 5–6 ·g	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

TABLE 8 Means and standard deviations of time spent at neuromuscular-based intensities of typical physical activities developing motor competence in first-grade-aged children. Bolded values signify the category that time was spent the most at after the 0 ·g category.

Impact category	Tag	Ball game	Crawl	Stair walking	Climbing	Balance walking
0 ·g	65.2 ± 3.0	61.2 ± 2.3	59.8± 4.1	63.0 ± 1.6	68.8 ± 2.9	66.8 ± 2.6
0.05–0.2 ·g	**10.1 ± 1.5**	**11.0 ± 2.0**	6.2 ± 2.0	**11.6 ± 3.4**	**19.0 ± 1.8**	**18.7 ± 3.3**
0.2–0.4 ·g	7.3 ± 1.3	10.1 ± 1.0	7.5 ± 1.8	9.5 ± 1.4	6.9 ± 1.8	8.6 ± 1.7
0.4–0.6 ·g	5.0 ± 0.9	6.3 ± 1.1	5.6 ± 1.9	5.5 ± 1.2	2.2 ± 0.9	3.0 ± 1.5
0.6–0.8 ·g	3.5 ± 0.7	4.0 ± 0.7	4.7 ± 1.5	3.4 ± 1.2	1.0 ± 0.4	1.2 ± 0.8
0.8–1 ·g	2.5 ± 0.5	2.6 ± 0.7	3.5 ± 1.1	2.0 ± 1.0	0.7 ± 0.3	0.6 ± 0.5
sum of 1–2 ·g	5.4 ± 1.5	4.3 ± 1.4	**9.8 ± 2.9**	3.9 ± 2.5	1.1 ± 0.7	0.8 ± 0.7
sum of 2–3 ·g	0.9 ± 0.6	0.5 ± 0.4	2.5 ± 1.3	1.0 ± 1.0	0.2 ± 0.1	0.2 ± 0.2
sum of 3–4 ·g	0.1 ± 0.1	0.1 ± 0.1	0.4 ± 0.9	0.1 ± 0.2	0.1 ± 0.1	0.1 ± 0.1
sum of 4–5 ·g	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.1	0.0 ± 0.0	0.1 ± 0.1	0.0 ± 0.0
sum of 5–6 ·g	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.1	0.0 ± 0.0

5.2 Intensity of physical activity associated with motor competence in 5–8-year-old children

To supplement the analysis of the relationship between objectively measured PA and MC, the accelerometer-derived PA was interpreted from both metabolic- and neuromuscular-based perspectives. Proportional time spent at metabolic- and neuromuscular-based PA intensities are represented in Tables 9 and 10. In general, boys spent a higher proportion of time at light and moderate ($2.26 < t < 3.33$, $p < 0.05$) metabolic-based PA intensities and girls more at sedentary ($2.79 < t < 2.92$, $p < 0.01$) intensity (Tables 9 and 10). Similarly, boys accumulated more time than girls at g-force impact categories ($2.48 < t < 3.64$, $p < 0.05$) and less time at zero g-force (primary schoolers, $t = 2.31$, $p < 0.05$). Primary school-aged children spent more time at g-force impact categories ($2.15 < t < 3.38$, $p < 0.05$) and counts intensity categories ($2.06 < t < 3.48$, $p < 0.05$) and were less sedentary ($t = 3.09$, $p < 0.01$) than preschool-aged children. Moreover, mean CPM values, referring to the mean level of PA, were higher among primary schoolers (652 ± 200 / min) ($t = 3.20$, $p < 0.01$) than preschoolers (532 ± 142 / min). The mean CPM was higher in primary school boys (boys 742 ± 225 / min) ($t = 2.27$, $p < 0.5$) compared to primary school girls (587 ± 156 / min), but no significant difference was found between the sexes in preschoolers (girls 502 ± 115 / min, boys 567 ± 162 / min).

TABLE 9 Means and standard deviations of proportional measurement times and accumulated minutes spent per day (mean in parentheses) at metabolic intensity categories.

Metabolic intensity category	*Preschoolers (5–6 year olds)*				*Primary schoolers (7–8 year olds)*		
	Girls (n = 28)		Boys (n = 25)		Girls (n = 18)		Boys (n = 13)
Sedentary	90.19 ± 2.60 (623.41)	**	87.84 ± 3.52 (617.01)	##	88.07 ± 3.48 (646.92)	**	83.12 ± 4.76 (638.39)
Light	4.65 ± 1.05 (32.01)	**	5.73 ± 1.33 (40.13)	#	5.18 ± 1.46 (37.87)	**	6.84 ± 1.38 (51.66)
Moderate	2.74 ± 0.82 (18.84)	*	3.41 ± 1.05 (24.23)	##	3.49 ± 1.06 (25.70)	**	5.22 ± 1.74 (38.03)
Vigorous	2.44 ± 1.18 (16.92)		3.05 ± 1.93 (21.91)	##	3.28 ± 1.45 (24.39)		4.85 ± 2.53 (34.98)

Significant difference between genders in percentage of measurement time in counts intensity categories * $p < 0.05$, ** $p < 0.01$ and between pre- and primary schoolers # $p < 0.05$, ## $p < 0.01$.

TABLE 10 Means and standard deviations of proportional measurement times and accumulated minutes spent per day (mean in parentheses) spent at neuromuscular impact-based g-force categories.

Neuromuscular intensity category	Preschoolers (5–6 year olds)				Primary schoolers (7–8 year olds)		
	Girls (*n* = 28)		Boys (*n* = 25)		Girls (*n* = 18)		Boys (*n* = 13)
0 ·g	89.86 ± 1.66 (621.05)		89.27 ± 1.55 (627.50)		89.66 ± 1.92 (658.84)	*	88.01 ± 1.94 (672.55)
0.05 ·g to 0.2 ·g	6.73 ± 1.00 (46.39)		6.80 ± 0.87 (47.80)		6.46 ± 1.06 (47.39)		6.94 ± 0.93 (52.78)
0.2 ·g to 0.4 ·g	1.90 ± 0.35 (13.11)	*	2.16 ± 0.40 (15.20)	##	2.19 ± 0.51 (16.06)	*	2.64 ± 0.49 (19.80)
0.4 ·g to 0.6 ·g	0.69 ± 0.16 (4.78)	*	0.82 ± 0.18 (5.76)	#	0.79 ± 0.24 (5.82)	**	1.09 ± 0.29 (8.12)
0.6 ·g to 0.8 ·g	0.32 ± 0.09 (2.18)		0.36 ± 0.10 (2.57)		0.33 ± 0.12 (2.41)	**	0.49 ± 0.15 (3.60)
0.8 ·g to 1 ·g	0.17 ± 0.06 (1.19)		0.19 ± 0.06 (1.37)		0.17 ± 0.05 (1.26)	**	0.25 ± 0.09 (1.87)
1 ·g to 2 ·g	0.30 ± 0.20 (1.86)		0.30 ± 0.20 (2.26)		0.30 ± 0.11 (2.22)	*	0.43 ± 0.19 (3.16)
2 ·g to 3 ·g	0.05 ± 0.02 (0.33)		0.06 ± 0.06 (0.45)	#	0.07 ± 0.04 (0.53)		0.10 ± 0.07 (0.72)
3 ·g to 4 ·g	0.01 ± 0.01 (0.08)		0.16 ± 0.02 (0.12)	#	0.02 ± 0.02 (0.15)		0.03 ± 0.03 (0.21)
4 ·g to 5 ·g	0.00 ± 0.00 (0.03)		0.01 ± 0.01 (0.04)		0.01 ± 0.01 (0.05)		0.01 ± 0.01 (0.07)
5 ·g to 6 ·g	0.00 ± 0.00 (0.01)		0.00 ± 0.00 (0.01)		0.00 ± 0.00 (0.01)		0.00 ± 0.00 (0.02)

Significant difference between the sexes in percentage of measurement time in g-force categories * $p < 0.05$, ** $p < 0.01$ and between preschoolers and primary schoolers # $p < 0.05$, ## $p < 0.01$.

Both preschoolers and primary schoolers were identified as typically developed (scores between 86 and 115), and primary school boys were identified as well developed in JS and MS (scores between 116 and 130) on the basis of KTK classification (Table 11). In general, primary schoolers performed significantly better in sub-items of WB, HH, JS and MS and on the overall KTK than preschoolers, regardless of the age-standardized variables used. Moreover, preschool boys performed better than preschool girls in KTK ($t = 2.44$, $p < 0.05$), HH ($t = 3.22$, $p < 0.01$) and JS ($t = 2.59$, $p < 0.05$). Similarly, primary school boys were better than girls in JS ($t = 2.45$, $p < 0.05$), although girls outperformed boys in WB ($t = 3.24$, $p < 0.01$).

TABLE 11 Means, standard deviations and ranges (in parentheses) of motor competence items used for analyzing associations with physical activity intensities.

Measures	Preschoolers (5–6 year olds)				Primary schoolers (7–8 year olds)		
	Girls (n = 28)		Boys (n = 25)		Girls (n = 18)		Boys (n = 13)
WB	91.07 ± 14.27 (64)		86.0 ± 12.77 (48)	#	102.22 ± 13.69 (46)	**	86.2 ± 14.42 (53)
HH	92.93 ± 16.63 (85)	**	108.04 ± 16.87 (55)	##	108.56 ± 11.59 (43)		110.67 ± 7.63 (22)
JS	101.00 ± 13.83 (57)	*	112.69 ± 18.63 (71)	#	109.33 ± 15.95 (59)	*	122.92 ± 11.66 (36)
MS	103.25 ± 14.12 (53)		108.81 ± 15.63 (60)	#	110.67 ± 11.68 (40)		115.92 ± 15.35 (47)
MC	94.86 ± 13.52 (55)	*	104.92 ± 16.69 (57)	##	109.72 ± 13.83 (60)		111.42 ± 11.92 (39)
TCB_raw	5.61 ± 2.63 (10)		6.46 ± 3.01 (10)		13.17 ± 3.81 (15)		14.83 ± 4.15 (13)
TCB_age-standardized	0.92 ± 0.43 (1.63)		1.06 ± 0.49 (1.66)		0.95 ± 0.28 (1.09)		1.07 ± 0.30 (0.94)

KTK, KörperkoordinationsTest für Kinder; WB, walking backwards; HH, hopping for height; JS, jumping sideways; MS, moving sideways; MC, overall gross motor coordination according to the KTK.
TCB_raw, throwing and catching a ball manipulative skill test raw score; TCB_age-standardized, age-standardized value of the manipulative skill test score. Significant difference between sexes * $p < 0.05$, ** $p < 0.01$ and between preschoolers and primary schoolers # $p < 0.05$, ## $p < 0.01$.

When BMI and age were controlled, correlations between KTK performance and intensities of PA revealed multifaceted trends (Figure 11). KTK performance correlated with the time spent sustaining impacts between 0.6 ·g and 1.2 ·g ($0.42 < r < 0.51$, $p < 0.05$) and with the time spent in PA of light ($r = 0.51$, $p < 0.05$) and moderate metabolic intensity ($r = 0.55$, $p < 0.01$), and negatively with sedentary time ($r = - 0.52$, $p < 0.05$) in preschool boys. Additionally, mean CPM was associated with KTK performance ($r = 0.45$, $p < 0.05$) in preschool boys. In primary school girls, KTK was associated with the time spent at 0.6 ·g to 1 ·g, 1.4 ·g to 1.6 ·g and 5.6 ·g to 6 ·g impacts ($0.50 < r < 0.57$, $p < 0.05$) and with the time spent at vigorous intensity ($r = 0.56$, $p < 0.05$).

Of the specific MC test items, the KTK item of MS correlated with the time spent sustaining impacts of 0.6 ·g to 0.8 ·g ($r = 0.67$, $p < 0.001$), 0.2 ·g to 0.6 ·g and 0.8 ·g to 2.4 ·g ($0.43 < r < 0.67$, $p < 0.05$), 0 ·g ($r = - 0.50$, $p < 0.05$) and with the time spent in light ($r = 0.53$, $p < 0.05$), moderate ($r = 0.69$, $p < 0.001$), vigorous ($r = 0.52$, $p < 0.05$), and inversely with sedentary ($r = - 0.69$, $p < 0.001$) categories in preschool boys (Figure 11). HH correlated with the time spent sustaining impacts between 0.4 ·g and 2.6 ·g ($0.41 < r < 0.64$, $p < 0.05$) and with the time spent in light ($r = 0.47$, $p < 0.05$), moderate $r = - 0.64$, $p < 0.001$), vigorous ($r = 0.51$, $p < 0.05$), and negatively with sedentary ($r = - 0.65$, $p < 0.01$) categories in preschool boys. Both MS and HH were significantly associated with mean CPM ($0.60 < r < 0.66$, $p < 0.01$) in preschool boys.

In preschool girls, MS was associated with the time spent sustaining impacts of 3.4 ·g to 4 ·g, 4.2 ·g to 4.4 ·g and 4.8 ·g to 5.4 ·g ($0.39 < r < 0.47$, $p < 0.05$), but not with the time spent at any counts intensity category or with mean CPM (Figure 11). In primary school girls, the TCB test was associated with the time spent sustaining impacts of 0.8 ·g to 1 ·g ($r = 0.65$, $p < 0.01$), WB with 1.6 ·g to 3.4 ·g and 4.8 ·g to 6 ·g ($0.50 < r < 61$, $p < 0.05$) and JS with 0.6 ·g to 1 ·g ($0.52 < r < 0.55$, $p < 0.05$). TCB, WB and JS correlated with the vigorous intensity category ($0.50 < r < 57$, $p < 0.05$) and WB with mean CPM ($r = 0.52$, $p < 0.05$) in primary school girls. On the whole, in primary school boys no significant associations were found between PA and MC.

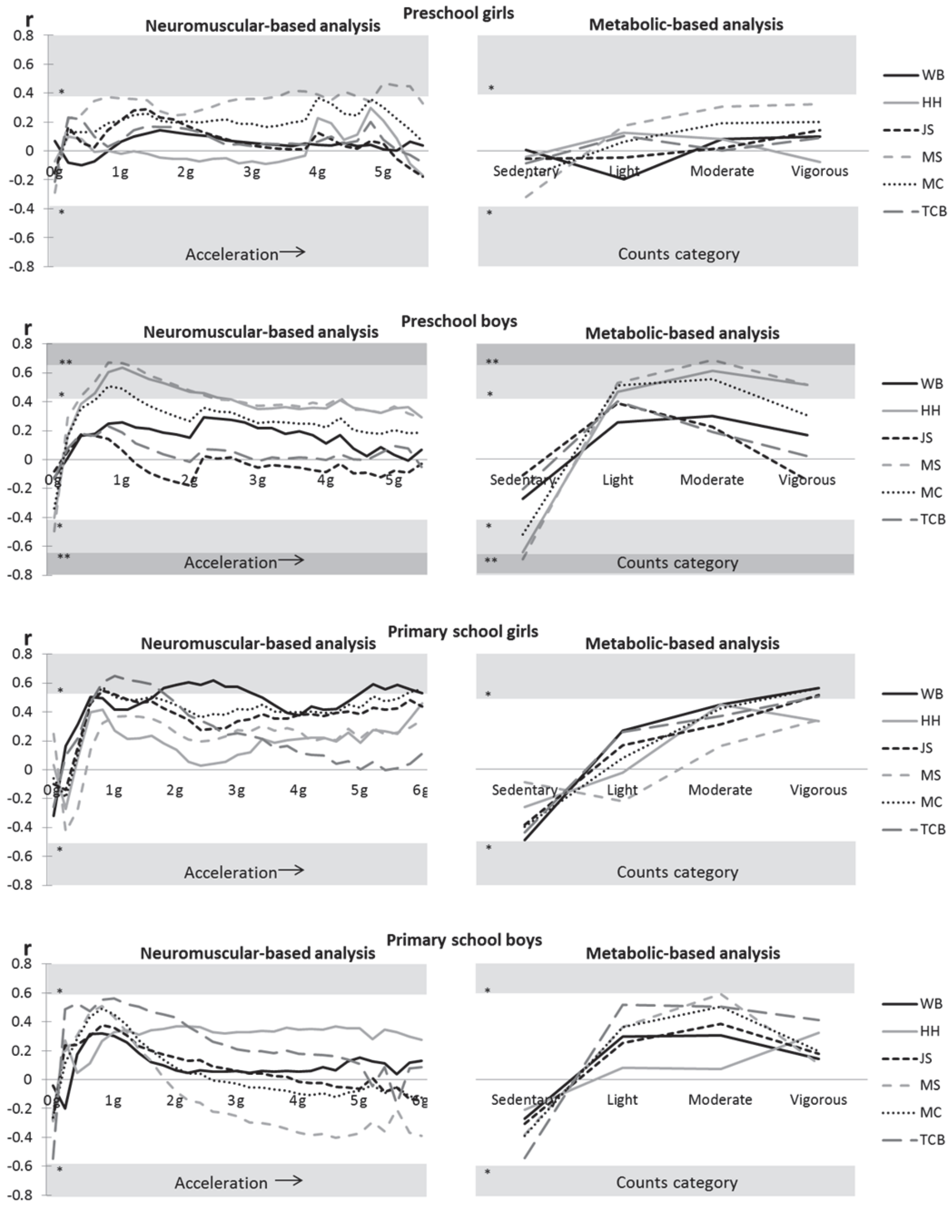


FIGURE 11 Display of relationships of gross motor skills and time spent at neuromuscular impact-based g-force categories and metabolic-based counts intensity categories after controlling for effects of BMI and age. The time spent at g-force categories and counts categories are plotted on the x-axis and Pearson's correlation coefficients (2-tailed) on the y-axis. WB, walking backwards; HH, hopping for height; JS, jumping sideways; MS, moving sideways; MC, overall gross motor coordination according to the KTK; TCB, throwing and catching a ball. Significant correlation * ($P < 0.05$) and ** ($P < 0.001$).

5.3 Overall intervention effect on physical activity and motor competence

In relation to the third research question of this thesis, it was examined whether a family-based cluster-randomized controlled trial enhances PA and MC in 4–7-year-old children. Like in many other longitudinal studies, the amount of participants changed from the beginning. A total of 3 intervention and 4 control children discontinued the study after enrollment because of busy life situations in the family or parents participating in another study (Figure 5). Four children (three intervention and one control) were excluded from analysis of the intervention effect on MC because of one or more missing covariance measures. Six children (two intervention and four control) were dropped out from all intervention effect analysis because of a sibling(s) taking part to the study. Finally, the overall intervention effect on PA was analyzed by 46 intervention and 45 control children, and the intervention effect on MC by 44 intervention and 45 control children.

On average, metabolic-based PA was measured for 5.04 days (11.79 ± 0.93 h/d), 5.17 days (11.74 ± 0.93 h/d), 5.22 days (11.84 ± 0.98 h/d), 5.15 days (11.59 ± 0.85 h/d) and 5.27 days (11.68 ± 0.90 h/d) at the baseline, three, six, nine and 12 months, respectively. Intervention group accumulated significantly less sedentary time (*t* = 2.23, p = .028) and more MVPA (*t* = 2.52, p = .013) at the baseline. Boys cumulated significantly less sedentary time (*t* = 2.78, p = .007) and more light PA (*t* = 3.64, p < .001) and MVPA (*t* = 2.02, p = .047) compared to girls at the baseline, but MC was similar between the sexes (Table 12). There were no other significant differences between the sexes or the intervention and control groups in the baseline assessments. Drop-outs did not statistically differ from other subjects involved in the analysis of the intervention effect.

TABLE 12 Means, standard deviations and ranges (in parentheses) of metabolic-based intensities of physical activity and motor competence in children at the baseline (paper III).

Variable	Intervention	Control
Physical activity (n)	46	45
Sedentary (%)	87.51 ± 4.05 (17.95)*##	89.25 ±3.33 (14.93)
Light (%)	5.44 ± 2.44 (8.12)###	5.08 ± 1.40 (6.84)
MVPA (%)	7.11 ± 2.94 (13.31)*#	5.73 ± 2.21 (10.11)
Motor competence (n)	44	45
KTK	30.09 ± 12.80 (48.0)	31.02 ± 11.50 (41.75)
TCB	4.47 ± 3.04 (10)	4.72 ± 2.91 (10)

KTK, mean value of all four items of KörperkoordinationsTest fur Kinder; TCB, raw scores of throwing and catching a ball. Significant difference between intervention and control groups, p < .05 (*), p < .01 (**) and between the sexes, p < .05 (#), p < .01 (##), p < .001 (###).

Group × Time interaction indicated a significant decline of MVPA (*D* = 10.45, *df* = 4, p =.033) in the intervention group when compared to the control group

(Figure 12 and Table 13). Group × Time × Sex interaction indicated no significant sex differences in the treatment effect on the proportion of time spent at different PA intensities.

The mean KTK score increased with time (F = 154.5, p < .001), as well as the mean of TCB test score (W = 7.46, p < .001) (Table 13, Figures 12–14). Group × Time interaction showed no study effect for the development of KTK performance. There were no significant differences between the sexes in study effect for the development of KTK. The TCB test indicated a slightly greater, nearly significant, improvement among the intervention group (increase of 2.25 ± 2.34 points) compared to the control group (increase of 1.34 ± 2.40 points) between the baseline and 6 months (U = 753.5, p = .051). The change of TCB did not differ between groups from the baseline to 12 months (U = 987.5, p = .984). When the sexes were analyzed separately, there were no significant differences between groups in the development of TCB.

Group × Time × Season interaction in KTK (D = 23.97, df = 10, p = .009) indicated a significant intervention effect on KTK when taking the influence of season into account (Table 13). More specifically, intervention and control groups who started during the winter differed in the progress of KTK during the transition from an active to inactive season in the latter half of the follow-up (from six to 12 months, difference of 11 percent points and seven mean points) (Figure 15). Season had no significant interaction effect on the changes of PA between groups.

TABLE 13 Change in physical activity and motor competence for intervention and control groups at 6 and 12 months.

Outcome	Period of change in months	Mean change (95% Confidence Interval) Intervention	Control	Mean difference between groups (95% Confidence Interval) Intervention – Control	p-values Time	Group × Time	Group × Time × Sex	Group × Time × Season
Physical activity								
Sedentary (%)	0-6	0.04 (-0.07 to 0.16)	-0.07 (-0.18 to 0.04)	0.11 (-0.03 to 0.26)				
	0-12	0.02 (-0.11 to 0.15)	-0.10 (-0.22 to 0.03)	0.11 (-0.02 to 0.25)	.506	.106	.642	.171
Light (%)	0-6	0.02 (-0.07 to 0.11)	0.04 (-0.05 to 0.13)	-0.02 (-0.14 to 0.10)				
	0-12	0.04 (-0.06 to 0.15)	0.06 (-0.04 to 0.17)	-0.02 (-0.13 to 0.09)	.775	.285	.511	.200
MVPA (%)	0-6	-0.11 (-0.24 to 0.02)	0.08 (-0.05 to 0.21)	-0.19 (-0.35 to 0.02)				
	0-12	-0.08 (-0.24 to 0.08)	0.08 (-0.08 to 0.24)	-0.16 (-0.32 to 0.001)	.172	**.033**	.507	.212
Motor competence								
KTK	0-6	18.80 (13.74 to 23.86)***	17.39 (12.22 to 22.56)***	1.41 (-5.89 to 8.71)				
	0-12	35.28 (29.6 to 41.0)***	36.76 (30.97 to 42.54)***	-1.47 (-9.52 to 6.58)	**< .001**	.737	.930	**.008**

*** Significant change with time, p<.001

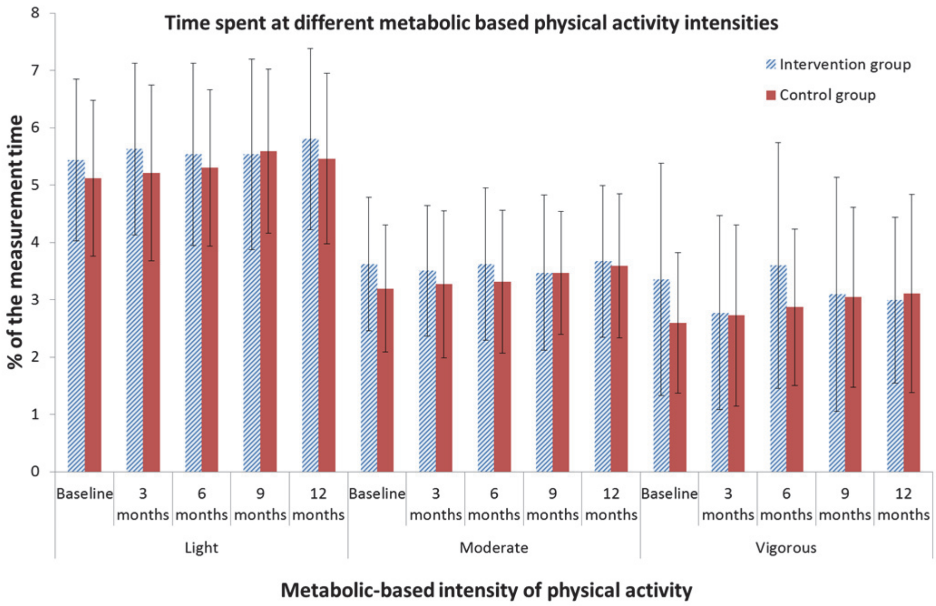


FIGURE 12 Means and standard deviations of the time spent at different metabolic-based intensities of physical activity in intervention and control groups during the 1-year study.

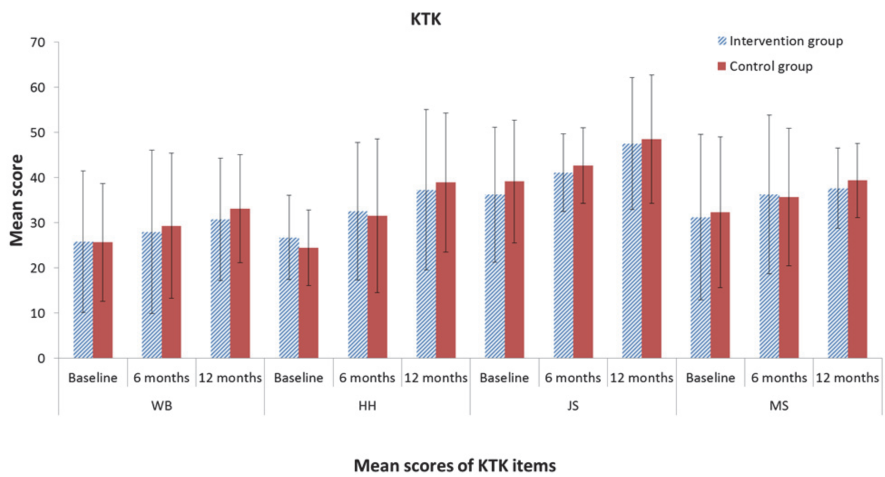


FIGURE 13 Means and standard deviations of KörperkoordinationsTest für Kinder sub-items in intervention and control groups along a time axis. WB = walking backwards, HH = hopping for height, JS = jumping sideways, MS = moving sideways.

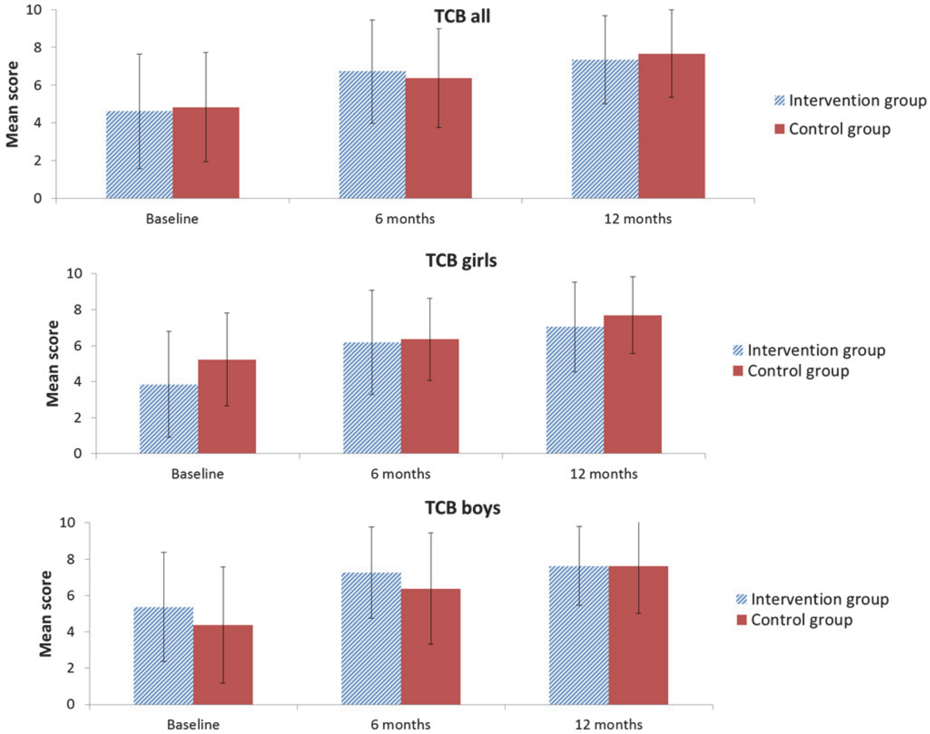


FIGURE 14 Means and standard deviations of throwing and catching a ball test scores in intervention and control groups.

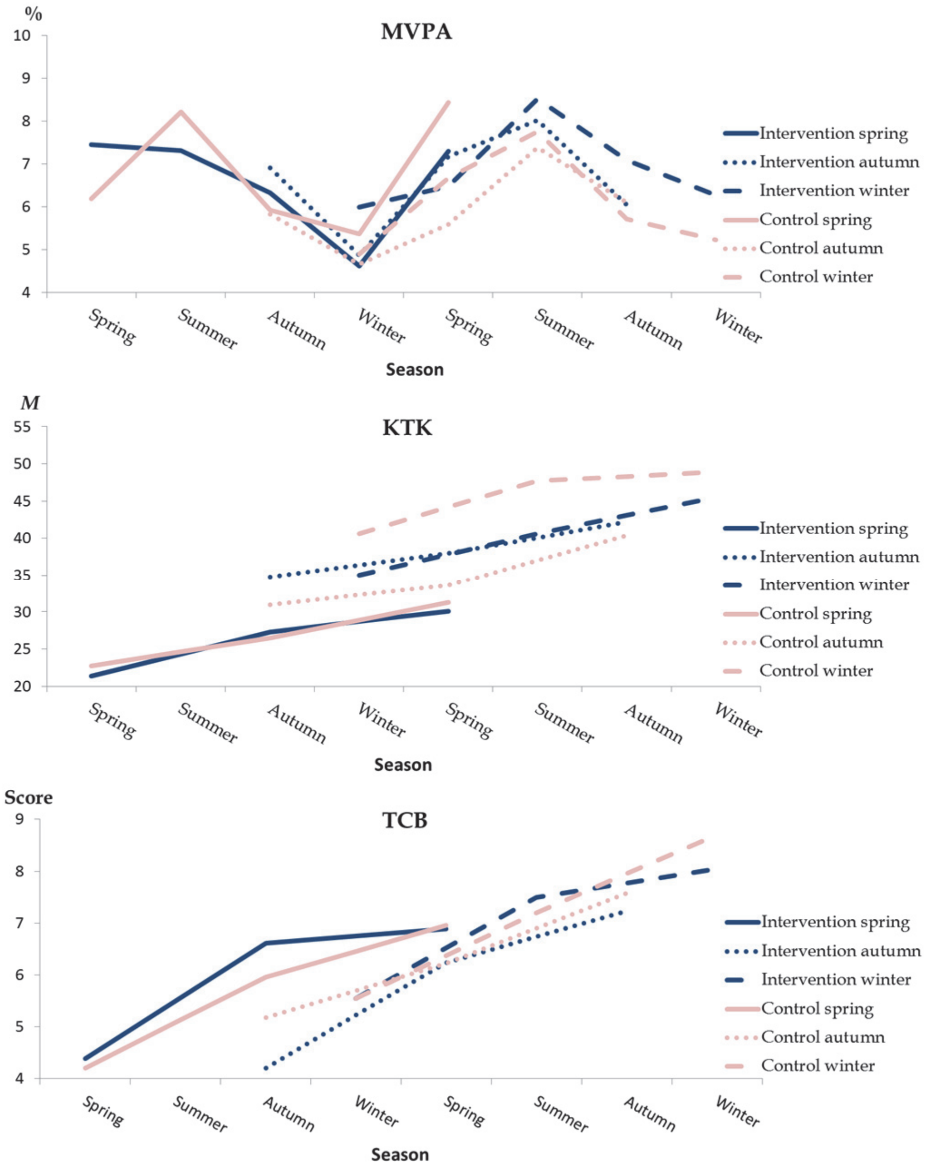


FIGURE 15 Seasonal variations in intervention and control groups who started in spring, autumn and winter in relation to proportional time spent at MVPA, and the development of mean of KTK and TCB. Season is plotted on the x-axis and the response variable on the y-axis. MVPA, moderate to vigorous physical activity; KTK, Körperkoordinationstest für Kinder; TCB, throwing and catching a ball.

5.4 Intervention effects on parental support and children's physical activity in tertiles of initial parental support

The fourth research question of this thesis examined whether initial parental support moderated the PA counseling effect on 4–7-year-old children's objectively measured overall level of PA. Those families who dropped out of parental support measurements after the baseline had more children ($\beta = 3.61$, $p < .05$) than families who continued for the full year. However, there were no other significant predictors for dropping out. According to the whole study sample's initial parental support (mean 3.43 ± 0.77), children were supported in PA by their parents approximately two to three times per week. Table 14 shows the frequency of parental support among the tertiles at the baseline. In general, considerable variation in initial parental support of children's PA was found because initial parental support was significantly higher ($t = 15.60$, $p < 0.001$) among the intervention and control tertiles of highest parental support (mean 4.47 ± 0.50, corresponding to four to five times a week of parental support), compared to the lowest parental support tertiles (mean of sum factor 2.76 ± 0.35, corresponding to less than once a week up to once a week of parental support). Mothers of the intervention group participated more in PA with their children ($t = 2.73$, $p < 0.01$) than mothers of control children (Table 14). Additionally, girls in the lowest tertile of parental support were significantly older ($t = 2.10$, $p < 0.05$) than the boys (Table 3).

The baseline level of leisure-time PA was, in general, 567.70 ± 188.0 counts per minute (Table 14). Boys were more active ($t = 2.75$, $p < .01$) than girls in general, and the same difference was found among the tertiles of the lowest parental support ($t = 2.55$, $p < .05$). On the other hand, girls were significantly older than boys ($t = 2.10$, $p < .05$) in these tertiles. However, among the tertiles of the highest parental support there was no significant difference between the sexes in leisure-time PA.

TABLE 14 Baseline means and standard deviations (ranges) of physical activity and parental support in initial parental support tertiles.

Variable	All		Lowest parental support tertile		Highest parental support tertile	
	Intervention	Control	Intervention	Control	Intervention	Control
Children (*N*)	44	47	15	16	16	14
Physical activity (CPM)	590.93 ± 217.24 (1185.94)##	519.82 ± 134.27 (552.82)	515.82 ± 155.68 (687.34)##	531.83 ± 151.49 (521.24)	577.43 ± 132.58 (477.86)	543.59 ± 135.62 (538.97)
Physical activity (CPM_log)	6.33 ± 0.32 (1.76)##	6.22 ± 0.26 (1.05)	6.20 ± 0.30 (1.33)##	6.24 ± 0.28 (0.95)	6.33 ± 0.23 (0.78)	6.27 ± 0.26 (1.03)
Organized PA(%)	60.5	65.2	53.3	68.8	62.5	84.6
Parental support (*N*)	44	47	15	16	16	14
Answerer female (%)	72.7	53.2	80	62.5	75	57.1
Father participates in PA with a child	3.48 ± 1.21 (5)	3.11 ± 1.05 (5)	2.53 ± 0.64 (2)	2.63 ± 0.81 (3)	4.25 ± 1.13 (3)	3.86 ± 1.24 (4)
Mother participates in PA with a child	3.64 ± 1.13 (4)**	3.13 ± 0.88 (4)	2.93 ± 0.46 (2)	2.63 ± 0.62 (2)	4.25 ± 1.24 (4)	3.64 ± 1.09 (4)
PA together as a family	3.61 ± 1.13 (4)	3.38 ± 1.08 (4)	2.87 ± 0.64 (2)	2.56 ± 0.52 (1)	4.63 ± 1.03 (3)	4.36 ± 0.93 (3)
Father provides support of PA	3.27 ± 1.09 (5)	3.23 ± 1.22 (5)	2.4 ± 0.64 (2)	2.69 ± 0.8 (3)	4.06 ± 1.13 (3)	4.43 ± 1.35 (5)
Mother provides support of PA	3.23 ± 1.06 (5)	3.3 ± 1.02 (5)	2.47 ± 0.75 (3)	2.75 ± 0.69 (3)	3.75 ± 1 (4)	4.14 ± 1.17 (4)
Father praises for PA	3.95 ± 1.38 (4)	3.72 ± 1.38 (5)	2.87 ± 0.75 (2)	2.81 ± 0.75 (3)	5.25 ± 1.19 (3)	5.07 ± 1.15 (4)
Mother praises for PA	4.23 ± 1.2 (4)	4.04 ± 1.31 (4)	3.33 ± 0.62 (2)	3.13 ± 0.81 (3)	5.37 ± 0.89 (3)	5.43 ± 0.76 (2)
Mean of parental support	3.63 ± 0.82 (3.58)	3.42 ± 0.82 (3.29)	2.78 ± 0.33 (1)	2.75 ± 0.38 (1.29)	4.51 ± 0.47 (1.72)	4.42 ± 0.56 (1.58)

Note. Data are presented as mean ± SD and range (in parentheses) from baseline measurements, except height, weight and BMI (kg/m2) for children, which are presented from midline measurements. CPM, mean accelerometer counts per minute on leisure time. Scale for parental support of PA is 1 to 6. Organized PA, participation to organized physical activity.
Significant difference between intervention and control groups, $p < 0.05$ (*), $p < 0.01$ (**) and between sexes, $p < 0.05$ (#), $p < 0.01$ (##).

On average, 63% of the children participated in organized PA at the baseline and the prevalence of participation generally showed an increasing trend over time, with a few exceptions: the children of the lowest intervention tertile showed a decreasing trend of participation from the baseline (53.3%) to 6 months (38.5%) and an increasing trend to 12 months (80%), while children of the highest control tertile showed a decreasing trend of participation from the baseline (84.6%) to 6 months (71.4%) and 12 months (66.7%) (Table 15).

TABLE 15 Percentages of children taking part in organized physical activity in intervention and control tertiles of initial parental support.

Initial parental support	Time (months)	Intervention (n)	Control (n)
All	0	60.5 (43)	65.2 (46)
	6	67.6 (37)	71.1 (45)
	12	85.7 (42)	73.2 (41)
Lowest tertile	0	53.3 (15)	68.8 (16)
	6	38.5 (13)	80.0 (15)
	12	80.0 (15)	83.3 (12)
Highest tertile	0	62.5 (16)	84.6 (13)
	6	91.7 (12)	71.4 (14)
	12	87.5 (16)	66.7 (12)

Parental support declined in the intervention and control groups with time, but this overall decline was not significant (unadjusted model, $F = 2.84$, $p = .062$), nor did the change differ between groups (Table 16 and Figure 16). A significant decline in parental support took place within the highest initial parental support tertile of the intervention group from the baseline to 6 months (-0.59 < range of change based on the models used < -0.44, .001 < p < .05) and to 12 months (-0.59 < range of change < -0.43, p < .05) and within the corresponding control tertile from the baseline to 12 months (-0.73 < range of change < -0.63, .001 < p < .05). The decrease in parental support did not differ between the highest intervention and control support tertiles. On the other hand, parental support increased significantly within the lowest intervention support tertile from the baseline to 6 months (0.27 < range of change < 0.34, p < .05), although this change was not significant either when compared with the corresponding control tertile. The three-way interaction of Group × Time × Sex indicated no differences between the sexes in the intervention effect on parental support (Appendix 12).

The lowest intervention tertile of initial parental support increased PA between the baseline and 6 months (0.26 < range of change based on the models used < 0.34, .001 < p < .05) and this change was significant between groups based on the unadjusted model and Model 2 (Table 17 and Figure 16). The mean of raw, non-adjusted counts per minute increased from 515.81 ± 155.68 to 666.49 ± 310.57 (change ~29%), and decreased from 531.82 ± 151.49 to 528.85 ± 199.35 between the baseline and 6 months among the lowest intervention and control support tertiles, respectively. There was no significant change in PA among the children of the highest parental support tertiles. The three-way interaction of Group × Time × Sex indicated no differences between the sexes in the intervention effect on PA (p > .05) (Appendix 12).

TABLE 16 Changes in parental support within and between intervention and control support tertiles of initial parental support.

Outcome	Time (months)	Unadjusted mean (SD) Intervention	Control	p-value	MODEL 1 Adjusted change between groups (95% CI)	p-value	MODEL 2 Adjusted change between groups (95% CI)	p-value
Parental support								
All	0	3.63 (0.82)	3.42 (0.81)					
	6	3.46 (0.61)	3.31 (0.83)	.102	0.07 (-0.19 to 0.32)	.612	0.04 (-0.23 to 0.32)	.751
	12	3.45 (0.70)	3.21 (0.80)	.915	0.10 (-0.23 to 0.44)	.543	0.08 (-0.26 to 0.43)	.635
Lowest parental support tertile	0	2.77 (0.33)	2.74 (0.37)					
	6	**3.04 (0.41)**| łǂ	2.90 (0.75)	.411	0.23 (-0.08 to 0.55)	.146	0.28 (-0.06 to 0.62)	.107
	12	2.95 (0.38)	2.78 (0.77)	.871	0.11 (-0.30 to 0.53)	.581	0.56 (-0.37 to 0.48)	.796
Highest parental support tertile	0	4.51 (0.46)	4.42 (0.55)					
	6	**3.92 (0.56)**||łǂ	4.20 (0.55)	.244	-0.22 (-0.80 to 0.36)	.450	-0.29 (-0.98 to 0.40)	.400
	12	**3.96 (0.74)**|ł	**3.68 (0.71)**||łǂǂ	.623	0.22 (-0.39 to 0.82)	.475	0.20 (-0.45 to 0.86)	.541

| Within group change from baseline significant at the level of p < .05 and || p < .01 (unadjusted model).
ł Within group change from baseline significant at the level of p < .05 (model 1).
ǂ Within group change from baseline significant at the level of p < .05 and ǂǂ p < .01 (model 2).

TABLE 17 Changes in overall physical activity within and between intervention and control support tertiles of initial parental support.

Outcome	Time (months)	Unadjusted mean (SD) Intervention	Control	p-value	MODEL 1 Adjusted change between groups (95% CI)	p-value	MODEL 2 Adjusted change between groups (95% CI)	p-value
Physical activity (CPM_log)								
All	0	6.33 (0.32)	6.22 (0.26)					
	6	6.41 (0.40)	6.25 (0.28)	.608	-0.12 (-0.29 to 0.05)	.154	-0.07 (-0.24 to 0.10)	.405
	12	6.28 (0.29)	6.28 (0.33)	.226	-0.10 (-0.28 to 0.09)	.306	-0.12 (-0.31 to 0.07)	.210
Lowest parental support tertile	0	6.20 (0.30)	6.24 (0.28)					
	6	**6.40 (0.47)**‖ł‡	6.21 (0.34)	**.041**	0.21 (-0.08 to 0.50)	.143	**0.30 (0.02 to 0.58)**	**.037**
	12	6.24 (0.30)	6.22 (0.30)	.801	0.35 (-0.31 to 0.38)	.839	0.05 (-0.29 to 0.38)	.788
Highest parental support tertile	0	6.33 (0.23)	6.27 (0.26)					
	6	6.37 (0.40)	6.37 (0.17)	.671	-0.19 (-0.43 to 0.05)	.118	-0.13 (-0.41 to 0.16)	.365
	12	6.29 (0.28)	6.42 (0.31)	.184	-0.13 (-0.38 to 0.12)	.290	-0.13 (-0.41 to 0.14)	.332

| Within group change from baseline significant at the level of p < .05 and ‖ p < .01 (unadjusted model).
ł Within group change from baseline significant at the level of p < .05 (model 1).
ǂ Within group change from baseline significant at the level of p < .05 and ‡ p < .01 (model 2).

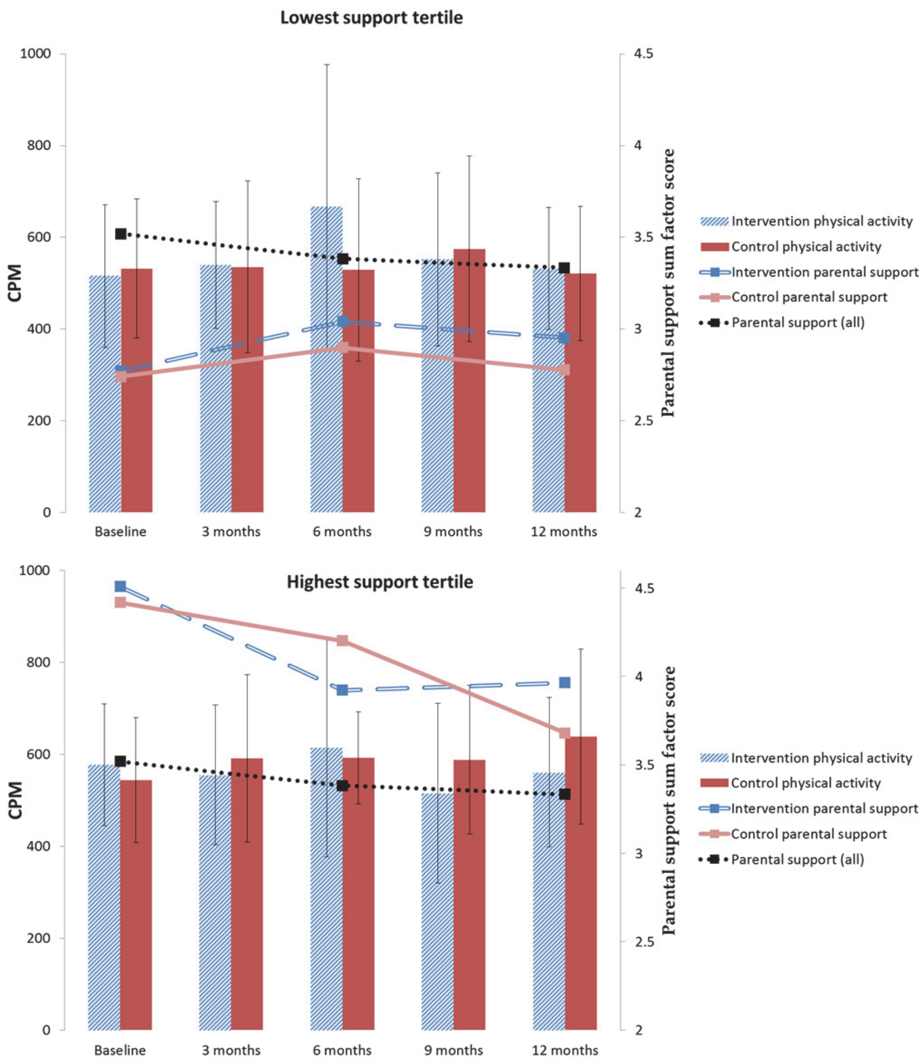


FIGURE 16 Physical activity and parental support in intervention and control groups of lowest parental support tertile. CPM = mean counts per minute.

5.5 Intervention evaluation

Compliance with the intervention was estimated on the basis of information of how often parents were reached for different parts of the counseling process. This was aimed to describe how well the planned treatment was delivered to the participants. Accordingly, every parent (n = 69) in the intervention group received a lecture (~ 30 minutes) and face-to-face counselling with individual goal setting (~ 30–60 minutes). Of the parents, 64 (93%) and 51 (74%) were reached for phone discussions at 2 and 5 months after the beginning of the study counseling, respectively. The compliance rate of phone counseling for the parents of the lowest and highest initial parental support tertiles were 95% and 92% at 2 months and 74% and 83% at 5 months, respectively. Goals set by the parents during the face-to-face counselling session contained on average 3.5 goals intended to increase the child's PA (Table 18). The most common goals were PA with family, PA outdoors, PA in the backyard or in the neighborhood, PA with peers and PA indoors. Another part of the compliance, answering the question of how well set goals were implemented in practice, was unfortunately not researched in this study. Based on the phone counseling, parents perceived weather and being busy as the most common barriers to goal implementation on weekdays. Correspondingly, being busy, weather and tiredness were the most commonly perceived barriers on weekends.

To evaluate the feasibility of the PA counselling of the present study, parents in the intervention group were asked to rank the PA counseling tools in order of importance from their own perspective. Interestingly, the parents of the lowest parental support tertile clearly perceived face-to-face counseling (44%) as the most important intervention tool, while the rest of the parents rated either feedback or the lecture as the most important intervention tool (Table 18). On the other hand, perceptions of the most important intervention tool were spread between several intervention tools among parents of the highest parental support tertile.

TABLE 18 Initial goals set, barriers perceived, and perceptions of the most important intervention tool in parents of the intervention group.

	All (*N* = 68)	Lowest parental support tertile (*n* = 19)	Highest parental support tertile (*n* = 23)
Goals set in the face-to-face counseling (%)			
PA with family	28	27	30
PA outdoors	25	19	28
PA in the backyard or in the neighborhood	22	18	28
PA with peers	18	21	12
PA indoors	6	12	2
Other	1	3	0
Barriers perceived in the phone counseling (%)			
On weekdays			
Weather	38	30	24
Being busy and other tasks to do	30	40	19
Own or child's tiredness	17	20	33
Other	15	10	24
On weekends			
Weather	21	0	21
Being busy and other tasks to do	35	55	53
Own or child's tiredness	10	27	11
Other	34	18	15
Intervention tool perceived as the most important (%)			
Face-to-face counseling	32	44	14
Feedback from measurements	25	33	21
Lecture	21	22	21
Phone counseling	7	0	14
Printed material	4	0	7
E-mails	4	0	7
Project webpages	0	0	0
Other things	7	0	14

6 DISCUSSION

There has been a call to build an evidence base for different models that better predict children's PA and which include parent- and child-mediating variables along with strategies that can affect changes in these variables (Davison et al. 2013b, O'Connor, Jago & Baranowski 2009). Consequently, the aim of this thesis was to examine the effect of family-based PA counseling on 4–7-year-old children's PA and motor competence (MC) when taking interaction of theory-based variables into account. While MC is hypothesized to interact with PA in childhood, there is a lack of understanding of how objective accelerometer-derived PA can be interpreted in terms of MC. The accelerometer output in physical activities typically considered to develop MC was therefore examined, and the association between accelerometer-derived PA and motor competence was researched. These methodological investigations were aimed at contributing towards an understanding of this developmentally important interaction between PA and MC, and for gaining insight into how PA intervention can mediate development of MC.

6.1 Theoretical implications

In the following chapters, the main findings of the thesis are discussed in light of previous research literature.

6.1.1 Association between accelerometer-derived physical activity and motor competence

When researching the accelerometer-derived intensity of physical activities typically considered to develop MC in childhood (paper I), greater standard deviations were found in task performance times among preschool-aged children (4–6 years old) than among first-grade-aged children (7–8 years old). This finding may suggest that chosen tasks represent domains of fundamental motor skills which are developing (at least) until school age (approximately 7–8 years old) (Gallahue & Ozmun 2002). On the other hand, the physical activities typically considered to develop MC were found to vary on the whole spectrum of the accelerometer-derived PA intensities. Tag, the ball game, crawling and stair walking were found mostly to induce moderate-to-vigorous metabolic PA intensity and high neuromuscular impacts. In particular, crawling was found to induce PA of vigorous metabolic intensity PA and a great proportion of time of high neuromuscular impacts. This may be simply because in the crawling the impacts induced to body are recorded by accelerometers more directly compared to movements performed in the upright position where the (whole) leg and its different constructs absorb impacts of movement measured from the waistline. Contrary to physical activities of moderate-to-vigorous intensity, intensity of PA was found to be mainly light or sedentary in one third of the chosen physical activities.

Climbing and balance beam walking were typically performed with low metabolic intensity, and mainly low neuromuscular impacts were induced on the body during these physical activities (paper I). Although these physical activities may not significantly increase energy expenditure nor stress the cardiorespiratory systems (see chapter 2.1), they can play a crucial role in motor development. Balance has been seen as one of the fundamental domains of motor competence and, importantly, as a foundation for the locomotive and manipulative domains of fundamental motor skills (Gallahue & Ozmun 2002). Basically, any kind of motion requires a sense of balance and stability (Haywood & Getchell 2009), and the balance beam walking task in this study was specifically aimed at stressing the need for balancing. In this PA task, one had limited stability for gait because of the smaller base of support from the beam, ultimately leading to a greater need for balancing. On the other hand, climbing represents a common PA during childhood (Fjortoft 2001). A typical movement pattern of climbing requires bilateral and reciprocal body coordination and crossing of the body centerline, which employs an interaction of the left and right sides of the brain. Specifically, crossing of body centerline has been seen as important for so-called "sensory integration," referring to the ability to process sensory information, which ultimately is assumed to give a basis for typical human behavior (Ayres 2008). Although evidence of the effectiveness of the interventions based on the sensory integration ideology is lacking, and the rationale of sensory integration should therefore be interpreted with reservations (Dawson & Watling 2000, Hyatt, Stephenson & Carter 2009), climbing can be seen to represent a typical motor skill pattern needed in physically active play typical of age and developmental level (Fjortoft 2001).

The findings of the study further suggest that some motor developmentally important physical activities are not captured by the current accelerometer signal interpretation techniques. For instance, there is probably a lot of isometric and slow concentric muscle work in climbing which does not cause significant acceleration forces (Mikkonen & Juutinen 2013). The same could be assumed regarding the efforts needed for balance beam walking in the current study. The findings underline that when PA is measured in children with a focus on motor competence aspects, the whole spectrum of accelerometer-derived PA intensities should be taken into account. When available, using motion recognition algorithms for capturing movement patterns from the raw accelerometer signal would be recommended. However, those signal interpretation techniques have to be validated with care in real-life conditions before being conducted in large-scale field investigations (Intille et al. 2012).

The real-time g-force analysis used to examine the relationship between accelerometer-derived PA and MC revealed that short and high neuromuscular impacts performed in daily life are associated with MC in girls especially (paper II). This novel finding suggests that girls who move vigorously and whose PA induces high neuromuscular impacts are more likely to have better MC than girls who do not engage in such physical activities on a regular basis. The relationship between MC and the ability to perform high neuromuscular forces is logical because the gain in force production is mainly explained by better motor coordination in children (Ozmun, Mikesky & Surburg 1994, Ramsay et al. 1990). Interestingly, this association was not observed in boys. The explanation may lie in the differences of habitual PA between the sexes. Based on field observations, girls are found to avoid physical activities that are vigorous and rough in nature in childhood (Pellegrini & Smith 1998), which could explain the better MC in girls who "stretch" these sex-related behavioral codes. To support this assumption, several reviews have concluded that a consistent difference exists between the sexes in the amount of PA, as well as in the amount of moderate-to-vigorous PA levels (Bauman et al. 2012, Hinkley et al. 2012, Sallis, Prochaska & Taylor 2000, Tucker 2008). Although cross-sectional inspection does not give information of the direction of causality, it can be assumed that the girls who perform physical activities of high intensities stick out of the typical crowd of girls in terms of development of MC. On the other hand, a strong relationship between MC and the overall level of PA in preschool-aged boys may indicate the low overall level of PA in children. This may be the case because when compared to overall levels of PA monitored in Dutch preschoolers, the preschool-aged boys of the current study were only moderately physically active (Cardon & De Bourdeaudhuij 2008). The low overall level of PA in the population may therefore strengthen the association between the higher overall level of PA and greater MC in preschool-aged boys (paper II). Overall, these findings support the hypothesis of the close developmental relationship between PA and MC in childhood (Robinson et al. 2015, Stodden et al. 2008).

6.1.2 Effects of the family-based physical activity intervention

The family-based PA counseling at the present study was primarily aimed at increasing objectively measured PA in 4-7-year-old children. The counseling was moderately intensive in nature, as it consisted of a single lecture, face-to-face counseling and goal setting, and two instances of phone counseling with the children's parents during a 6-month intervention period. The counseling was based on the Social Cognitive Theory (SCT) and Theory of Planned

Behavior (TPB), as these frameworks give solid theory-based tools for affecting parents' behavior to support their children's PA in daily life. Choices of everyday life were emphasized as a foundation to habitual PA, and parents were encouraged to think thoroughly about possibilities for setting goals (for instance, possibilities for enhancing physically active commuting between home and childcare/school, enhancing possibilities for physically active play). The strategy was not to give ready-made tools of how to increase PA in children; parents were instead encouraged to think of those from their own perspective and possibilities in everyday life.

The results, however, indicated a statistically significant decline of objectively measured MVPA in children of the intervention group when compared to children of the control group. The finding underlines the challenging nature of influencing objectively measured PA behavior in children, since the majority of PA interventions have not been effective to increase objectively assessed PA in children (Metcalf, Henley & Wilkin 2012). Besides, family-based interventions have been found to be especially challenging as negative changes in PA behavior have not been exceptional (Gordon et al. 2013). However, there is generally a lack of family-based PA interventions, and little is known of how to involve families in PA enhancement in their children (O'Connor, Jago & Baranowski 2009, Riethmuller, Jones & Okely 2009). It is known that families face conflicting interests when it comes to time management (Thompson et al. 2010), and it may be that the goals set during the present study (considering, for instance, children's physically active commuting) may increase pressures in terms of time management. On the other hand, the cluster-randomized children in the current study represented a typical population, which means that possible changes in PA behavior would have meant exceeding the common PA level of the age group. In other words, there would be more potential to achieve enhancement in PA in children with a low baseline level of PA. However, a low baseline level of PA would not probably have made it any easier to influence the children's parents to provide more support for their PA. Consequently, the intervention strategies affecting parenting practices and behavioral change for supportive parenting should be in focus when considering family-based PA enhancement in children. The counseling protocol of the present study was shown to be ineffective in increasing PA in 4–7-year-old children.

It was hypothesized that PA counseling would be reflected in the development of MC in the children. In the secondary outcome of MC, a nearly significant greater development of ball-handling skills in children (TCB) during the reinforced intervention period (0–6 months) was observed, although the effect was attenuated and absent at the 12-month follow-up. While the present findings should be interpreted with caution because of a lack of statistical significance, they support rather than contradict the statement that encouraging parents to change behavior to support PA in their children may contribute to the development of object control skills, without a change in objectively measured PA. This may be an important result for the family-based approach, because object control skills (i.e. ball-handling skills) have been stated as more difficult to influence than locomotor skills (Morgan et al. 2013) and, most importantly, acquired ball-handling skills have been shown to predict PA and fitness later in life, especially for girls (Barnett et al. 2009a, Barnett et al. 2008b). However, as previous intervention studies have shown good sustainability of the acquired MC in children (Lai et al. 2013, Zask et al. 2012), the development of object control skills in the intervention children was attenuated after a reinforced intervention period in the present study. This occurred regardless of the individualized feedback given on the level of children's MC and informational tips on how these domains could be further improved. Providing context and developmentally specific information to families based on the developmental level of the child could be a strategy worth of considering in the forthcoming family-based PA interventions because most parents do not likely have the background to understand how to address developmentally appropriate PA in everyday life. On the other hand, it can be speculated that family-based PA intervention itself does not guarantee the further development of ball skills (for example, in a school context) because girls especially have little ball game-orientated lesson contents at school in Scandinavian countries (Redelius & Larsson 2010), which may also reflect lesson-break activities. Therefore, home context should be seen as a potential reinforcer of the development of ball skills. Ideally, educational, curricular and other environmental contexts should be affected at the same time in order to strengthen the sustainability of the skill development.

Results of the present study run parallel with previous interventions employing parents as promoters of PA and MC in their own children. In the study of Hamilton et al. (1999), children at risk of developmental delay significantly outperformed their control peers in ball-handling skills after an investigator-led and mother-assisted eight-week motor skill intervention. Secondly, Cliff et al. (2011) recruited obese children to participate in structured PA sessions led by a qualified PE teacher over a ten-week period. Families were educated to enhance social support for PA, to monitor behavior, to identify barriers for PA, and to set goals enhancing PA in their obese children. As a result, motor skills improved significantly compared to control peers, but objectively measured PA stayed unchanged between groups. Therefore, family involvement would be a serious intervention component to include when aiming to enhance gross motor development in girls, while improved MC may act as a mediator for increased PA (Cohen et al. 2015). However, it is crucial to also further research direct strategies for affecting PA, as interventions aimed at affecting PA in children have produced modest effects in general (Metcalf, Henley & Wilkin 2012). We clearly need more knowledge about how to efficiently involve, for example, families themselves in enhancing PA in children.

It was also researched whether seasonal variation interacts with the intervention effect on PA and MC. This question was studied on the basis of evidence showing significant variation in PA and fitness in children in association with seasonal variation (Augste & Künzell 2014, Carson & Spence 2010). Results suggested an interaction between season and intervention effect on the development of MC in children. Specifically, if PA counseling was started during an inactive season, the development of KTK performance was steadier (no decline of MC) during the follow-up (6–12 months) taking place during an inactive season. The result would therefore suggest a sustained intervention effect on the development of MC when PA counseling is delivered during an inactive season. Perhaps the PA counseling given during a naturally inactive season and followed by a naturally active season may be a beneficial combination for a steadier development of MC. However, these conclusions remain suggestive, as this finding relates to a relatively small group of children.

Interestingly, although some intervention effects on development of KTK and TCB were found, there were no observed differences in objectively measured PA between children of the intervention and control groups. The reason for this contradiction can be explained by the multifaceted relationship between PA and MC shown in the sub-studies of the present thesis (papers I and II) and in previous research in the field. Because object-control skills require training of these specific skill domains in order to be developed and are not simply the result of accumulated PA (Logan et al. 2011), it is likely that current accelerometer-based PA monitoring and signal interpretation techniques are not able to detect this kind of activity or training. As shown in paper I of this thesis, counts cut-off points –based sedentary-to-light intensity PA, along with MVPA, was associated with physical activities typically seen as developing gross motor skills in children. Thus, it seems difficult to track some developmentally appropriate PA via current accelerometer techniques. Interestingly, aside from the proportion of time spent in MVPA, brief but high-impact peaks may play a role in the development of MC in girls especially (paper II). This finding further highlight the need for developing and validating more precise accelerometer signal interpretation techniques for better examining habitual PA from the motor developmental perspective.

Differences between groups regarding changes of PA analyzed on the basis of the neuromuscular-based method were not researched at the present thesis. This was because of the preliminary state of the neuromuscular data interpretation technique. Apparently, there were no differences between intervention and control groups regarding changes of PA analyzed on the basis of the neuromuscular-based method (Appendix 13) although this remains speculative. Clearly, more comprehensive interpretation of accelerometer-derived PA from the view of motor development warrants future study. Motion recognition on the basis of accelerometer raw data is one of the most promising developments in this field (Bonomi et al. 2009, Brezmes, Gorricho & Cotrina 2009, Chambers et al. 2015, Intille et al. 2012). The ability to objectively capture motor developmentally important movement patterns (for example, fundamental movement skills) (Gallahue & Ozmun 2002) may better explain why MC develops even though there does not appear to be remarkable changes in the overall level of PA. Until now, there is very little knowledge about what kind of PA is associated with motor development in children. The overall estimations of quantity and intensity are generally well researched, but the next step remains to research PA in more detail from the perspective of motor development. Also, self-reporting or reports from parents would be useful supplementary tools for assessing PA, as children may engage in activities that help their MC development but are not shown in the monitor readings.

Behavioral theories such as social cognitive theory (Bandura 1986), as well as qualitative (Thompson et al. 2010) and quantitative research evidence (e.g. Cleland et al. 2011, Telford et al. 2013), argue that the family environment is a key context for children's PA. Given the strong theoretical basis and research evidence of family influences on children, family-based PA interventions have not succeeded in finding effective strategies to increase objectively measured PA in children (Davison et al. 2013b, Metcalf, Henley & Wilkin 2012, O'Connor, Jago & Baranowski 2009, van Sluijs, Kriemler & McMinn 2011). This failure indicates a need to better understand PA parenting and associated constructs, which would contribute to family-based intervention design and implementation. Parents would probably gain even more from instant feedback about children's PA and MC and practical advice for enhancing the development of MC in their children. On the other hand, a significant decrease in MVPA in the intervention group compared to control group in the present study (paper III) was unexpected, although there are some parallel findings (Gordon et al. 2013). Perhaps the increased time spent with family was compensated for with decreased time spent with peers, which may have led to decreased physically active play overall. Additionally, the PA in diversified outdoor environments was emphasized in the counseling lecture and discussions, and it may be that time spent, for instance, in forests instead of parks may partly explain the compensation of accelerometry-derived MVPA by PA of lighter intensity. Time spent in diversified environments might also associate with the significant intervention effect on the KTK performance. On the other hand, it may be that the advance knowledge of being part of a study where PA counseling is given may have induced an unwanted treatment effect already at the baseline PA assessments potentially explaining the significantly higher baseline level of MVPA and lower baseline level of sedentary time in children of the intervention group compared to the control group. However, these explanations remain speculative.

6.1.3 Initial parental support as intervention effect moderator

This cluster-randomized, controlled trial aimed at enhancing objectively measured PA in children aged 4 to 7 years via individually tailored PA counseling with their parents. It was hypothesized that initial parental support of children's PA would influence the intervention effect, and therefore analyses were done separately for children with different levels of initial parental support. As a main result, it was found that counseling did not have a significant overall effect on PA in the children (paper III). However, the novel finding relates to the children of the intervention group with lowest parental support at the baseline, and who increased their objectively measured leisure-time PA significantly when compared with their control peers. At the same time, parental support provided to the children of the lowest intervention tertile increased, although this change was not significant compared to the corresponding control tertile. These findings suggest that targeting parents who provide low support for their children's PA could be a promising intervention procedure when aiming to enhance PA in children, at least in the short term.

The general level of parental support (2–3 times per week), independent of the child's sex at the baseline, and a trend of declining parental support over time are in accordance with the results found in two groups of Australian children (aged 5–6 and 10–12) (Cleland et al. 2011). A unique finding of the present study was that the developmental trend of parental support was different in parents according to the initial level of support they provided to the children. Parents of the lowest tertile increased support of their children from the baseline to 6 months, a change that was significant within the intervention tertile. However, individual counseling was not seen as an influential procedure for affecting parents of the highest support tertile. For highly supportive parents, the aim of family-based PA interventions should probably be the maintenance of the initial level of support. This is because a target of increasing parental support may be perceived as unrealistic, and it could decrease motivation to reach the target.

It has been suggested that promoting parental support in childhood is important when considering changes in PA later in adolescence (Davison & Jago 2009, Kahn et al. 2008). This may be especially crucial for girls, because parental support in childhood and later in adolescence predicts the maintenance of PA level in girls (Davison & Jago 2009). A positive finding in the present study was that intervention effects are independent of children's sex and that family-based counseling can be seen as a tool for enhancing parental support in both girls and boys equally.

Even though the absolute level of parental support in the intervention children of lowest parental support tertile did not reach even the average of the total sample, the physical activity level increased considerably in these children at six months. It is possible that the change in parental support, regardless of the absolute level, may have a significant effect on children's PA, a possible effect that should be examined in further studies. On the other hand, the baseline level of counts per minute (567.70 ± 188.0) found in the present study, indicating the overall level of PA, was lower than the counts per minute of 701 found in 4–5 year olds elsewhere (Cardon & De Bourdeaudhuij 2008). The level of 666.49 counts per minute recorded in the children of the lowest parental support tertile after the intervention period can be seen as more comparable to the overall level of PA found in similarly aged children.

Interestingly, intervention had a significant effect on leisure-time PA in children in the lowest parental support tertile independent of organized PA. It appears that children with the lowest parental support favored unorganized leisure-time activities with their parents during the reinforced intervention period. On the other hand, parents of the highest intervention support tertile seemed to encourage their children to participate more in organized PA. Maybe providing possibilities for taking part in organized activities was considered as the most probable way to increase the level of PA in these children, because increasing support in the home environment would have been difficult, given the high baseline level of support. Unfortunately, this did not convert into an increased level of objectively measured PA in these children.

Recently, Rhodes et al. (2013) stated that a mother's perceived control over supporting a child in healthy PA habits predicted actual behavior, that is, it provided support for the child's PA. Notably, the attitude of mothers towards providing support for children's PA predicted intention but not actual behavior. Rather than merely increasing knowledge of the benefits of the intended behavior, supporting parents in the behavior-changing process should therefore be the primary focus when promoting PA via family-based interventions. This assumption is supported by the present study, in which the majority of parents, and especially the parents of lowest initial parental support tertile, rated individually tailored face-to-face counseling as the most important intervention tool. Actually, face-to-face counseling was especially highly appreciated among the parents who initially provided the least support for their child's PA. This is an important result, as the PA in their children significantly increased during the reinforced intervention period compared to control peers. Maybe this shows that face-to-face counseling has potential to support parents' perceived control over supporting their child's PA (Rhodes et al. 2013). It is also an important result, because a 30–45 minute counseling session can be practically implemented. This should be investigated by further research, however, since it was not examined in the present thesis. Furthermore, feedback from measurements and an informative lecture were seen next frequently as the most important intervention tools in the present study. Surprisingly, the phone discussions aimed at continuing the individual counseling were perceived as only the fourth most useful intervention tool after feedback from measurements and the counseling lecture. Maybe a follow-up on the achievement of goals would have been better implemented face-to-face instead of over the phone, because direct contact with parents and direct involvement of parents have been found to be effective strategies in family-based PA and nutritional interventions (Hingle et al. 2010, O'Connor, Jago & Baranowski 2009). However, in the search for convenient implementation strategies, minimal personal contact is perceived to be more cost-effective, and intervention examinations should therefore aim to find a balance between the ideal treatment and the treatment that is feasible in real-life circumstances.

As parents inevitably face many barriers challenging perceived control over providing support for children's PA (Rhodes et al. 2013), the barriers itemized in the present study paralleled those of parents of children aged 10 to 11 in the United Kingdom (Thompson et al. 2010). In the present study, individual counseling aimed at encouraging parents first to identify locations and occasions where it is possible to promote PA in their children and, secondly, to set feasible small goals that fit these conditions. Moreover, individual counseling enabled confidential discussion of the barriers that parents perceived. Interestingly, the barriers perceived on weekdays were somewhat different among the parents of the lowest and the highest support tertiles. Although positive intervention effects were found regarding both parental support and objectively measured PA in the lowest intervention tertile children, this trend did not continue after the reinforced period. It may be that continuous reinforcement for supporting PA in children and individual support, such as regular feedback on the level of children's PA, are needed in order to maintain the positive short-term effects. This finding endorses the value of parent-authority interaction and justifies the use of PA-targeted counselling for parents with low support of their children (for instance, as a part of maternity and child welfare clinic visits). To be able to effectively allocate that kind of counseling to the target group, parents who provide the least support for their children's PA should be screened and identified. The FPAE questionnaire, for instance, would be suitable for that purpose, although the reliability and validity of the format in the target culture should be investigated thoroughly before larger investigations.

6.2 Methodological considerations

Various methodological issues arose from the design of the four different studies described in this thesis. The findings of the thesis must be interpreted in light of the methodological choices made, including, for instance, the study population, PA and MC measurement methods, parental support questionnaire and statistical methods.

All of the children enrolled in the studies of this thesis were aged between 4 and 7 years old at the baseline. This holds also for the children participating in the sub-study of paper I. As the reviewed literature indicates (see chapter 2.1.1), there are some differences in children's PA behavior with regard to age and developmental level, which may cause bias in the findings. It is likely that the relationship between PA and MC is different in children of different ages (Stodden et al. 2008). It is also likely that children of different ages react differently to the PA counseling delivered to their parents. Thus, it would be optimal to have similarly aged children in the research. On the other hand, age has not been found to be a consistent correlate of the level of PA in children (e.g. Hinkley et al. 2008). It is likely, although not researched in this thesis, that solely inter-individual variability in PA is larger than age-related variability. Anyway, in all the statistical tests testing either associations between PA and MC or intervention effect, the child's age was covaried (studies III and IV) or taken into consideration by analyzing preschool-aged (4–6 years old) children and primary school-aged (7–8 years old) children separately (papers I and II). Secondly, as reviewed earlier (see chapter 2.1.1), there obviously exist differences between girls and boys regarding the level of PA, as well as the quality of PA. Also, the responsiveness to PA intervention may differ, depending on the sex of a child. However, there was an aim to decrease possible bias caused by sex differences by enrolling an equal number of girls and boys in the sub-studies of this thesis.

Further, sex was always covaried in the statistical analysis when perceived to be necessary.

Various methodological issues can be raised in relation to the PA measurements (see chapter 2.3.3). Although accelerometers have obvious advantages for measuring habitual PA in children in an objective way, there are certain limitations that may threaten the validity of this method. Probably the most well-known limitation is so-called reactivity to the device, which means that awareness of being monitored by the device may affect habitual PA (Dössegger et al. 2014). Ideally, it would be recommended for the first measurement day to be omitted from the final analysis. Similarly, it could be recommended to randomize the first day, as it may make a difference if the starting day is a weekday or on the weekend. For the present thesis, the first PA measurement day was basically a random weekday; subjects always received devices on a random weekday at each measurement point. However, a choice was made not to remove the first PA measurement day from the statistical tests. The reason was that a minimum of 3 days (2 weekdays and 1 weekend day) was set as a threshold for an acceptable PA measurement point (Penpraze et al. 2006). There were few subjects with this minimum of 3 valid measurement data at the baseline, and removal of the first measurement day would have "cost" the removal of these subjects from the intervention effect analyses. It was decided, therefore, to accept all valid PA measurement days, even at the cost of possible bias caused by the first measurement day, in order to maximize the study subjects and thus the statistical power of the intervention analyses. Secondly, the amount of valid measurement days was maintained as three because this was seen to be a more preferable procedure than lowering the minimum day of valid measurement days to two days (1 weekday and 1 weekend day). There is literature showing that 3 days of accelerometer measurement provides satisfactory (Cronbach's alpha > .60) measurement reliability (Penpraze et al. 2006) while less days result in lower and more days in better reliability (Cliff, Reilly & Okely 2009). In the first study of the present thesis (paper I), PA was measured only during supervised tasks and there was no aim to monitor habitual PA. Therefore, all PA measurements with acceptable technical validity were accepted for the analyses in paper I.

The accelerometers used in this particular thesis for monitoring PA in children were not standard devices, such as ActiGraph. Several studies have shown a strong positive correlation between ActiGraph accelerometer output and PA in children (e.g. Pate, O'Neill & Mitchell 2010, Reilly et al. 2003, Rowlands 2007, Sirard et al. 2005, van Cauwenberghe et al. 2011), and ActiGraphs have been considered as feasible and reliable tools for measuring PA in children (e.g. Cliff, Reilly & Okely 2009, Pate, O'Neill & Mitchell 2010, Rowlands 2007). The non-standard devices used in this thesis (Gulf Coast Data Concepts) were first piloted, as recommended (Intille et al. 2012) (see chapter 4.6.1). Additionally, the calibration of the devices used in this study was conducted in accord with the protocol recommended by the manufacturer (see chapter 4.6.1). Also, all PA measurements were visually analyzed for proper device functioning and for possible malfunctions. In case of malfunction, the period of data was removed from further considerations. Generally speaking, the accelerometers used in this thesis showed very few malfunctions. Two of the twenty devices used were broken during the two years of data collection and around 3000 days of PA measurement.

The time period used for analyzing sum of counts was 15 seconds in all of the investigations in this thesis. This may be problematic, since children's PA is known to be intermittent in nature (e.g. Bailey et al. 1995) and the averaging of counts over a relatively long time period may hide short-term PA behaviors, such as those that are vigorous in nature. To compensate for this issue, PA was analyzed using the real-time-based g-force histogram in the sub-studies of papers I and II. In papers III and IV, PA measurements could have been analyzed using this real-time method, but was not conducted because of the immature phase of the signal interpretation technique. However, this approach warrants future research. Overall, through use of standardized accelerometer signal interpretation techniques, as counts cut-off points at the moment, it is possible to internationally compare the findings of the present thesis with similar studies.

The validity of the indoor physical activities chosen for the first study (paper I) of this thesis can be argued. The main point of this study was to measure objectively, and as reliably as possible, a wide scale of typical physical activities in children. There is no evidence showing that particularly the physical activities chosen for examination would be the most typical activities performed indoors or that they would be the most important for motor development in childhood. However, there was relatively high consensus among the panel of PA research experts who chose the physical activities to be measured in this study. There would have been several other physical activities to be measured, but various issues affected the choices (e.g. reliability issues, considering objective measurement of the physical activities). For instance, it would be difficult to show the accelerometer-derived intensity of PA for free soccer play, since there is likely very high variability in intensities of PA between players and game sessions and individually during a single game. Therefore, physical activities believed to show relatively high consistency in PA intensity between individuals and sessions and within individual performance were prioritized for the study.

Various methodological issues can be raised in terms of MC measurements. The KörperkoordinationsTest für Kinder (KTK) (Kiphard & Schilling 1974, Kiphard & Schilling 2007) was used as a primary tool for assessing MC in children. The KTK measurement protocol is designed for children aged 5–15, but children under 5 years of age at the baseline (n = 9) were also included in this study. Because the developmental rate of KTK was statistically consistent between children under and over 5 years old, the inclusion of children under 5 was considered justified.

As reliability of the KTK has been found to be moderate-to-high in several investigations (see chapter 4.6.3), the greatest methodological issue may be raised from the validity of this protocol to measure MC in children. The KTK has shown moderately strong (r = .44 - .64) correlation with a Movement ABC test battery total score (Henderson & Sugden 1992, Smits-Engelsman & Henderson 1998), as well as with BOT-2 total and gross motor composite score (Fransen et al. 2014). Both of these tests have been widely used for assessing motor functions in children (Cools et al. 2009). Moderate correlations indicate that the different protocols measure only partly the same domains of MC in children. This is also confirmed in the different sensitivity of these tools to categorize children in the lowest 15th percentile, which is generally seen as indicating a risk of motor impairment (Fransen et al. 2014, Smits-Engelsman & Henderson 1998). There is a lack of consensus, however, which tool is the so-called "golden standard" that other tools should be compared to (Venetsanou et al. 2011). Therefore, when interpreting the findings of the present thesis in terms of MC, the characteristics of the KTK tool for assessing MC have to be taken into account. The KTK has been seen to emphasize coordinative capacities, as well as strength and speed (Vandorpe et al. 2011), but on the other hand there are no tests for ball-handling competence. To make up for the lack of this in the KTK protocol, a throwing and catching a ball test (TCB), originally researched and validated by Numminen (1995), was utilized. Although the reliability of the TCB test has been found to be acceptable in the original validation study (Numminen 1995), some caution should be paid when interpreting the results of the present thesis regarding the TCB test. The greatest limitation regarding the TCB test in the present thesis was that it was found to be too challenging by some of the youngest participants, resulting in a few null performances at the baseline (floor effect) and therefore making the sample distribution non-normal. It is also probable that the test protocol, even after making it more difficult, became less powerful among the oldest children, while the variance of the TCB test decreased when the end of the research approached (ceiling effect). Therefore, other validated measurement tools for assessing manipulative skills should be considered in the forthcoming PA interventions investigating this wide age group of children.

There are also some methodological issues considering the FPAE questionnaire used for measuring parental support of children's PA. The FPAE form has been validated in 5–12-year-old Australian children (Cleland et al. 2011), but its validity and reliability in other countries has not been investigated. However, the FPAE questionnaire was carefully translated into the local language, and its language and suitability for the local culture were pretested. Additionally, the internal consistency of the questionnaire items was found to be acceptable. Secondly, the subgroups in paper IV were relatively small after being divided into the lowest and highest initial parental support tertiles, a fact which may hinder the intervention effect. There is, however, a general lack of family-based PA interventions for children, and more pilot or moderate-scale experiments are needed to find promising strategies before conducting larger, population-level interventions.

The results of the present thesis should be generalized to the population with care, because the families enrolled in this study mainly represented highly educated families and single-parent families were underrepresented. It is possible that these factors may affect, for example, what kind of challenges parents face when it comes to providing support for children's PA, which again may affect the counseling effect. Although these confounding factors were taken into account in the statistical modelling of the study (papers III and IV), a low number of families in the total may cause a potential source of bias in the findings. More research is needed with larger sample sizes in order to confirm these findings. A further limitation of the study was a lack of a dose-response analysis of the intervention efficacy for answering the question on whether the families with greater engagement with the intervention tools or goals benefited from them more than families with lower engagement. Specifically, examining the parents' delivery of the intervention in practice would be an important issue to be researched in a more systematic manner in the forthcoming family-based PA interventions because parental behavior change forms the primary mechanism hypothesized to affect children's PA. In general, more attention should be paid to the issues behind low parental support of children's PA, as this study and the literature reviewed (see chapters 2.2.2 and 2.4.2.2) suggest that they could be a target group for PA enhancement in children.

6.3 Strengths of the study

This study aimed to utilize interdisciplinary knowledge for contributing to the understanding of objective PA measurement in relation to MC in children. As a result, this work created a unique approach for interpreting accelerometer-derived PA from a neuromuscular-based perspective together with a metabolic-based perspective. Specifically, the neuromuscular perspective on the interpretation of accelerometer-derived PA was found to give meaningful information about the relationship between habitual PA and MC in children. In addition, it can be seen as a strength that knowledge of behavioral and psychological sciences was utilized to build a solid theory basis for family-based PA counseling intervention and for analysis of the study results. In general, this study can be seen as important for gaining knowledge of how parents with sedentary work could be involved in PA enhancement in children, considering that occupations related to sedentary work are likely to become even more common in the future.

6.4 Practical implications and future research considerations

The findings of the present thesis hold various implications for practice and future research considerations. These perspectives concern, firstly, the need to consider the whole spectrum of PA intensities in child-related PA research and communications, and secondly, a need for cautious interpretation of accelerometer-derived PA in light of MC in children. On the other hand, recommendable strategies in family-based PA enhancement in real-life conditions are represented parallel to the further research needs in this field.

The results of the present thesis state that accelerometer-derived PA of all intensities is associated with MC in children. In addition, even intermittent and short-term PA impacts were found to be associated with MC in children. High short-term PA impacts were found to be associated with MC in girls especially. These findings suggest, firstly, that PA of all intensities should be encouraged in children: from very low to very high in intensity. Secondly, this comprehensive perspective should be taken into account in scientific communications to the professional community and the public. This means that general PA guidelines should include statements about the developmental importance of PA of all intensities. On the other hand, PA research should not only be focused on MVPA, because this excludes developmentally important information of PA behavior.

It is important from the perspective of motor development to have physical activities that are very light as well as MVPA in nature. This finding raises a significant question for objective PA monitoring in children: do current accelerometer-signal interpretation techniques offer a valid way to measure PA of children when the interest is other than energy consumption (e.g. motor competence)? According to the results presented here, there is a definitive need for developing accelerometer-signal processing that takes the quality of PA better into account. Motion capturing from the accelerometer signal is already more or less possible in adults, which make it possible to capture real movement patterns, such as running and walking patterns. However, there is a need to capture movements that are meaningful for motor development, since there is a great need to find determinants of MC development in childhood. It is recommendable to develop accelerometer-signal processing for capturing typical motor tasks among children, such as jumping, hopping, sliding, swinging, throwing, etc. There is definitely a need for objective measurement of the quality of PA in children. At the moment, it is likely that research on the association between accelerometer-derived PA and motor competence, fitness or other health-related factors is limited due to inaccuracy in accelerometer-signal processing techniques. This limitation considers also the reflections of PA interventions on MC, as some motor developmentally important PA behavior is likely omitted due to the inability of present accelerometer techniques to accurately capture real behavior patterns.

The present thesis shows that PA enhancement in children via moderate-intensity family-based counseling is challenging. It would be easy to recommend highly intensive PA enhancement, including for instance regular PA services with a hope of greater effect on PA in children. However, from the view of efficiency that would be unrealistic as costs of preventive health care should be reasonable. As this study aimed to find a practically feasible and effective way to enhance PA in children via parents, two suggestions are presented for further consideration. Firstly, screening parents who provide low support for their child's PA and conducting long-term face-to-face tailored PA counseling with them would be a potential method to enhance PA in their children. This kind of PA enhancement would be practicable, for instance, during child welfare clinic visits, childcare center parent-teacher meetings, and in primary school healthcare parent-nurse meetings. Most likely, children's PA habits are already discussed in many of these communications. However, there is presumably a need for a theoretical rationale of the emphasis on child-parent interaction when it comes to habitual PA, and a need for a theory-based understanding of behavior change process. In practice, screening the level of parental support by the FPAE questionnaire used in this study would take approximately five minutes (done at home), after which a discussion of individual barriers and possibilities for enhancing PA in a child could be suggested for those parents who are found to provide a low level of support for their child's PA. Similar protocol is already relatively typical in parent-authority interactions in child welfare clinics, annual daycare parent meetings or school nurse meetings, indicating the feasibility of this protocol. Regular consideration of parental support for child's PA could be followed up in a similar way as child's body mass, height, head circumstance, nutrition, motor skills, and linguistic and arithmetic skills. The research literature presented in this thesis and the results of the present counseling suggest that parental support for child's PA is a powerful factor that affects habitual PA in children. However, there is a great need to better understand the underlying behavior change processes in this regard, as there is a lack of theory-based knowledge of how to effectively and, in a sustainable fashion, counsel parents with low support for their child's PA.

As the intervention of the present study was conducted in a highly controlled environment by research personnel, transferability of the utilized intervention methods to other environments should be researched. It is highly likely that in "real-life" conditions PA enhancement will face different challenges than in highly controlled and research-focused environments. Therefore, randomized controlled trials examining the effect of a parental support targeted PA counseling should be conducted, for instance, in contexts of child welfare clinics and child care centers. The effectiveness of screening and counseling parents with low support on their children's PA could be examined, for instance in Finland, in context of children's comprehensive physical examinations.

Seasonality is known to greatly interact with habitual PA across all ages of people, but to the writer's knowledge this was the first to show interaction between seasonal variation and intervention effects on children's MC. However, as the results in this regard were suggestive, more research on the interaction between season and PA counseling effectiveness in children should be conducted. The hypothesis put forward states that initiation of PA counseling during an inactive season may strengthen the effect of family-based PA interventions on motor development in children.

Lastly, it has to be emphasized that there generally exist several ethical considerations when PA and MC are investigated in children and PA counseling is delivered to parents. In the present study, there was one child who was not willing to participate in MC measurements. In that case, the child was left out of the MC measurements. In two cases, MC measurements were delayed for a couple of days because of the child's bad temper. Also, some parents reported their child's unwillingness to carry the accelerometer device for several days. In these cases parents were discreetly asked to encourage the children to carry the device for at least two weekdays and one weekend day, if possible. However, parents were not pressured about that. In the PA counseling, parents were not pressured to set goals regarding their child's PA nor pressured to carry through with the goals set in the counseling. Accordingly, the parent's own will was set as the first priority.

MAIN FINDINGS AND CONCLUSIONS

The present study showed that cluster-randomized and controlled family-based physical activity (PA) counseling was found to have distinct influences on PA behavior and the development of MC in children. Additionally, the initial level of parental support on children's PA was found to act as a moderator of the family-based PA counseling on children's leisure time PA. The methodological examinations of the relationship between accelerometry-derived PA and motor competence (MC) emphasized the need to take the whole spectrum of accelerometer-derived PA intensities into account when the development of MC is concerned. As the current methods for interpreting accelerometer output has many limitations, developing methods able to recognize real motion patterns from the raw accelerometer signal are recommended. The main findings and conclusions of the present thesis are summarized as follows:

1. Typical indoor physical activities seen to be important for motor development varied on the whole spectrum of accelerometer-derived PA intensities. Tag, a ball game, crawling and stair walking were classified as moderate-to-vigorous and included high neuromuscular impacts. On the other hand, the intensity of climbing and balance beam walking was found to be mostly light or sedentary. This finding underlines the need for more sophisticated objective measurement techniques for PA monitoring in children, since it is likely impossible to capture some PA that is important for motor development by means of the present techniques. On the other hand, along with moderate-to-vigorous PA, the role of unhurried and concentration-demanding physical activities for motor development should be taken into account when PA guidelines are communicated to the public (parents, teachers, educators, etc.).
2. MC was associated with a high proportion of time spent at moderate-to-high neuromuscular impacts, PA of vigorous metabolic intensity, and mean level of PA in primary school-aged girls, as well as with high neuromuscular impacts in preschool-aged girls. Mod-

erate neuromuscular impacts, light-to-vigorous PA, and mean level of PA were associated with MC in preschool-aged boys. These results emphasize the close relationship between MC and PA, stressing both the neuromuscular- and metabolic-based systems in children. The nature of intermittent and high intensity PA should be further investigated, as it was shown to be especially associated with MC in girls.

3. Family-based counseling associated with the decrease of moderate-to-vigorous PA in children of the intervention group in comparison to children of the control group. This finding emphasizes the lack of knowledge of family constructs associating with the effectiveness of family-based PA counseling.
4. Ball-handling skills were nearly significantly improved among children in the intervention group, compared to children in the control group during the 6-month family-based PA reinforcement. Although the finding was low in terms of statistical magnitude, it suggests a possibility to enhance ball skills in children through family-based PA counseling. This is a promising sign, as mastery of ball-handling skills may predict PA later in adolescence, especially in girls. However, support for the development of MC should likely be regular, and the importance of MC development should be emphasized not only in the home context, but also in childcare and primary school environments for achieving sustained benefits in MC development.
5. Compared to control peers, the intervention group had a steadier development of MC measured by the KTK protocol during the transition from active to inactive season from six to 12 months. A hypothesis can be put forward that counseling during an inactive season rather than an active season may provide a more lasting effect on the development of KTK performance in children.
6. Low initial parental support of child's PA moderated the effect of a randomized and controlled family-based tailored counseling session aimed at increasing PA in 4–7-year-old children. The children whose parents provided the least support for their PA before the tailored counseling increased their PA significantly during the 6-month reinforcement period. At the same time, these parents increased support of their children's PA, although the change was non-significant compared to the corresponding control parents. However, changes were not maintained in the 12-month follow-up. The majority of the parents who provided the least support before the reinforcement period rated the face-to-face discussion with goal setting as the most important intervention tool in the present study. In conclusion, screening parents who provide low support for their children's PA and delivering tailored PA counseling to them on a regular basis could be an effective way to enhance habitual PA in

children. Regular follow-up of parental support of child's PA could be practically implemented in a similar way as follow-up of a child's growth, development and nutrition during child welfare clinic visits and scheduled parent-teacher meetings at daycares and primary schools. The screened parents should be informed about available services and information sources.

YHTEENVETO (FINNISH SUMMARY)

Fyysinen aktiivisuus ja motorinen pätevyys 4-8-vuotiailla lapsilla: perhelähtöisen ryvässatunnaistetun ja kontrolloidun liikuntaintervention vaikutus

Fyysisen aktiivisuuden edistäminen lapsilla

Lasten fyysisen aktiivisuuden edistämisellä on kaksi tutkimustietoon pohjautuvaa perustelua. Jo lapsena säännöllisen fyysisen aktiivisuuden on osoitettu olevan yhteydessä vähäisempiin terveyden riskitekijöihin (Booth, Roberts & Laye 2012, Strong et al. 2005, Timmons et al. 2012) ja myönteisiin muutoksiin kehon fyysisissä ominaisuuksissa, motorisessa kehityksessä, sosiaalisaffektiivisessa ja psykologisessa hyvinvoinnissa sekä kognitiivisessa suorituskyvyssä (mm. Biddle & Asare 2011, Carson et al. 2015, Hinkley et al. 2014, Holfelder & Schott 2014, Nikander et al. 2010, Park 2004, Strong et al. 2005, Tomporowski, Lambourne & Okumura 2011). Fyysisellä aktiivisuudella on lisäksi tärkeä välinearvo lapsuusiän kehityksellisissä vaiheissa, kuten ympäristön tutkimisessa ja muokkaamisessa sekä sosiaalisissa roolileikeissä ja -peleissä (mm. Pellegrini & Smith 1998, Piaget 1952, Storli & Sandseter 2015), mitkä näkyvät mm. kouluun sopeutumisessa (Pellegrini et al. 2002, Pellegrini et al. 2004). Tiedetään myös, että merkittävä osa lapsista liikkuu suosituksia vähemmän (Soini et al. 2012, Spittaels et al. 2012), mikä voi osaltaan heijastella mm. niiden lasten osuuden lisääntymisenä, joilla on heikko tai erittäin heikko motorinen pätevyys (Vandorpe et al. 2011). Motorisen pätevyyden, eli liikuntataitojen ja kehon koordinaation, edistäminen on nähty yhtenä tärkeänä liikunnan edistämisen tukikeinona, sillä se on yhteydessä yksilön mahdollisuuksiin osallistua ikä- ja kehitystasolle tyypillisiin, fyysistä aktiivisuutta vaativiin leikkeihin ja peleihin (Robinson et al. 2015, Stodden et al. 2008) (kts. kuvio 1).

Lasten liikunnan edistämisen kannalta on oleellista ymmärtää ympäristön erittäin vaikutusvaltainen rooli. Lasten fyysinen aktiivisuus on tutkitusti aikuisia merkittävästi enemmän sidottuna vallitsevaan ympäristöön (Bauman et al. 2012, Fisher et al. 2015). Käytännössä ympäristö voi mahdollistaa ja kannustaa tai toisaalta estää ja heikentää lapsen liikkumisen mahdollisuuksia (Kyttä 2004). Sosiaaliskognitiivisen teorian mukaan lapsi muokkaa käsityksiään ja käyttäytymistään tiiviissä vuorovaikutuksessa läheisten ihmisten, kuten omien vanhempiensa, kanssa (Bandura 1986, Bandura 2004). Vanhempien osoittaman tuen lapsen liikuntaa kohtaan onkin osoitettu olevan yksi merkittävimmistä tekijöistä lapsen liikunnallisen aktiivisuuden taustalla (Yao & Rhodes 2015). Tähän mennessä on kuitenkin tutkittu hyvin vähän, kuinka lasten liikuntaa tai liikuntataitoja voitaisiin edistää perhelähtöisesti (Davison et al. 2013b, O'Connor, Jago & Baranowski 2009, Riethmuller, Jones & Okely 2009, van Sluijs, Kriemler & McMinn 2011). Tarve perhelähtöisten liikunnan edistämisen tapojen tutkimiselle on suuri, sillä tähän mennessä käytettyjen liikunnanedistämistapojen on todettu tuottavan laihoja tuloksia (Metcalf, Henley & Wilkin 2012).

Tutkimuksen tavoitteet ja tutkimuskysymykset

Tämän neljästä tieteellisestä osajulkaisusta ja niiden yhteenvedosta koostuvan väitöskirjatutkimuksen tavoitteena oli ensisijaisesti selvittää, voidaanko perhelähtöisellä liikuntaneuvonnalla edistää 4-7-vuotiaiden lasten fyysistä aktiivisuutta ja motorista pätevyyttä. Tarkemmassa interventioanalyysissä vanhemman tuen merkitystä tutkittiin liikuntaneuvonnan vaikutusta välittävänä tekijänä. Toissijaisena tarkoituksena tutkimuksessa oli selvittää, minkälainen on objektiivisesti mitatun fyysisen aktiivisuuden ja motorisen pätevyyden välinen yhteys. Tämän tiedon oletettiin auttavan ymmärtämään laajemmin aktiivisuuden ja motorisen pätevyyden välisen yhteyden luonnetta ja sitä, kuinka objektiivinen mittausmenetelmä kategorisoi motorisen kehityksen kannalta tärkeinä pidettyjen liikkumismuotojen intensiteetin.

Täsmennetyt tutkimuskysymykset olivat:

1. Kuinka intensiivisiä ovat fyysiset aktiviteetit, joiden tyypillisesti ajatellaan kehittävän lasten motorista pätevyyttä? (osajulkaisu I)
2. Kuinka fyysisen aktiivisuuden eri intensiteetit, energiankulutuksen ja hermolihastoiminnan näkökulmista analysoituna, ovat yhteydessä motoriseen pätevyyteen? (osajulkaisu II)
3. Kuinka perhelähtöinen liikuntaneuvonta vaikuttaa lasten fyysiseen aktiivisuuteen ja motoriseen pätevyyteen? (osajulkaisu III)
4. Kuinka perhelähtöinen liikuntaneuvonta vaikuttaa fyysiseen aktiivisuuteen lapsilla, joiden vanhemmilta saama tuki ennen intervention alkua on joko alhaista tai korkeaa? (osajulkaisu IV)

Aineisto ja mittausmenetelmät

Väitöskirjan aineisto kerättiin vuosina 2011–2013 Jyväskylän seudulta. Väitöskirjan ensimmäinen (I) osajulkaisu perustui yhden päivän poikittaistutkimukseen, johon osallistui vuoden 2013 helmikuussa 18 päiväkoti-ikäistä (keski-ikä 6,3 vuotta, minimi 5,3 ja maksimi 7,0 vuotta) ja 12 ensimmäisen luokan oppilasta (7,6 vuotta, minimi 7,2 ja maksimi 8,0 vuotta). Kaikki lapset suorittivat ohjatusti seuraavat yksilö- ja ryhmätehtävät: hippa, pallopeli, konttaus, porraskävely, kiipeily ja tasapainokävely. Jokaisen lapsen fyysinen aktiivisuus mitattiin kunkin ohjatun liikuntatehtävän aikana 3-suuntaisilla (3D) kiihtyvyysantureilla, jotka mittaavat kiihtyvyyttä dynaamisesti ±6 g:n alueelta (X6-1a, Gulf Coast Data Concepts Inc, USA). Kiihtyvyysantureiden tallentama informaatio analysoitiin kahdella eri tavalla: käyttäen aktiivisuusluku-pohjaista analysointia (van Cauwenberghe et al. 2011), joka luokittelee aktiivisuuden erittäin kevyeen, kevyeen, reippaaseen ja erittäin reippaaseen liikkumisen intensiteettiluokkaan. Lisäksi aktiivisuuden intensiteettiä arvioitiin käyttäen Jyväskylän yliopistossa kehitettyä kehoon kohdistuvien törmäysvoimien histogrammin analysointimenetelmää. Sekä aktiivisuusluku- että törmäysvoima-analyysin tulokset laskettiin suhteellisina osuuksina kuhunkin tehtävään käytetystä ajasta.

Väitöskirjan toisen (II), kolmannen (III) ja neljännen (IV) osajulkaisun aineistot perustuivat toukokuun 2011 ja toukokuun 2012 välillä satunnaistetulla ryväsotannalla rekrytoituihin, vapaaehtoisesti interventiotutkimukseen osallistuneiden lasten ja heidän vanhempiensa mittauksiin. Jyväskylän keskustan ja sen lähistön satunnaistetuilta interventioalueilta rekrytoidut perheet saivat liikuntaneuvontaa ensimmäisen puolen vuoden ajan, jonka jälkeen heidän tilaansa seurattiin puolen vuoden ajan ilman minkäänlaista neuvontaa. Kontrollialueilta rekrytoidut lapset ja heidän vanhempansa osallistuivat vastaaviin tutkimuksen mittauksiin kuin interventioperheet, mutta kontrolliperheet eivät saaneet minkäänlaista liikuntaneuvontaa tutkimuksen aikana. Liikuntaneuvonta perustui sosiaaliskognitiivisen (Bandura 1986) ja suunnitellun käyttäytymisen (Ajzen 1985) teorioiden mukaisiin käyttäytymismuutoksen strategioihin. Liikuntaneuvonta koostui yhden illan liikuntaneuvontatilaisuudesta, jossa pidettiin vanhemmille noin puolen tunnin mittainen luento liikunnan merkityksestä lapsen kasvun ja kehityksen näkökulmista sekä perheen roolista liikuntatottumusten muokkaajana. Luennon jälkeen jokaisen tutkimukseen osallistuvan vanhemman kanssa käytiin kahdenkeskinen, noin 30-60 minuutin mittainen keskustelu, jossa vanhempia pyydettiin kertomaan perheen liikkumisrutiineista koskien arkiaamuja, -iltapäiviä ja iltoja ja viikonloppupäiviä. Vanhempia kannustettiin miettimään tapoja, joilla ns. arkiliikkumista voisi lisätä lasten arkeen, korvaamalla mm. passiivisia toiminta- ja liikkumistapoja enemmän fyysistä aktiivisuutta suosiviksi. Vanhempia kannustettiin harkitsemaan, milloin liikuntaa on tapana rajoittaa, ja milloin näitä rajoituksia olisi mahdollista vähentää. Vanhemmat kirjasivat omaehtoisesti tavoitteita koskien lapsen arkiaktiivisuuden lisäämiseksi. Tavoitteiden toteutumista seurattiin kaksi kertaa puolen vuoden aikana puhelinkeskustelujen kautta, joissa vanhempia pyydettiin itsearvioimaan tavoitteiden toteutumiseksi antamaansa panostusta, havaittuja esteitä tavoitteiden tiellä ja toisaalta positiivisia havaintoja tavoitteiden toteutumisen seurauksena. Vanhemmille lähetettiin lisäksi kuukausittainen lähiliikuntapainotteinen perheliikunnan vinkkilista ja lasten motorisesta kehityksestä annettiin palautetta puolen vuoden kohdalla tutkimuksen aloituksesta.

Lasten fyysistä aktiivisuutta mitattiin kuuden perättäisen päivän ajan sekä lähtötilanteessa, kolmen, kuuden, yhdeksän ja 12 kuukauden kohdilla vastaavilla mittareilla ja analysointitavoilla kuin osajulkaisu I:ssä (kts. kuvio 4). Motorista pätevyyttä mitattiin Körperkoordinationstest für Kinder (KTK) (Kiphard & Schilling 1974, Kiphard & Schilling 2007) –kehon karkeamotoriikan testillä, joka on todettu validiksi ja reliaabeliksi mittariksi motorisen pätevyyden arvioinnissa 5-15-vuotiailla lapsilla. Lisäksi pallonkäsittelytaitoja arvioitiin APM-testistön (Numminen 1995) pallon heitto-kiinniotto -testillä. Vanhempien osoittamaa tukea lasten liikuntaa kohtaan arvioitiin soveltuvin osin 5-12-vuotiailla australialaislapsilla validoidulla (Cleland et al. 2011) perheen liikuntaympäristökyselyllä, johon yhtä vanhemmista pyydettiin vastaamaan lähtötilanteessa, kuuden ja 12 kuukauden kohdilla tutkimuksen alkamisesta. Vanhemman tuen määrittäminen perustui seitsemään kysymykseen koskien sitä 1-2) kuinka usein vanhemmat (isä ja äiti erikseen kysyttyinä) osallistuvat fyysisesti aktiiviseen toimintaa tutkimukseen osallistuvan lapsensa kanssa, 3) kuinka usein perhe liikkuu yhdessä, 4-5) kuinka usein vanhemmat osoittavat suoraa tukea lapsen liikkumista kohtaan mm. hankkimalla liikuntavarusteita ja välineitä tai kuljettamalla harrastuksiin, ja viimeiseksi 6-7) kuinka usein vanhemmat kannustavat ja kehuvat lasta tämän liikunnallisen aktiivisuuteen liittyen.

Toisen (II) osajulkaisun tilastolliseen tarkasteluun valittiin kaikki interventiotutkimukseen osallistuneet lapset, joilta oli onnistuneesti mitattu fyysinen aktiivisuus ja motorinen pätevyys sekä kehon paino ja pituus. Lasten motorisen pätevyyden ja fyysisen aktiivisuuden eri intensiteeteillä suhteessa koko mittausjakson kestoon vietetyn ajan välistä yhteyttä tutkittiin osittaiskorrelaatiolla, jossa kehon painoindeksi vakioitiin. Osajulkaisuissa kolme (III) ja neljä (IV) interventio- ja kontrolliryhmään kuuluvien koehenkilöiden muutoksia vastemuuttujissa testattiin, suurimman todennäköisyyden estimointiin sovitetulla sekamallinnuksella (IBM SPSS Statistics 20 tai uudempi ja R 3.0.1 –tilasto-ohjelmat), lähtötilanteen ja kuuden kuukauden välillä sekä lähtötilanteen ja 12 kuukauden välillä. Sekamallinnuksessa vakioitiin vastemuuttujien muutosta sekoittavat tekijät, kuten lapsen ikä ja sukupuoli sekä vuodenajan lämpötilojen vaihtelu. Neljännessä (IV) osajulkaisussa lapset ja heidän vanhempansa jaettiin tertiileihin sen mukaan, kuinka korkea vanhemman osoittama tuki lapsen liikuntaa kohtaan oli lähtötilanteen mittauksessa ennen interventiota. Intervention vaikutusta lasten fyysiseen aktiivisuuteen tutkittiin näin ollen IV osajulkaisussa erikseen vanhemman tuen perusteella vähiten ja eniten alun perin tuettujen lasten kohdalla. Kaikilta liikuntaneuvontaan osallistuneilta vanhemmilta kerättiin tutkimuksen lopussa palautetta liikuntaneuvonnan tärkeimmiksi kokemista työkaluista.

Kaiken kaikkiaan väitöskirjatutkimukseen osallistuneet 4-8-vuotiaat lapset (n=126) edustivat normaalipainoista väestönosaa, eikä yksikään lapsista ollut lähellä kansainvälistä iän mukaan luokiteltavaa lihavuusrajaa (Cole et al. 2000). Interventiotutkimukseen osallistuneet vanhemmat olivat keskimäärin yleisemmin korkeasti koulutettuja kuin Jyväskylän seudulla asuvat aikuiset (71- 84% tutkimukseen osallistuneet vanhemmat / 35% koko Jyväskylän seudun keskiarvo).

Tulokset

Väitöskirjan ensimmäisen osajulkaisun perusteella tyypillisten motorista pätevyyttä kehittävien liikuntamuotojen todettiin vaihtelevan kaikilla kiihtyvyysanturimittaamisen intensiteettiluokilla, erittäin kevyestä aina erittäin reippaaseen luokkaan (kts. kuviot 9 ja 10 sekä taulukot 8 ja 9). Kun hippa, pallolla pelaaminen, konttaaminen ja porraskävely kategorisoituivat vähintään reippaaksi liikunnaksi, niin kiipeily ja tasapainokävely olivat intensiteetiltään enimmäkseen kevyttä tai jopa erittäin kevyttä. Toinen (II) osajulkaisu puolestaan tuki aiempaa näkemystä siitä, että lasten motorinen pätevyys ja fyysinen aktiivisuus ovat yhteydessä toisiinsa (kts. kuvio 11). Uutena löydöksenä havaittiin, että suurten kehoon kohdistuvien törmäysvoimien suhteellinen osuus mittausajasta oli merkitsevän myönteisesti yhteydessä motoriseen pätevyyteen erityisesti tytöillä.

Perhelähtöisen intervention vaikutusta tutkittaessa havaittiin, että liikuntaneuvonta vähensi reippaan ja rasittavan liikunnan määrää interventioryhmään kuuluvilla lapsilla verrattuna kontrolliryhmän lapsiin (kts. kuvio 12 ja taulukko 14). Vähiten tukea vanhemmiltaan saaneiden interventioryhmän lasten fyysinen aktiivisuus kuitenkin kohosi merkitsevästi suhteessa verrokkilapsiin lähtötilanteen ja kuuden kuukauden välillä (kts. kuvio 16 ja taulukko 17). Samalla vanhempien osoittama tuki nousi merkitsevästi näiden lasten kohdalla, vaikkei muutos ollut merkitsevä verrokkivanhempiin verrattuna (kts. kuvio 16 ja taulukko 17). Lisäksi pallonkäsittelytaidot paranivat lähes merkitsevästi interventioryhmän lapsilla verrattuna verrokkiryhmän lapsiin interventiojakson aikana (0-6 kuukautta) (kts. kuviot 14 ja 15 sekä taulukko 14). Mitkään mainituista muutoksista eivät kuitenkaan säilyneet 12 kuukauden seurantamittauksiin asti. Interventiolla havaittiin merkitsevä myönteinen vaikutus KTK-mittarilla mitatun motorisen pätevyyden kehitykseen. Tämä näkyi erityisesti 6-12 kuukauden seurantajakson aikana, kun liikuntaneuvonta oli aloitettu inaktiivisena vuodenaikana, eli talvella (kts. kuvio 15). Liikuntaneuvonnan läpi käyneistä vanhemmista enemmistö (32%) arvioi kahdenkeskisen liikuntaneuvontakeskustelun tärkeimmäksi neuvontatyökaluksi. Vähiten lapsilleen fyysisen aktiivisuuden tukea ennen tutkimusta osoittaneiden vanhempien keskuudessa neuvontakeskustelu koettiin jopa vielä useammin (44%) tärkeimmäksi neuvontatyökaluksi, kun vastaavasti eniten tukea osoittaneet vanhemmat arvioivat sen vasta kolmanneksi tärkeimmäksi (14%) (kts. taulukko 18).

Tutkimuksen rajoitteet ja vahvuudet

Tutkimukseen liittyy rajoittavia tekijöitä, jotka tulisi ottaa huomioon, kun tuloksia ja niiden yleistettävyyttä arvioidaan. Kuten väitöskirjan kirjallisuuskatsauksessa todetaan (kts. luku 2.1.1), niin lasten fyysisessä aktiivisuudessa on piirteitä, jotka muuttuvat iän ja kehityksen myötä. Tästä syystä mm. ympäristön virikkeillä on todennäköisesti hieman erilainen rooli lapsen liikuntakäyttäytymisen muovaajana. Tätä taustaa vasten ideaali-tilanteessa olisi parasta tutkia mahdollisimman samanikäisiä lapsia yhdellä kertaa, sillä se todennäköisesti vähentäisi yhden käyttäytymistä sekoittavan tekijän, iän, vaikutusta. Toisaalta yleiset tarkastelut eivät ole havainneet systemaattisia eroja eri-ikäisten lasten fyysisen aktiivisuudessa. Tämän väitöskirjatutkimuksen osajulkaisuissa iän mukanaan tuomaa mahdollista sekoittavaa vaikutusta pyrittiin kuitenkin kompensoimaan huomioimalla iän tuoma vaikutus tilastollisissa mallinnuksissa. Yleisimmin ikää käytettiin kontrolloivana tekijänä (osajulkaisut III ja IV) tai tutkittavaa ilmiötä tarkasteltiin päiväkoti-ikäisillä (4-6-vuotiaat) ja ensimmäisen luokan oppilailla (7-8-vuotiaat) erikseen (osajulkaisut I ja II). Toisaalta poikien on johdonmukaisesti todettu olevan tyttöjä aktiivisempia (kts. luku 2.1.1), joka voi tuoda haasteita tutkimuksen tulosten tulkinnalle. Siksi myös sukupuoli huomioitiin tilastollisissa mallinnuksissa joko kontrolloivana tekijänä (osajulkaisut III ja IV) tai tekemällä analyysit erikseen tytöille ja pojille (osajulkaisut I ja II).

Fyysisen aktiivisuuden mittaamisessa on myös tekijöitä, jotka voivat vaikuttaa tulosten tulkintaan (kts. luku 2.3.3). Vaikka kaikissa osatutkimuksissa käytetyillä kiihtyvyysantureilla on vahvuutena liikkumisen määrän ja intensiteetin objektiivinen ja reliaabeli mittaaminen, niin niihin sisältyy myös rajoitteita. Kenties yleisesti tunnetuin rajoite on mittareihin liittyvä uutuudenviehätys, jonka on joissain tutkimuksissa osoitettu tuottavan liian suuria aktiivisuusarvioita suhteessa myöhempiin mittauspäiviin. Lisäksi aloituspäivän valinnalla voi olla vaikutusta havaittuun aktiivisuuteen, sillä esimerkiksi viikonpäivien ja viikonloppupäivien välillä voi olla systemaattista eroa aktiivisuuden kannalta (mm. Dössegger et al. 2014). Osajulkaisussa I näitä kyseisiä ongelmia ei ollut, sillä lasten fyysistä aktiivisuutta mitattiin vain yhden päivän aikana suoritettujen, kontrolloitujen liikuntatuokioiden aikana. Osajulkaisuissa II, III ja IV mittaamisen aloituspäivä oli käytännössä satunnainen viikonpäivä, sillä lasten vanhemmat saivat mittarit satunnaisina päivinä. Ensimmäistä mittauspäivää ei päätetty poistaa tilastollisesta tarkastelusta, vaikka tämä saattaa tuoda virhettä mittaustuloksiin. Tähän ratkaisuun päädyttiin, sillä karsimalla ensimmäinen mittauspäivä pois tarkasteluista olisi interventiotutkimuksen tutkimusjoukosta pudonnut kokonaan pois muutamia lapsia, sillä heillä oli vain minimirajaksi asetettu kolme hyväksyttävästi onnistunutta mittauspäivää (Penpraze et al. 2006). Toisin sanoen hyväksymättä ensimmäisen päivän mittausaineistoa olisi tutkimuksen vaikuttavuustarkasteluista menetetty muutamia koehenkilöitä.

Väitöskirjan osajulkaisuissa käytetyt kiihtyvyysanturit eivät olleet ns. standardi-mittareita, joka voi kyseenalaistaa sen, ovatko käytetyt mittarit reliaabeleja ja valideja lasten aktiivisuuden mittaamiseen. Useat tutkimukset ovat osoittaneet standardi-kiihtyvyysmittareiden olevan luotettavia ja helposti käytettäviä fyysisen aktiivisuuden määrittämisessä (mm. Pate, O'Neill & Mitchell 2010). Väitöskirjan osajulkaisuissa käytettyjen kiihtyvyysmittareiden toistettavuutta ja pätevyyttä esitestattiin suositellulla tavalla (Intille et al. 2012), eli vertaamalla informaatiota, joka oli mitattu yhdenaikaisesti standardi-kiihtyvyysantureilla ja standardoimattomilla mittareilla. Yhdenmukaisuus standardimittareiden ja standardoimattomien mittareiden välillä saavutettiin määrittämällä laskentakaava, jota käyttämällä tutkimuksen aikana mitattu kiihtyvyysinformaatio muunnettiin vastaamaan standardimittareilla mitattua. Lisäksi tutkimuksessa käytettyjen kiihtyvyysmittareiden tekninen toimivuus testattiin valmistajan suosittelemalla testausprotokollalla (kts. luku 4.5). Yleisesti kiihtyvyysmittareissa esiintyi hyvin vähän virhetoimintoja. Yhteensä 20:sta käytetystä mittalaitteesta vioittui kahden vuoden ja noin 3000 mittauspäivän aikana vain kaksi mittalaitetta.

Tutkimuksessa käytetty motorisen pätevyyden ensisijainen mittari, KTK-mittari, on tutkimuksissa osoitettu olevan hyvin toistettava mittaustapa (kts. luku 4.7). Samoin APM-mittarin pallon heitto-kiinniotto on todettu olevan toistettava testi alkuperäisessä validointitutkimuksessa. Merkittävin tulosten tulkintaan vaikuttava kysymys kohdistuneekin siihen, kuinka laaja-alaisesti ja kattavasti KTK että APM-mittarit mittaavat lasten motorista pätevyyttä. KTK-mittarin on todettu olevan kohtuullisen yhdenmukainen muiden motoriikan määrittämiseen tarkoitettujen mittareiden kanssa, yhdenmukaisuuden ollessa kuitenkin melko kaukana täydellisestä. APM-mittarin yhdenmukaisuutta muiden mittareiden kanssa ei toistaiseksi ole selvitetty. Loppujen lopuksi jokainen motorisen pätevyyden mittari mittaa hieman erilaista motorisen pätevyyden aluetta, jolloin jatkossa onkin suositeltu käytettävän eri mittareiden yhdistelmiä paremman kattavuuden takaamiseksi (Luz et al. 2015). Yhteenvetona tässä tutkimuksessa käytetyistä motorisen pätevyyden mittareista voidaan sanoa, että havaittujen löydösten tulkinnassa tulee ottaa huomioon KTK-mittarin kehon koordinaatiota ja voimaa sekä nopeutta painottava luonne (Vandorpe et al. 2011), sekä APM pallon heitto-kiinniotto -mittarin alakautta heiton ja pallon kiinnioton elementtejä painottava luonne.

Ensimmäiseen (I) osajulkaisuun valittujen liikuntamuotojen oikeellisuutta ja kykyä kuvastaa tyypillisiä motorista pätevyyttä kehittäviä liikkumismuotoja voi kyseenalaistaa. Ei ole olemassa tutkimusta, joka osoittaisi juuri näiden valittujen liikuntamuotojen olevan ratkaisevan tärkeitä lapsen motorisen kehityksen ja pätevyyden kannalta. Arvioitaessa liikuntamuotojen pätevyyttä kuvastaa motorisen kehityksen kannalta oleellisimpia liikuntamuotoja, on otettava huomioon se, että niiden valintaan vaikutti kyseisessä tutkimuksessa suuresti niiden mittaamisen toistettavuus ja yksiselitteisyys. Toisekseen liikuntamuotojen valinnasta päätti fyysisen aktiivisuuden tutkimiseen erikoistunut asiantuntijajoukko, jolloin valinnan pätevyydellä on lähtökohtaisesti hyvä pohja.

Neljännessä (IV) osajulkaisussa käytetyn muuttujan, vanhemman osoittaman tuen lapsen liikkumista kohtaan, mittaamiseen liittyy myös tiettyjä rajoitteita. Alun perin tuen mittaamiseen käytetty mittari on todettu validiksi 5-12-vuotiailla australialaislapsilla ja heidän vanhemmillaan. Tämän tutkimuksen tarpeisiin kyselylomake käännettiin niin kielellisesti ja kulttuurisesti yleisien suositusten mukaisesti, mutta varsinaista tutkimusta mittarin validiteetista ja reliabiliteetista ei ole suomalaisvanhemmilla ja heidän lapsillaan saatavilla. Vaikka vanhemman tuen -mittari osoitti tämän tutkimuksen tilastollisissa tarkasteluissa hyväksyttävää luotettavuutta, niin sen jatkotutkimusta ja käytettävyyttä suomalaisväestössä on syytä systemaattisemmin ja suuremmilla tutkimusjoukoilla tutkia.

Väitöskirjan tulosten yleistettävyyteen liittyy tiettyjä rajoitteita. Tutkimukseen osallistuneet lasten vanhemmat olivat muuta Jyväskylän seudun aikuisväestöä korkeammin koulutettuja, joka asettanee suurimman kysymyksen yleistettävyydestä. Vaikka vanhempien koulutuksen taso otettiin osajulkaisujen tilastollisissa analyyseissä huomioon, niin tutkimuksessa mukana olleiden perheiden pienehkö määrä tuo mukanaan merkittävää virheen mahdollisuutta tuloksissa. Siksi jatkotutkimuksia, mieluiten suuremmilla tutkimusjoukolla, tarvitaan arvioimaan tässä tutkimuksessa havaittuja löydöksiä.

Tämän väitöskirja-projektin osajulkaisujen ja koontiosan vahvuuksina voi pitää suhteellisen huolellista paneutumista objektiivisen fyysisen aktiivisuuden mittaamisen vahvuuksiin, heikkouksiin ja sen menetelmällisiin puutteisiin mm. arvioida motorisen pätevyyden kannalta oleellisia tekijöitä. Tätä kautta tutkimus on tuonut uutta tietoa lasten motorisen kehityksen kannalta tyypillisistä liikkumisen elementeistä ja motorisen pätevyyden kanssa yhteydessä olevasta fyysisestä aktiivisuudesta. Toisaalta tutkimuksen liikuntaneuvonta tuo kaivattua lisätietoa siihen, kuinka lasten liikuntaa voidaan edistää perheiden kautta. Liikuntaneuvonnan teorialähtöisyyttä voidaan pitää vahvuutena, sillä teorialähtöiset interventiot ovat tutkitusti vaikuttavampia kuin ilman teoriapohjaa toteutetut. Liikuntaneuvonnan vaikutusta mitattiin lisäksi suhteellisen intensiivisesti, joka parantaa vaikutusten arvioinnin luotettavuutta. Vahvuutena voidaan pitää myös sitä, että tässä tutkimuksessa käytettyä liikuntaneuvontamallia voidaan pitää soveltumiskelpoisena käytännön kenttätoiminnan kannalta, esimerkiksi neuvola-, päiväkoti- ja kouluympäristöissä. Koska neuvola-, päiväkoti- ja koulutoiminta koskettavat lähes kaikkia suomalaislapsia ja heidän perheitään, niin tutkimuksella on merkittävä potentiaali vaikuttaa laajan väestöryhmän osan liikkumistottumusten muotoutumiseen.

Pohdinta ja johtopäätökset

Väitöskirjatutkimus antoi uutta ja tarkempaa tietoa lasten objektiivisesti mitatun fyysisen aktiivisuuden ja motorisen pätevyyden välisestä yhteydestä. Perhelähtöisen liikuntaneuvonnan ei yleisesti ottaen havaittu olevan tehokas keino lisätä fyysistä aktiivisuutta 4-7-vuotiailla lapsilla. Tutkimustulokset sen sijaan osoittavat, että ennen neuvontaa vähiten tuettujen lasten fyysisessä aktiivisuudessa tapahtui myönteisiä muutoksia liikuntaneuvonnan johdosta. Alla on listattu yhteenveto väitöskirjatutkimuksen päälöydöksistä ja niiden käytännön sovelluskeinoista lasten liikunnanedistämistyössä:

1. Lasten tyypilliset sisäliikuntamuodot, jotka on nähty tärkeäksi motorisen pätevyyden kehityksen kannalta, vaihtelivat objektiivisen mittaamisen perusteella intensiteetiltään erittäin kevyestä erittäin reippaaseen. Kiihtyvyysanturimittauksen perusteella hippa, pallopeli, konttaus ja porraskävely edustivat joko reipasta tai erittäin reipasta fyysistä aktiivisuutta ja toisaalta kiipeily ja tasapainokävely kevyttä tai jopa erittäin kevyttä fyysistä aktiivisuutta. Löydös tuo esiin tarpeen objektiivisten kiihtyvyysantureiden kehittämiselle, että ne asianmukaisesti tunnistaisivat motorisen kehityksen kannalta tärkeitä liikkumismuotoja. Tällä hetkellä motorisen kehityksen kannalta tärkeitä liikkumismuotoja, kuten keskittymistä vaativia kiipeilyä ja tasapainokävelyä, ei välttämättä voida tunnistaa kiihtyvyysanturimittaamisen pohjalta. Tutkimus alleviivaa sitä, että myös intensiteetiltään kevyt liikkuminen on tärkeää, erityisesti motorisen pätevyyden kehittymisen kannalta. Tämä tulisikin huomioida esimerkiksi siinä, että uusissa liikuntasuosituksissa tuotaisiin selkeästi esiin myös kevyen liikunnan rooli lapsen kasvun ja kehityksen kannalta.
2. Menetelmällisissä tarkasteluissa havaittiin, että 5-8-vuotiaiden lasten motorinen pätevyys oli myönteisesti yhteydessä reippaa-

seen ja erittäin reippaaseen fyysiseen aktiivisuuteen. Päiväkoti-ikäisillä pojilla näiden lisäksi jo kevyt-intensiteettinen fyysinen aktiivisuus oli yhteydessä parempaan motoriseen pätevyyteen. Lisäksi havaittiin, että motorinen pätevyys oli parempi tytöillä, joilla päivittäisessä elämässä mitattiin suhteellisen paljon suuria kehoon kohdistuvia, lyhytluontoisia tärähdysvoimia. Löydökset painottavat pojilla yleisen liikuntamäärän tärkeää yhteyttä motorisen pätevyyden kanssa, kun taas erityisesti reippaasti liikkuvilla tytöillä näyttäisi olevan todennäköisimmin parempi motorinen pätevyys. Syy-seuraussuhdetta tekijöiden välisestä dynamiikasta ei voida vetää, sillä tutkimus oli luonteeltaan poikittaistarkastelu.

3. Interventioryhmään kuuluvien lasten motorinen pätevyys pallonkäsittelytaidoissa koheni lähes merkitsevästi liikuntaneuvonnan aikana. Tämä suuntaa antava löydös ehdottaa, että vanhemmille suunnatulla liikuntaneuvonnalla voidaan vaikuttaa lasten motorisen pätevyyden kehittymisen tukemiseen. Tämä on lupaava löydös, sillä juuri hyvät pallonkäsittelytaidot voivat ennustaa parempaa fyysisen aktiivisuuden määrää myöhemmin murrosikäisenä. Koska liikuntaneuvonnan vaikutus kuitenkin lakkasi puoli vuotta neuvonnan jälkeen seuranneella seurantajaksolla, niin myös motorisen pätevyyden kehittymiseen vaadittaisiin säännöllistä ja jatkuvaa tukea. Käytännössä päiväkotien ja koulujen liikuntakasvatuksen rooli on tässä keskeinen, sillä lapsille tulisi taata riittävät päivittäisen liikkumisen mahdollisuudet. Yleisesti lapsia tulisi ohjata liikunnallisten leikkien pariin, jotta motorinen pätevyys kehittyisi lapsuusiällä.
4. Kontrolliryhmän lapsiin verrattuna, interventioryhmän lasten motorisen pätevyyden (KTK-mittarilla mitattu) kehitys oli merkitsevästi tasaisempaa siirryttäessä vuodenajasta toiseen. Löydös antaa aihetta esittää hypoteesi siitä, että liikuntaneuvonnan antaminen inaktiivisen vuodenajan aikana voi edesauttaa kestävämmän vaikutuksen syntymiseen motorisen pätevyyden kehittymisessä 4-7-vuotiailla lapsilla. Käytännössä liikuntaneuvonnan vaikutusvoima voi olla vähäistä, jos se ajoitetaan jo muutenkin fyysisesti aktiiviseen vuodenaikaan.
5. Matala lähtötaso vanhemman osoittamassa tuessa lapsen liikuntaa kohtaan toimi tämän ryvässatunnaistetun ja kontrolloidun perhelähtöisen liikuntaneuvonnan vaikutuksen välittäjänä. Lähtötilanteessa vähiten tuetut lapset lisäsivät fyysistä aktiivisuutta puoli vuotta kestäneen neuvontajakson aikana vastaaviin verrokkilapsiin nähden. Vaikutus lasten aktiivisuuteen kuitenkin lakkasi puoli vuotta liikuntaneuvonnan jälkeen kestäneen seurantajakson aikana. Enemmistö vanhemmista, jotka tukivat lastaan vähiten ennen neuvontaa, arvioivat kasvokkain tapahtu-

neen keskustelun ja omaehtoisen tavoitteenasettelun tärkeimmäksi liikuntaneuvonnan työkaluksi. Lastaan vähän liikunnallisesti tukevien vanhempien seulontaa ja säännöllisen liikuntaneuvonnan tarjoamista heille voidaan tutkimustulosten mukaan ehdottaa keinoksi edistää 4-7-vuotiaiden lasten fyysistä aktiivisuutta. Käytännössä vanhempien liikunnallisen tuen seuraaminen voisi täydentää nykyistä monipuolista lapsen kasvun, kehityksen ja ravitsemuksen seurantaa osana neuvolajärjestelmän, päiväkodin ja alakoulun sekä perheiden yhteistoimintaa. Vanhemman tuen seulonta ja seuranta olisi nopeaa ja vaivatonta, sillä esim. tässä tutkimuksessa käytettyyn kyselyyn vastaamiseen arvioitiin menevän aikaa noin 5 minuuttia. Kohdennettu vanhempien liikuntaneuvonta todennäköisesti lisäisi resurssien tarvetta neuvoloissa, päiväkodeissa ja kouluissa, mutta sen vaikuttavuus lasten fyysiseen aktiivisuuteen voisi tämän tutkimuksen perusteella olla merkitsevä. Tässä tutkimuksessa lupaaviksi osoittautuneiden liikuntaneuvontamenetelmien hyväksyttävyyttä, käytettävyyttä ja vaikuttavuutta tulisikin seuraavaksi tutkia neuvola, päiväkoti ja kouluympäristöissä ja niiden toteuttamassa yhteistyössä perheiden kanssa.

Asiasanat: fyysinen aktiivisuus, motoriset taidot, lapsi, liikuntaneuvonta, perhe, vanhemmat

REFERENCES

Adamo, K. B., Prince, S. A., Tricco, A. C., Connor-Gorber, S. & Tremblay, M. 2009. A comparison of indirect versus direct measures for assessing physical activity in the pediatric population: A systematic review. International Journal of Pediatric Obesity 4 (1), 2-27.

Ajzen, I. 1985. From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckmann (Eds.) Berlin, Germany: Springer, 11-39.

Ajzen, I. 2002. Constructing a TpB questionnaire: Conceptual and methodological considerations. Available in: http://people.umass.edu/aizen/pdf/tpb.measurement.pdf. Accessed: October 5, 2009.

Augste, C. & Künzell, S. 2014. Seasonal variations in physical fitness among elementary school children. Journal of Sports Sciences 32 (5), 415-423.

Ayres, A. J. 2008. Aistimusten aallokossa, sensorisen integraation häiriö ja terapia. Translated from original work "Sensory Integration and the Child". (Opetus 2000 -sarja edition) Jyväskylä: PS-kustannus.

Bailey, R. C., Olson, J., Pepper, S. L., Porszasz, J., Barstow, T. J. & Cooper, D. M. 1995. The level and tempo of children's physical activities: An observational study. Medicine & Science in Sports & Exercise 27 (7), 1033-1041.

Bandura, A. 2004. Health promotion by social cognitive means. Health Education & Behavior 31 (2), 143-164.

Bandura, A. 1986. Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall.

Baquet, G., Stratton, G., Van Praagh, E. & Berthoin, S. 2007. Improving physical activity assessment in prepubertal children with high-frequency accelerometry monitoring: A methodological issue. Preventive Medicine 44 (2), 143-7.

Barbeau, P., Litaker, M. S., Howe, C., Barry, K. & Gutin, B. 2003. Effect of a PA intervention on bone mineral density in black girls: Relative contribution of changes in fat mass and fat free tissue. Medicine & Science in Sports & Exercise 35 (5 (supplement 1)), S82.

Barnett, L. M., Morgan, P. J., van Beurden, E. & Beard, J. R. 2008a. Perceived sports competence mediates the relationship between childhood motor skill proficiency and adolescent physical activity and fitness: A longitudinal assessment. The International Journal of Behavioral Nutrition and Physical Activity 5 (40), 1-12.

Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O. & Beard, J. R. 2009a. Childhood motor skill proficiency as a predictor of adolescent physical activity. The Journal of Adolescent Health 44 (3), 252-259.

Barnett, L. M., Van Beurden, E., Morgan, P. J., Brooks, L. O. & Beard, J. R. 2008b. Does childhood motor skill proficiency predict adolescent fitness? Medicine and Science in Sports and Exercise 40 (12), 2137-2144.

Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O. & Beard, J. R. 2010. Gender differences in motor skill proficiency from childhood to adolescence: A longitudinal study. Research Quarterly for Exercise and Sport 81 (2), 162-70.

Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O., Zask, A. & Beard, J. R. 2009b. Six year follow-up of students who participated in a school-based physical activity intervention: A longitudinal cohort study. The International Journal of Behavioral Nutrition and Physical Activity 6 (48), September 21, 2015-http://www.ijbnpa.org/content/pdf/1479-5868-6-48.pdf.

Barnett, L., Hinkley, T., Okely, A. D. & Salmon, J. 2013. Child, family and environmental correlates of children's motor skill proficiency. Journal of Science and Medicine in Sport 16 (4), 332-336.

Basterfield, L., Reilly, J. K., Pearce, M. S., Parkinson, K. N., Adamson, A. J., Reilly, J. J. & Vella, S.A. 2014. Longitudinal associations between sports participation, body composition and physical activity from childhood to adolescence. Journal of Science and Medicine in Sport 18 (2), 178-182.

Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J. F. & Martin, B. W. 2012. Correlates of physical activity: Why are some people physically active and others not? The Lancet 380 (9838), 258-271.

Bauman, A. & Chau, J. 2009. The role of media in promoting physical activity. Journal of Physical Activity & Health 6 Suppl 2, S196-S210.

Beets, M. W., Beighle, A., Erwin, H. E. & Huberty, J. L. 2009. After-school program impact on physical activity. American Journal of Preventive Medicine 36 (6), 527-537.

Beets, M. W., Cardinal, B. J. & Alderman, B. L. 2010. Parental social support and the physical activity-related behaviors of youth: A review. Health Education & Behavior 37 (5), 621-644.

Berkey, C. S., Rockett, H. R., Field, A. E., Gillman, M. W., Frazier, A. L., Camargo, C. A. & Colditz, G. A. 2000. Activity, dietary intake, and weight changes in a longitudinal study of preadolescent and adolescent boys and girls. Pediatrics 105 (4), E56-E56.

Biddle, S. J. H. & Asare, M. 2011. Physical activity and mental health in children and adolescents: A review of reviews. British Journal of Sports Medicine 45 (11), 886-895.

Bonomi, A. G., Goris, A. H. C., Yin, B. & Westerterp, K. R. 2009. Detection of type, duration, and intensity of physical activity using an accelerometer. Medicine and Science in Sports and Exercise 41 (9), 1770-1777.

Bonvin, A., Barral, J., Kakebeeke, T. H., Kriemler, S., Longchamp, A., Schindler, C., Marques-vidal, P. & Puder, J. J. 2013. Effect of a governmentally-led physical activity program on motor skills in young children attending child care centers: A cluster randomized controlled trial. International Journal of Behavioral Nutrition and Physical Activity 10 (1), September 21, 2015-http://www.ijbnpa.org/content/10/1/90.

Booth, F. W., Roberts, C. K. & Laye, M. J. 2012. Lack of exercise is a major cause of chronic diseases. Comprehensive Physiology 2 (2), 1143-1211.

Booth, F. W., Chakravarthy, M. V. & Spangenburg, E. E. 2002. Exercise and gene expression: Physiological regulation of the human genome through physical activity. The Journal of Physiology 543, 399-411.

Bornstein, D. B., Beets, M. W., Byun, W. & McIver, K. 2011. Accelerometer-derived physical activity levels of preschoolers: A meta-analysis. Journal of Science and Medicine in Sport 14 (6), 504-11.

Braithwaite, R., Spray, C. M. & Warburton, V. E. 2011. Motivational climate interventions in physical education: A meta-analysis. Psychology of Sport and Exercise 12 (6), 628-638.

Brezmes, T., Gorricho, J. & Cotrina, J. 2009. Activity recognition from accelerometer data on mobile phones. Proceedings of the 10th International WorkConference on Artificial Neural Networks. IWANN '09, 796-799.

Brown, W. H., Pfeiffer, K. A., McIver, K. L., Dowda, M., Addy, C. L. & Pate, R. R. 2009. Social and environmental factors associated with preschoolers' nonsedentary physical activity. Child Development 80 (1), 45-58.

Buhrmester, D. & Furman, W. 1987. The development of companionship and intimacy. Child Development 58 (4), 1101-1113.

Bürgi, F., Meyer, U., Granacher, U., Schindler, C., Marques-Vidal, P., Kriemler, S. & Puder, J. J. 2011. Relationship of physical activity with motor skills, aerobic fitness and body fat in preschool children: A cross-sectional and longitudinal study (ballabeina). International Journal of Obesity 35 (7), 937-944.

Camacho-Araya, T., Woodburn, S. S. & Boschini, C. 1990. Reliability of the body coordination test for children. Perceptual and Motor Skills 70 (3), 832-834.

Cardon, G. M. & De Bourdeaudhuij, I.,M.M. 2008. Are preschool children active enough? Objectively measured physical activity levels. Research Quarterly for Exercise and Sport 79 (3), 326-32.

Carson, V., Hunter, S., Kuzik, N., Wiebe, S. A., Spence, J. C., Friedman, A., Tremblay, M. S., Slater, L. & Hinkley, T. 2015. Systematic review of physical activity and cognitive development in early childhood. Journal of Science and Medicine in Sport , September 21, 2015-http://dx.doi.org/10.1016/j.jsams.2015.07.011.

Carson, V. & Spence, J. C. 2010. Seasonal variation in physical activity among children and adolescents: A review. Pediatric Exercise Science 22 (1), 81-92.

Caspersen, C. J., Powell, K. E. & Christenson, G. M. 1985. Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. Public Health Reports 100 (2), 126-131.

Chakravarthy, M. V. & Booth, F. W. 2004. Eating, exercise, and "thrifty" genotypes: Connecting the dots toward an evolutionary understanding of modern chronic diseases. Journal of Applied Physiology 96 (1), 3-10.

Chambers, R., Gabbett, T. J., Cole, M. H. & Beard, A. 2015. The use of wearable microsensors to quantify sport-specific movements. Sports Medicine 45 (7), 1065-1081.

Chan, C. B. & Ryan, D. A. 2009. Assessing the effects of weather conditions on physical activity participation using objective measures. International Journal of Environmental Research and Public Health 6 (10), 2639-2654.

Chen, A. & Zhu, W. 2005. Young childrens intuitive interest in physical activity: Personal , school , and home factors. Journal of Physical Activity and Health 2 (1), 1-15.

Chen, K. Y. & Bassett, D. R. 2005. The technology of accelerometry-based activity monitors: Current and future. Medicine and Science in Sports and Exercise 37 (11 (supplement)), S490-S500.

Chia, L. C., Guelfi, K. J. & Licari, M. K. 2010. A comparison of the oxygen cost of locomotion in children with and without developmental coordination disorder. Developmental Medicine and Child Neurology 52 (3), 251-255.

Church, T. S., Thomas, D. M., Tudor-Locke, C., Katzmarzyk, P. T., Earnest, C. P., Rodarte, R. Q., Martin, C. K., Blair, S. N. & Bouchard, C. 2011. Trends over 5 decades in U.S. occupation-related physical activity and their associations with obesity. PLoS ONE 6 (5), 1-7.

Cleland, V., Dwyer, T. & Venn, A. 2012. Which domains of childhood physical activity predict physical activity in adulthood? A 20-year prospective tracking study. British Journal of Sports Medicine 46 (8), 595-602.

Cleland, V., Timperio, A., Salmon, J., Hume, C., Telford, A. & Crawford, D. 2011. A longitudinal study of the family physical activity environment and physical activity among youth. American Journal of Health Promotion 25 (3), 159-167.

Cliff, D. P., Jones, R. A., Burrows, T. L., Morgan, P. J. & Collins, C. E. 2013. Volumes and bouts of sedentary behavior and physical activity: Associations with cardio- metabolic health in obese children 22 (5), E112-E118.

Cliff, D. P., Okely, A. D., Morgan, P. J., Steele, J. R., Jones, R. A., Colyvas, K. & Baur, L. A. 2011. Movement skills and physical activity in obese children: Randomized controlled trial. Medicine and Science in Sports and Exercise 43 (1), 90-100.

Cliff, D. P., Okely, A. D., Smith, L. M. & McKeen, K. 2009. Relationships between fundamental movement skills and objectively measured physical activity in preschool children. Pediatric Exercise Science 21 (4), 436-49.

Cliff, D. P., Reilly, J. J. & Okely, A. D. 2009. Methodological considerations in using accelerometers to assess habitual physical activity in children aged 0 to 5 years. Journal of Science and Medicine in Sport 12 (5), 557-567.

Cohen, K. E., Morgan, P. J., Plotnikoff, R. C., Barnett, L. M. & Lubans, D. R. 2015. Improvements in fundamental movement skill competency mediate the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children. Journal of Sports Sciences 33 (18), 1908–1918.

Cole, T. J., Bellizzi, M. C., Flegal, K. M. & Dietz, W. H. 2000. Establishing a standard definition for child overweight and obesity worldwide: International survey. Bmj 320 (1240), 1-6.
Cools, W., De Martelaer, K., Samaey, C. & Andries, C. 2011. Fundamental movement skill performance of preschool children in relation to family context. Journal of Sports Sciences 29 (7), 649-60.
Cools, W., Martelaer, K. D., Samaey, C. & Andries, C. 2009. Movement skill assessment of typically developing preschool children: A review of seven movement skill assessment tools. Journal of Sports Science and Medicine 8 (2), 154-168.
Corder, K., Craggs, C., Jones, A. P., Ekelund, U., Griffin, S. J. & van Sluijs, E. M. 2013. Predictors of change differ for moderate and vigorous intensity physical activity and for weekdays and weekends: A longitudinal analysis. The International Journal of Behavioral Nutrition and Physical Activity 10 (1), 69-69.
Council on Sport Medicine and Fitness and Council on School Health 2006. Active healthy living: Prevention of childhood obesity through increased physical activity. Pediatrics 117 (5), 1834-1842.
Craggs, C., Corder, K., Van Sluijs, E. M. F. & Griffin, S. J. 2011. Determinants of change in physical activity in children and adolescents: A systematic review. American Journal of Preventive Medicine 40 (6), 645-658.
Curlik, D. M. & Shors, T. J. 2013. Training your brain: Do mental and physical (MAP) training enhance cognition through the process of neurogenesis in the hippocampus? Neuropharmacology 64 (1), 506-514.
Davis, C. L., Tomporowski, P. D., McDowell, J. E., Austin, B. P., Miller, P. H., Yanasak, N. E., Allison, J. D. & Naglieri, J. A. 2011. Exercise improves executive function and achievement and alters brain activation in overweight children: A randomized, controlled trial. Health Psychology 30 (1), 91-8.
Davison, K. K., Jurkowski, J. M., Li, K., Kranz, S. & Lawson, H. A. 2013a. A childhood obesity intervention developed by families for families: Results from a pilot study. The International Journal of Behavioral Nutrition and Physical Activity 10 (3), 1-11.
Davison, K. K., Mässe, L.,C., Timperio, A., Frenn, M. D., Saunders, J., Mendoza, J. A., Gobbi, E., Hanson, P. & Trost, S. G. 2013b. Physical activity parenting measurement and research: Challenges, explanations, and solutions. Childhood Obesity 9, 103-109.
Davison, K. K. & Jago, R. 2009. Change in parent and peer support across ages 9 to 15 yr and adolescent girls' physical activity. Medicine and Science in Sports and Exercise 41 (9), 1816-1825.
Dawson, G. & Watling, R. 2000. Interventions to facilitate auditory, visual, and motor integration in autism: A review of the evidence. Journal of Autism and Developmental Disorders 30 (5), 415-421.
De Craemer, M., De Decker, E., De Bourdeaudhuij, I., Vereecken, C., Deforche, B., Manios, Y. & Cardon, G. 2012. Correlates of energy balance-related

behaviours in preschool children: A systematic review. Obesity Reviews 13 Suppl 1 (6), 13-28.
de la Haye, K., Robins, G., Mohr, P. & Wilson, C. 2011. How physical activity shapes, and is shaped by, adolescent friendships. Social Science and Medicine 73 (5), 719-728.
Decorby, K., Halas, J., Dixon, S., Wintrup, L. & Janzen, H. 2005. Classroom teachers and the challenges of delivering quality physical education. The Journal of Educational Research 98 (4), 208-221.
Dennis, W. & Dennis, M. G. 1940. Effect of cradling upon the onset of walking in hopi children.pdf. The Journal of Genetic Psychology 56, 77-86.
Ding, D., Sallis, J. F., Kerr, J., Lee, S. & Rosenberg, D. E. 2011. Neighborhood environment and physical activity among youth: A review. American Journal of Preventive Medicine 41 (4), 442-455.
Dössegger, A., Ruch, N., Jimmy, G., Braun-Fahrländer, C., Mäder, U., Hänggi, J., Hofmann, H., Puder, J. J., Kriemler, S. & Bringolf-Isler, B. 2014. Reactivity to accelerometer measurement of children and adolescents. Medicine and Science in Sports and Exercise 46 (6), 1140-1146.
Dowda, M., Pfeiffer, K., Brown, W. H., Mitchell, J., Byun, W. & Pate, R. R. 2011. Parental and environmental correlates of physical activity of children attending preschool. Archives of Pediatrics and Adolescent Medicine 165 (10), 939-944.
Duncan, S. C., Duncan, T. E. & Strycker, L. A. 2005. Sources and types of social support in youth physical activity. Health Psychology 24 (1), 3-10.
Durante, R. & Answorth, B. E. 1996. The recall of physical activities in children. Medicine & Science in Sports & Exercise 28 (10), 1282-1291.
Durlak, J. A. & DuPre, E. P. 2008. Implementation matters: A review of research on the influence of implementation on program outcomes and the factors affecting implementation. American Journal of Community Psychology 41 (3-4), 327-350.
Dwyer, G. M., Baur, L. A. & Hardy, L. L. 2009. The challenge of understanding and assessing physical activity in preschool-age children: Thinking beyond the framework of intensity, duration and frequency of activity. Journal of Science and Medicine in Sport 12 (5), 534-6.
Dyment, J. & O'Connell, T. S. 2013. The impact of playground design on play choices and behaviors of pre-school children. Children's Geographies 11 (3), 263-280.
Dzewaltowski, D. A., Estabrooks, P. A., Welk, G., Hill, J., Milliken, G., Karteroliotis, K. & Johnston, J. A. 2009. Healthy youth places: A randomized controlled trial to determine the effectiveness of facilitating adult and youth leaders to promote physical activity and fruit and vegetable consumption in middle schools. Health Education & Behavior 36 (3), 583-600.
Eather, N., Morgan, P. J. & Lubans, D. R. 2013. Social support from teachers mediates physical activity behavior change in children participating in the

fit-4-fun intervention. The International Journal of Behavioral Nutrition and Physical Activity 10 (1), 68-68.
Eaton, S. B. & Eaton, S. B. 2003. An evolutionary perspective on human physical activity: Implications for health. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology 136 (1), 153-159.
Edwardson, C. L. & Gorely, T. 2010. Parental influences on different types and intensities of physical activity in youth: A systematic review. Psychology of Sport & Exercise 11 (6), 522-535.
Ekelund, E., Heian, F. & Hagen, K. B. 2005. Can exercise improve self esteem in children and young people? A systematic review of randomised controlled trials. British Journal of Sports Medicine 39 (11), 792-8.
Evenson, K. R., Catellier, D. J., Gill, K., Ondrak, K. S. & McMurray, R. G. 2008. Calibration of two objective measures of physical activity for children. Journal of Sports Sciences 26 (14), 1557-1565.
Fabel, K., Wolf, S. A., Ehninger, D., Babu, H., Leal-Galicia, P. & Kempermann, G. 2009. Additive effects of physical exercise and environmental enrichment on adult hippocampal neurogenesis in mice. Frontiers in Neuroscience 3 (50), 1-7.
Faigenbaum, A. D. & Myer, G. D. 2010. Pediatric resistance training: Benefits, concerns, and program design considerations. Current Sports Medicine Reports 9 (3), 161-168.
Farley, T. A., Meriwether, R. A., Baker, E. T., Rice, J. C. & Webber, L. 2008. Where do the children play? The influence of playground equipment on physical activity of children in free play. Journal of Physical Activity & Health 5 (2), 319-31.
Ferreira, I., van, d. H., Wendel-Vos, W., Kremers, S., van Lenthe, F. J. & Brug, J. 2007. Environmental correlates of physical activity in youth - a review and update. Obesity Reviews 8 (2), 129-54.
Finn, K., Johannsen, N. & Specker, B. 2002. Factors associated with physical activity in preschool children. The Journal of Pediatrics 140 (1), 81-5.
Finni, T., Sääkslahti, A., Laukkanen, A., Pesola, A. & Sipilä, S. 2011. A family based tailored counselling to increase non-exercise physical activity in adults with a sedentary job and physical activity in their young children: Design and methods of a year-long randomized controlled trial. BMC Public Health 11 (1), 944.
Fisher, A., Reilly, J. J., Kelly, L. A., Montgomery, C., Williamson, A., Paton, J. Y. & Grant, S. 2005. Fundamental movement skills and habitual physical activity in young children. Medicine and Science in Sports and Exercise 37 (4), 684-88.
Fisher, A., Smith, L., van Jaarsveld, C. H. M., Sawyer, A. & Wardle, J. 2015. Are children's activity levels determined by their genes or environment? A systematic review of twin studies. Preventive Medicine Reports 2, September 21, 2015-doi:10.1016/j.pmedr.2015.06.011.

Fitzgerald, A., Fitzgerald, N. & Aherne, C. 2012. Do peers matter? A review of peer and/or friends' influence on physical activity among american adolescents. Journal of Adolescence 35 (4), 941-958.

Fjortoft, I. & Gundersen, K. A. 2007. Promoting motor learning in young children through landscapes. In J. Liukkonen, Y. V. Auweele, B. Vereijken, D. Alfermannn & Y. Theodorakis (Eds.) Psychology for physical educators. Student in focus. (2nd edition) Champaign IL: Human Kinetics, 201-218.

Fjortoft, I. 2001. The natural environment as a playground for children: The impact of outdoor play activities in pre-primary school children. Early Childhood Education Journal 29 (2), 111-117.

Fjortoft, I. 2004. Landscape as playscape: The effects of natural environments on childrens play and motor development. Children, Youth and Environments 14 (2), 1-24.

Foley, J. T., Beets, M. W. & Cardinal, B. J. 2011. Monitoring children's physical activity with pedometers: Reactivity revisited. Journal of Exercise Science and Fitness 9 (2), 82-86.

Fransen, J., D'Hondt, E., Bourgois, J., Vaeyens, R., Philippaerts, R. M. & Lenoir, M. 2014. Motor competence assessment in children: Convergent and discriminant validity between the BOT-2 short form and KTK testing batteries. Research in Developmental Disabilities 35 (6), 1375-83.

Freedson, P., Pober, D. & Janz, K. F. 2005. Calibration of accelerometer output for children. Medicine & Science in Sports & Exercise 37, S523-S530.

Freitas, D. L., Lausen, B., Maia, J. A., Lefevre, J., Gouveia, É R., Thomis, M., Antunes, A. M., Claessens, A. L., Beunen, G. & Malina, R. M. 2015. Skeletal maturation, fundamental motor skills and motor coordination in children 7–10 years. Journal of Sports Sciences 33 (9), 924-934.

Frost, J. L., Brown, P., Sutterby, J. A. & Thornton, C. 2004. The developmental benefits of playgrounds. Olney, MD: Association for childhood education international.

Frost, J. L. & Woods, I. C. 2006. Perspectives on play and playground. In D. P. Fromberg & D. Bergen (Eds.) Play from birth to twelve. Context, perspectives, and meanings. (2nd edition) New York: Routledge, 337-348.

Fukunaga, T., Funato, K. & Ikegawa, S. 1992. The effects of resistance training on muscle area and strength in prepubescent age. The Annals of Physiological Anthropology 11 (3), 357-364.

Gallahue, D. L. & Ozmun, J. C. 2002. Understanding motor development : infants, children, adolescents, adults. (5th edition) Dubuque Iowa: McGraw-Hill.

Go, A. S., Mozaffarian, D., Roger, V., Benjamin, E. J., Berry, J. D., Borden, W. B., Bravata, D. M., Dai, S., Ford, E. S., Fox, C. S., Franco, S., Fullerton, H. J., Gillespie, C., Hailpern, S. M., Heit, J. a., Howard, V. J., Huffman, M. D., Kissela, B. M., Kittner, S. J., Lackland, D. T., Lichtman, J. H., Lisabeth, L. D., Magid, D., Marcus, G. M., Marelli, A., Matchar, D. B., McGuire, D. K., Mohler, E. R., Moy, C. S., Mussolino, M. E., Nichol, G., Paynter, N. P., Schreiner, P. J., Sorlie, P. D., Stein, J., Turan, T. N., Virani, S. S., Wong, N.

D., Woo, D. & Turner, M. B. 2013. Heart disease and stroke statistics-2013 update: A report from the american heart association. Circulation 127 (1), e6-e245.

Golley, R. K., Hendrie, G. A., Slater, A. & Corsini, N. 2011. Interventions that involve parents to improve children's weight-related nutrition intake and activity patterns: What nutrition and activity targets and behaviour change techniques are associated with intervention effectiveness? Obesity Reviews 12 (2), 114-130.

Goodway, J. D. & Branta, C. F. 2003. Influence of a motor skill intervention on fundamental motor skill development of disadvantaged preschool children. Research Quarterly for Exercise & Sport 74 (1), 36-46.

Gordon, E. S., Tucker, P., Burke, S. M. & Carron, A. V. 2013. Effectiveness of physical activity interventions for preschoolers: A meta-analysis. Research Quarterly for Exercise and Sport 84 (3), 287-294.

Gould, E., Beylin, A., Tanapat, P., Reeves, A. & Shors, T. J. 1999. Learning enhances adult neurogenesis in the hippocampal formation. Nature Neuroscience 2 (3), 260-265.

Gracia-Marco, L. & Ortega, F. B. 2013. Seasonal variation in physical activity and sedentary time in different european regions. The HELENA study. Journal of Sports Sciences 31 (16), 1831-1840.

Graf, C., Koch, B., Kretschmann-Kandel, E., Falkowski, G., Christ, H., Coburger, S., Lehmacher, W., Bjarnason-Wehrens, B., Platen, P., Tokarski, W., Predel, H. G. & Dordel, S. 2004. Correlation between BMI, leisure habits and motor abilities in childhood (CHILT-project). International Journal of Obesity and Related Metabolic Disorders 28 (1), 22-26.

Gustafson, S. L. & Rhodes, R. E. 2006. Parental correlates of physical activity in children and early adolescents. Sports Medicine 36 (1), 79-97.

Gutin, B., Barbeau, P., Owens, S., Lemmon, C. R., Bauman, M., Allison, J., Kang, H. & Litaker, M. S. 2002. Effects of exercise intensity on cardiovascular fitness, total body composition, and visceral adiposity of obese adolescents. The American Journal of Clinical Nutrition 75 (5), 818-826.

Haerens, L., Cerin, E., Maes, L., Cardon, G., Deforche, B. & De Bourdeaudhuij, I. 2008. Explaining the effect of a 1-year intervention promoting physical activity in middle schools: A mediation analysis. Public Health Nutrition 11 (5), 501-512.

Hamer, M. & Fisher, A. 2012. Are interventions to promote physical activity in children a waste of time? BMJ 345, September 21, 2015-doi: http://dx.doi.org/10.1136/bmj.e6320.

Hamilton, M., Goodway, J. & Haubenstricker, J. 1999. Parent-assisted instruction in a motor skill program for at-risk preschool children. Adapted Physical Activity Quarterly 16 (4), 415-426.

Hattie, J. 2003. Distinguishing expert teachers from novice and experienced teachers. Teachers make a difference. What is the research evidence? In Australian Council for Educational Research Annual Conference on

Building Teacher Quality. Melbourne, Australia: University of Auckland, 1-17.

Haug, E., Torsheim, T. & Samdal, O. 2008. Physical environmental characteristics and individual interests as correlates of physical activity in norwegian secondary schools: The health behaviour in school-aged children study. The International Journal of Behavioral Nutrition and Physical Activity 5, 47-47.

Haywood, K. & Getchell, N. 2009. Life span motor development. (5th edition) Champaign, IL: Human Kinetics.

Hearst, M. O., Patnode, C. D., Sirard, J. R., Farbakhsh, K. & Lytle, L. A. 2012. Multilevel predictors of adolescent physical activity: A longitudinal analysis. The International Journal of Behavioral Nutrition and Physical Activity 9 (1), 8-8.

Heath, G. W., Parra, D. C., Sarmiento, O. L., Andersen, L. B., Owen, N., Goenka, S., Montes, F. & Brownson, R. C. 2012. Evidence-based intervention in physical activity: Lessons from around the world. Lancet 380 (9838), 272-81.

Henderson, S. E. & Sugden, D. A. 1992. Movement Assessment Battery for Children. London: Psychological Corporation.

Hillman, C. H., Pontifex, M. B., Castelli, D. M., Khan, N., Raine, L. B., Scudder, M. R., Drollette, E. S., Moore, R. D., Wu, C. & Kamijo, K. 2014. Effects of the FIT-kids randomized controlled trial on executive control and brain function. Pediatrics 134 (4), e1063-e1071.

Hills, A. P., King, N. A. & Armstrong, T. P. 2007. The contribution of physical activity and sedentary behaviours to the growth and development of children and adolescents: Implications for overweight and obesity. Sports Medicine 37 (6), 533-45.

Hingle, M. D., Connor, T. M. O., Dave, J. M. & Baranowski, T. 2010. Parental involvement in interventions to improve child dietary intake : A systematic review. Preventive Medicine 51 (2), 103-111.

Hinkley, T., Crawford, D., Salmon, J., Okely, A. D. & Hesketh, K. 2008. Preschool children and physical activity: A review of correlates. American Journal of Preventive Medicine 34 (5), 435-441.

Hinkley, T., Salmon, J., Okely, A. D., Crawford, D. & Hesketh, K. 2012. Preschoolers' physical activity, screen time, and compliance with recommendations. Medicine and Science in Sports and Exercise 44 (3), 458-65.

Hinkley, T., Teychenne, M., Downing, K. L., Ball, K., Salmon, J. & Hesketh, K. D. 2014. Early childhood physical activity, sedentary behaviors and psychosocial well-being: A systematic review. Preventive medicine 62, September 21, 2015-doi: 10.1016/j.ypmed.2014.02.007.

Hirvensalo, M. & Lintunen, T. 2011. Life-course perspective for physical activity and sports participation. European Review of Aging and Physical Activity 8 (1), 13-22.

Holfelder, B. & Schott, N. 2014. Relationship of fundamental movement skills and physical activity in children and adolescents: A systematic review. Psychology of Sport and Exercise 15 (4), 382-391.

Holopainen, S. 1990. Koululaisten liikuntataidot : motorisen taitavuuden kehittyminen kehon rakenteen, kehitysiän ja liikuntaharrastusten selittämänä ja taitavuuden pedagoginen merkitys. University of Jyväskylä. Studies in sport, physical education and health 26.

Hyatt, K. J., Stephenson, J. & Carter, M. 2009. A review of three controversial educational practices: Perceptual motor programs, sensory integration, and tinted lenses. Education and Treatment of Children 32 (2), 313-342.

Iannotti, R. J., Sallis, J. F., Chen, R., Broyles, S. L., Elder, J. P. & Nader, P. R. 2005. Prospective analyses of relationships between mothers' and children's physical activity. Journal of Physical Activity and Health 2 (1), 16-34.

Iivonen, S., Sääkslahti, A. & Nissinen, K. 2011. The development of fundamental motor skills of four to five year old preschool children and the effects of a preschool physical education curriculum. Early Child Development and Care 181 (3), 335-343.

Iivonen, S. & Sääkslahti, A. K. 2014. Preschool children ' s fundamental motor skills : A review of significant determinants. Early Child Development and Care 184 (7), 1107-1126.

Iivonen, S. 2008. Early Steps -liikuntaohjelman yhteydet 4-5-vuotiaiden päiväkotilasten motoristen perustaitojen kehitykseen. Jyväskylä: Jyväskylän yliopisto. Studies in sport, physical education and health 131.

Intille, S. S., Lester, J., Sallis, J. F. & Duncan, G. 2012. New horizons in sensor development. Medicine & Science in Sports & Exercise 44 (1), 24-31.

Jaakkola, T., Yli-Piipari, S., Huotari, P., Watt, A. & Liukkonen, J. 2015. Fundamental movement skills and physical fitness as predictors of physical activity: A 6-year follow-up study. Scandinavian Journal of Medicine & Science in Sports , September 21, 2015-DOI: 10.1111/sms.12407.

Jaakkola, T. & Washington, T. 2013. The relationship between fundamental movement skills and self-reported physical activity during finnish junior high school. Physical Education & Sport Pedagogy 18 (5), 492-505.

Jago, R., Fox, K. R., Page, A. S., Brockman, R. & Thompson, J. L. 2010. Parent and child physical activity and sedentary time: Do active parents foster active children? BMC Public Health 10, 194-194.

Jämsen, A., Villberg, J., Mehtälä, A. & Soini, A. 2013. 3-4 -vuotiaiden lasten fyysinen aktiivisuus päiväkodissa eri vuodenaikoina sekä varhaiskasvattajan kannustuksen yhteys lasten fyysiseen aktiivisuuteen. Jyväskylän yliopisto. Pro gradu -tutkielma.

Jones, R. A., Hinkley, T., Okely, A. D. & Salmon, J. 2013. Tracking physical activity and sedentary behavior in childhood: A systematic review. American Journal of Preventive Medicine 44 (6), 651-658.

Kahn, J. A., Huang, B., Gillman, M. W., Field, A. E., Austin, S. B., Colditz, G. A. & Frazier, A. L. 2008. Patterns and determinants of physical activity in U.S. adolescents. Journal of Adolescent Health 42 (2), 369-377.

Kalaja, S. P., Jaakkola, T. T., Olavi, J. & Digelidis, N. 2012. Development of junior high school students ' fundamental movement skills and physical activity in a naturalistic physical education setting. Physical Education and Sport Pedagogy 17 (4), 411-428.

Kambas, A., Michalopoulou, M., Fatouros, I. G., Christoforidis, C., Manthou, E., Giannakidou, D., Venetsanou, F., Haberer, E., Chatzinikolaou, A., Gourgoulis, V. & Zimmer, R. 2012. The relationship between motor proficiency and pedometer-determined physical activity in young children. Pediatric Exercise Science 24 (1), 34-44.

Kim, Y., Beets, M. W. & Welk, G. J. 2012. Everything you wanted to know about selecting the "right" actigraph accelerometer cut-points for youth, but...: A systematic review. Journal of Science and Medicine in Sport 15 (4), 311-21.

Kiphard, E. J. & Schilling, F. 2007. KörperkoordinationTest für Kinder. (2. Überarbeitete und ergänzte Auflage. edition) Weinheim: Belzt test GmbH.

Kiphard, E. J. & Schilling, F. 1974. KörperkoordinationsTest für kinder. Weinheim: Beltz-Verlag.

Kipping, R. R., Jago, R. & Lawlor, D. A. 2012. Developing parent involvement in a school-based child obesity prevention intervention: A qualitative study and process evaluation. Journal of Public Health 34 (2), 236-244.

Koka, A. & Hein, V. 2003. Perceptions of teacher's feedback and learning environment as predictors of intrinsic motivation in physical education. Psychology of Sport and Exercise 4 (4), 333-346.

Kuh, L. P., Ponte, I. & Chau, C. 2013. The impact of a natural playscape installation on young children's play behaviors. Children, Youth and Environments 23 (2), 49-77.

Kumpulainen, S., Avela, J., Gruber, M., Bergmann, J., Voigt, M., Linnamo, V. & Mrachacz-Kersting, N. 2014. Differential modulation of motor cortex plasticity in skill- and endurance-trained athletes. European Journal of Applied Physiology 115 (5), 1107-1115.

Kyttä, M. 2004. The extent of children's independent mobility and the number of actualized affordances as criteria for child-friendly environments. Journal of Environmental Psychology 24 (2), 179-198.

Lai, S. K., Costigan, S. A., Stodden, D. F., Salmon, J. & Barnett, L. M. 2013. Do school-based interventions focusing on physical activity , fitness , or fundamental movement skill competency produce a sustained impact in these outcomes in children and adolescents ? A systematic review of follow-up studies. Sports Medicine 44 (1), 67-79.

Li, Y., Kwan, M. Y. W., King-Dowling, S. & Cairney, J. 2015. Determinants of physical activity during early childhood: A systematic review. Advances in Physical Education 5 (2), 116-127.

Lloyd, M., Saunders, T. J., Bremer, E. & Tremblay, M. S. 2014. Long-term importance of fundamental motor skills: A 20-year follow-up study. Adapted Physical Activity Quarterly 31 (1), 67-78.

Lobo, Y. B. & Winsler, A. 2006. The effects of a creative dance and movement program on the social competence of head start preschoolers. Social Development 15 (3), 501-519.

Logan, S. W., Robinson, L. E., Wilson, A. E. & Lucas, W. A. 2011. Getting the fundamentals of movement: A meta-analysis of the effectiveness of motor skill interventions in children. Child: Care, Health and Development 38 (3), 305-315.

Lopes, V. P., Rodrigues, L. P., Maia, J. A. R. & Malina, R. M. 2011. Motor coordination as predictor of physical activity in childhood. Scandinavian Journal of Medicine & Science in Sports 21 (5), 663-669.

Lopes, V. P., Stodden, D. F., Bianchi, M. M., Maia, J. A. & Rodrigues, L. P. 2012a. Correlation between BMI and motor coordination in children. Journal of Science and Medicine in Sport 15 (1), 38-43.

Lopes, V. P., Maia, J. A. R., Rodrigues, L. P. & Malina, R. 2012b. Motor coordination, physical activity and fitness as predictors of longitudinal change in adiposity during childhood. European Journal of Sport Science 12 (4), 384-391.

Lopes, V. P., Gabbard, C. & Rodrigues, L. P. 2015. Effects of psychosocial variables in the similarity and interdependence of physical activity levels among adolescent best friend dyads. Journal of sports sciences , September 21, 2015-DOI:10.1080/02640414.2015.1075054.

Loprinzi, P. D. & Trost, S. G. 2010. Parental influences on physical activity behavior in preschool children. Preventive Medicine 50 (3), 129-33.

Lubans, D. R. & Sylva, K. 2009. Mediators of change following a senior school physical activity intervention. Journal of Science and Medicine in Sport 12 (1), 134-140.

Lubans, D. R., Sylva, K. & Morgan, P. J. 2007. Factors associated with physical activity in a sample of british secondary school students university of newcastle. Australian Journal of Educational & Developmental Psychology 7 (1), 22-30.

Luz, C., Rodrigues, L. P., Almeida, G. & Cordovil, &. R. 2015. Development and validation of a model of motor competence in children and adolescents. Journal of Science and Medicine in Sport , doi:10.1016/j.jsams.2015.07.005.

Malina, R., Bouchard, C. & Bar-Or, O. 2004. Growth, maturation and physical activity. (2.th edition) United Kingdom: Human Kinetics.

Malina, R. M. 2000. Growth and maturation: do regular physical activity and training for sport have a significant influence? In N. Armstrong & W. V. Mechelen (Eds.) Paediatric exercise science and medicine.Oxford: University Press, 95-106.

Martin-Diener, E., Wanner, M., Kriemler, S. & Martin, B. W. 2013. Associations of objectively assessed levels of physical activity, aerobic fitness and motor coordination with injury risk in school children aged 7 −9 years: A cross-sectional study. BMJ Open , September 21, 2015-doi: 10.1136/bmjopen-2013-003086.

Martins, D., Maia, J., Seabra, A., Garganta, R., Lopes, V., Katzmarzyk, P. & Beunen, G. 2010. Correlates of changes in BMI of children from the azores islands. International Journal of Obesity 34 (10), 1487-1493.

Matvienko, O. & Ahrabi-Fard, I. 2010. The effects of a 4-week after-school program on motor skills and fitness of kindergarten and first-grade students. American Journal of Health Promotion 24 (5), 299-303.

McArdle, W. D., Katch, F. I. & Katch, V. L. 2001. Exercise physiology: Energy, nutrition, and human performance. (5th edition) Philadelphia: Lippincott Williams & Wilkins.

McEachan, R. R. C., Conner, M., Taylor, N. J. & Lawton, R. J. 2011. Prospective prediction of health-related behaviours with the theory of planned behaviour: A meta-analysis. Health Psychology Review 5 (2), 97-144.

McKenzie, T. L., Sallis, J. F., Broyles, S. L., Zive, M. M., Nader, P. R., Berry, C. C. & Brennan, J. J. 2002. Childhood movement skills: Predictors of physical activity in anglo american and mexican american adolescents? Research Quarterly for Exercise and Sport 73 (3), 238-44.

Mehtälä, M. A. K., Sääkslahti, A. K., Inkinen, M. E. & Poskiparta, M. E. H. 2014. A socio-ecological approach to physical activity interventions in childcare: A systematic review. International Journal of Behavioral Nutrition and Physical Activity 11 (22), 1-12.

Metcalf, B. S., Hosking, J., Jeffery, A. N., Voss, L. D., Henley, W. & Wilkin, T. J. 2010. Fatness leads to inactivity , but inactivity does not lead to fatness: A longitudinal study in children (EarlyBird 45). Archives of Disease in Childhood 96, September 21, 2015-doi: 10.1136/adc.2009.175927.

Metcalf, B., Henley, W. & Wilkin, T. 2012. Effectiveness of intervention on physical activity of children: Systematic review and meta-analysis of controlled trials with objectively measured outcomes (EarlyBird 54). Bmj 345, e5888-e5888.

Michie, S. & Abraham, C. 2004. Interventions to change health behaviours: Evidence-based or evidence-inspired? Psychology & Health 19 (1), 29-49.

Mikkonen, M. & Juutinen, T. 2013. Vipinää pieniinkin kinttuihin. Available in: http://wikiliikkuja.com/2012/10/08/vipinaa-pieniinkin-kinttuihin/. Accessed: September 4, 2013.

Morgan, P. J., Barnett, L. M., Cliff, D. P., Okely, A. D., Scott, H. A., Cohen, K. E. & Lubans, D. R. 2013. Fundamental movement skill interventions in youth: A systematic review and meta-analysis. Pediatrics 132 (5), e1361-1383.

Morgan, P. J., Lubans, D. R., Plotnikoff, R. C., Callister, R., Burrows, T., Fletcher, R., Okely, A. D., Young, M. D., Miller, A., Clay, V., Lloyd, A. & Collins, C. E. 2011. The 'healthy dads, healthy kids' community effectiveness trial: Study protocol of a community-based healthy lifestyle program for fathers and their children. BMC Public Health 11, 876-876.

Murdey, I. D., Cameron, N., Biddle, S. J. H., Marshall, S. J. & Gorely, T. 2005. Short-term changes in sedentary behaviour during adolescence: Project

STIL (sedentary teenagers and inactive lifestyles). Annals of Human Biology 32 (3), 283-296.

National Institute for Health and Clinical Excellence 2009. NICE public health guidance 17: Promoting physical activity for children and young people.

Naylor, P., Nettlefold, L., Race, D., Hoy, C., Ashe, M. C., Wharf Higgins, J. & McKay, H. A. 2015. Implementation of school based physical activity interventions: A systematic review. Preventive medicine 72, September 21, 2015-doi:10.1016/j.ypmed.2014.12.034.

Nicaise, V., Kahan, D. & Sallis, J. F. 2011. Correlates of moderate-to-vigorous physical activity among preschoolers during unstructured outdoor play periods. Preventive Medicine 53 (4–5), 309-315.

Nikander, R., Sievänen, H., Heinonen, A., Daly, R. M., Uusi-Rasi, K. & Kannus, P. 2010. Targeted exercise against osteoporosis: A systematic review and meta-analysis for optimising bone strength throughout life. BMC Medicine 8 (47), 1-16.

Numminen, P. 1995. APM inventory: manual and test booklet for assessing pre-school childrens' perceptual and basic motor skills. Jyväskylä: LIKES.

Numminen, P. 1991. The role of imagery in physical education. University of Jyväskylä. Studies in sport, physical education and health 27.

O'Connor, T. M., Hilmers, A., Watson, K., Baranowski, T. & Giardino, A. P. 2013. Feasibility of an obesity intervention for paediatric primary care targeting parenting and children: Helping HAND. Child: Care, Health and Development 39 (1), 141-149.

O'Connor, T. M., Jago, R. & Baranowski, T. 2009. Engaging parents to increase youth physical activity a systematic review. American Journal of Preventive Medicine 37 (2), 141-149.

OECD family database 2010. Enrolment in day-care and pre-schools. Available in: http://www.oecd.org/edu/school/44975703.pdf. Accessed: 16 September, 2015.

Okely, A. D., Booth, M. L. & Patterson, J. W. 2001. Relationship of physical activity to fundamental movement skills among adolescents. Medicine and Science in Sports and Exercise 33 (11), 1899-1904.

Oliver, M., Schofield, G. M. & Kolt, G. S. 2007. Physical activity in preschoolers: Understanding prevalence and measurement issues. Sports Medicine 37 (12), 1045-70.

Oliver, M., Schofield, G. M., Kolt, G. S. & Schluter, P. J. 2007. Pedometer accuracy in physical activity assessment of preschool children. Journal of Science and Medicine in Sport 10 (5), 303-310.

Owens, S., Gutin, B., Allison, J., Riggs, S., Ferguson, M., Litaker, M. & Thompson, W. 1999. Effect of physical training on total and visceral fat in obese children. Medicine & Science in Sports & Exercise 31 (1), 143-148.

Ozdoba, R., Corbin, C. & Le Masurier, G. 2004. Does reactivity exist in children when measuring activity levels with unsealed pedometers? Pediatric Exercise Science 16 (2), 158-166.

Ozmun, J. C., Mikesky, A. E. & Surburg, P. R. 1994. Neuromuscular adaptations following prepubescent strength training. Medicine and Science in Sports and Exercise 26 (4), 510-514.

Park, N. 2004. The role of subjective well-being in positive youth development. The Annals of the American Academy of Political and Social Science 591 (1), 25-39.

Pate, R. R., Baranowski, T., Dowda, M. & Trost, S. G. 1996. Tracking of physical activity in young children. Medicine and Science in Sports and Exercise 28 (1), 92-96.

Pate, R. R. & O'Neill, J. R. 2009. After-school interventions to increase physical activity among youth. British Journal of Sports Medicine 43 (1), 14-18.

Pate, R. R., Almeida, M. J., Mciver, K. L., Pfeiffer, K. A. & Dowda, M. 2006. Validation and calibration of an accelerometer in preschool children. Obesity 14 (11), 2000-2006.

Pate, R. R., Pfeiffer, K. A., Trost, S. G., Ziegler, P. & Dowda, M. 2004. Physical activity among children attending preschools. Pediatrics 114 (5), 1258 - 1263.

Pate, R. R., Neill, J. R. O., Brown, W. H., Pfeiffer, K. A., Dowda, M. & Addy, C. L. 2015. Prevalence of compliance with a new physical activity guideline for preschool-age children. Childhood Obesity 11 (4), 415-420.

Pate, R. R., O'Neill, J. R. & Mitchell, J. 2010. Measurement of physical activity in preschool children. Medicine and Science in Sports and Exercise 42 (3), 508-512.

Payne, V. G., Morrow Jr.,J.R., Johnson, L. & Dalton, S. N. 1997. Resistance training in children and youth: A meta-analysis. Research Quarterly for Exercise & Sport 68 (1), 80-88.

Payne, V. G. & Isaacs, L. D. 2008. Human motor development. A lifespan approach. (7th edition) NY: McGraw Hill.

Pellegrini, A. D. & Smith, P. K. 1998. Physical activity play: The nature and function of a neglected aspect of playing. Child Development 69 (3), 577-598.

Pellegrini, A. D., Blatchford, P., Kato, K. & Baines, E. 2004. A short-term longitudinal study of children's playground games in primary school: Implications for adjustment to school and social adjustment in the USA and the UK. Social Development 13 (1), 107-123.

Pellegrini, A., Kato, K., Blatchford, P. & Baines, E. 2002. A short-term longitudinal study of children's playground games across the first year of school: Implications for social competence and adjustment to school. American Educational Research Journal 39 (4), 991-1015.

Penpraze, V., Reilly, J. J., MacLean, C. M., Montgomery, C., Kelly, L. A., Paton, J. Y., Aitchison, T. & Grant, S. 2006. Monitoring of physical activity in young children: How much is enough? Pediatric Exercise Science 18 (4), 483-491.

Piaget, J. 1952. The origins of intelligence in children. New York: International Universities Press.

Pönkkö, A. 1999. Vanhemmat ja lastentarhanopettajat päiväkotilasten minäkäsityksen tukena. Jyväskylän yliopisto. Studies in sport, physical education and health 62.

Prochaska, J. O. & Velicer, W. F. 1997. The transtheoretical model of health behavior change. American Journal of Health Promotion 12 (1), 38-48.

Prochaska, J. J., Rodgers, M. W. & Sallis, J. F. 2002. Association of parent and peer support with adolescent physical activity. Research Quarterly for Exercise and Sport 73 (2), 206-210.

Pucher, J. & Buehler, R. 2008. Making cycling irresistible: Lessons from the netherlands, denmark and germany. Transport Reviews 28 (4), 495-528.

Pugliese, J. & Tinsley, B. 2007. Parental socialization of child and adolescent physical activity: A meta-analysis. Journal of Family Psychology 21 (3), 331-343.

Ramsay, J. A., Blimkie, C. J., Smith, K., Garner, S., MacDougall, J. D. & Sale, D. G. 1990. Strength training effects in prepubescent boys. Medicine and Science in Sports and Exercise 22 (5), 605-614.

Redelius, K. & Larsson, H. 2010. Physical education in scandinavia: An overview and some educational challenges. Sport in Society 13 (1), 691-703.

Reilly, J. J., Coyle, J., Kelly, L., Burke, G., Grant, S. & Paton, J. Y. 2003. An objective method for measurement of sedentary behavior in 3- to 4-year olds. Obesity Research 11 (10), 1155-1158.

Reilly, J. J., Kelly, L., Montgomery, C., Williamson, A., Fisher, A., McColl, J. H., Lo Conte, R., Paton, J. Y. & Grant, S. 2006. Physical activity to prevent obesity in young children: Cluster randomised controlled trial. BMJ 333, September 21, 2015-doi: http://dx.doi.org/10.1136/bmj.38979.623773.55.

Reunamo, J., Hakala, L., Saros, L. & Lehto, S. 2014. Children's physical activity in day care and preschool. Early Years 34 (1), 32-48.

Rhodes, R. E., Berry, T., Craig, C. L., Faulkner, G., Latimer-Cheung, A., Spence, J. C. & Tremblay, M. S. 2013. Understanding parental support of child physical activity behavior. American Journal of Health Behavior 37 (4), 469-477.

Rhodes, R. E., Naylor, P. J. & McKay, H. A. 2010. Pilot study of a family physical activity planning intervention among parents and their children. Journal of Behavioral Medicine 33 (2), 91-100.

Riethmuller, A. M., Jones, R. A. & Okely, A. D. 2009. Efficacy of interventions to improve motor development in young children: A systematic review. Pediatrics 124 (4), e782-e792.

Robertson-Wilson, J., Lévesque, L. & Holden, R. R. 2007. Development of a questionnaire assessing school physical activity environment. Measurement in Physical Education and Exercise Science 11 (2), 93-107.

Robinson, L. E., Stodden, D. F., Barnett, L. M., Lopes, V. P., Logan, S. W., Rodrigues, L. P. & D'Hondt, E. 2015. Motor competence and its effect on positive developmental trajectories of health. Sports Medicine 45 (9), 1273-1284.

Rodearmel, S. J., Wyatt, H. R., Barry, M. J., Dong, F., Pan, D., Israel, R. G., Cho, S. S., McBurney, M. I. & Hill, J. O. 2006. A family-based approach to preventing excessive weight gain. Obesity 14 (8), 1392-1401.

Rogers, R. W. 1975. A protection motivation theory of fear appeals and attitude change. Journal of Psychology 91 (1), 93-114.

Rosenstock, I. M. 1974. The health belief model and preventive health behavior. Health Education Monographs 2 (4), 354–386.

Rouvali, T. 2015. Motor coordination test as an indicator for skating performance in ice hockey for pre-puberty children. A master's thesis. University of Jyväskylä.

Rowe, D. a., Mahar, M. T., Raedeke, T. D. & Lore, J. 2004. Measuring physical activity in children with pedometers: Reliability, reactivity, and replacement of missing data. Pediatric Exercise Science 16, 1-12.

Rowlands, A. V. 2007. Accelerometer assessment of physical activity in children: An update. Pediatric Exercise Science 19 (3), 252-266.

Sääkslahti, A., Numminen, P., Niinikoski, H., Rask-Nissilä, L., Viikari, J., Tuominen, J. & Välimäki, I. 1999. Is physical activity related to body size, fundamental motor skills, and CHD risk factors in early childhood? Pediatric Exercise Science 11 (4), 327-340.

Sääkslahti, A. 2005. Liikuntaintervention vaikutus 3-7-vuotiaiden lasten fyysiseen aktiivisuuteen ja motorisiin taitoihin sekä fyysisen aktiivisuuden yhteys sydän- ja verisuonitautien riskitekijöihin. Jyväskylän yliopisto. Studies in sport, physical education and health 104.

Sacher, P. M., Kolotourou, M., Chadwick, P. M., Cole, T. J., Lawson, M. S., Lucas, A. & Singhal, A. 2010. Randomized controlled trial of the MEND program: A family-based community intervention for childhood obesity. Obesity 18 (1 (supplement)), S62-S68.

Sallis, J. F., Owen, N. & Fisher, E. B. 2008. Ecological models of health behavior. In K. Glanz, B. K. Rimer & K. Viswanath (Eds.) Health behavior and health education: theory, research, and practice. (4th edition) San Francisco, CA: Jossey-Bass, 465-86.

Sallis, J. F. & Saelens, B. E. 2000. Assessment of physical activity by self-report: Status, limitations, and future directions. Research Quarterly for Exercise and Sport 71 (2), S1-14.

Sallis, J. F., Prochaska, J. J. & Taylor, W. C. 2000. A review of correlates of physical activity. Medicine & Science in Sports & Exercise 32 (5), 963-975.

Sallis, J. F., Taylor, W. C., Freedson, P. S., Pate, R. R. & Dowda, M. 2002. Correlates of vigorous physical activity for children in grades 1 through 12: Comparing parent-reported and objectively measured physical activity measured physical activity. Pediatric Exercise Science 14 (1), 30-44.

Sallis, J. F. & Owen, N. 1999. Physical activity and behavioral medicine. Thousand Oaks, CA: London: SAGE,. Behavioral medicine and health psychology series.

Salmon, J., Timperio, A., Chu, B. & Veitch, J. 2010. Dog ownership, dog walking, and children's and parents' physical activity. Research Quarterly for Exercise and Sport 81 (3), 264-271.

Salvy, S., Bowker, J. W., Roemmich, J. N., Romero, N., Kieffer, E., Paluch, R. & Epstein, L. H. 2007. Peer influence on children's physical activity: An experience sampling study. Journal of Pediatric Psychology 33 (1), 39-49.

Saudino, K. J. 2009. Do different measures tap the same genetic influences? A multi-method study of activity level in young twins. Developmental Science 12 (4), 626-633.

Schmidt, R. A. & Lee, T. D. 2005. Motor control and learning: A behavioral emphasis. (4th edition) Champaign IL: Human Kinetics.

Seefeldt, V. 1980. Developmental motor patterns: Implications for elementary school physical education. In C. Nadeau, W. Holliwell, K. Newell & G. Roberts (Eds.) Psychology of motor behavior and sport.Champaign, IL: Human Kinetics, 314-323.

Seghers, J. & Rutten, C. 2010. Clustering of multiple lifestyle behaviours and its relationship with weight status and cardiorespiratory fitness in a sample of flemish 11- to 12-year-olds. Public Health Nutrition 13 (11), 1838-46.

Sewall, L. & Micheli, L. J. 1986. Strength training for children. Journal of Pediatric Orthopedics 6 (2), 143-146.

Shors, T. J., Anderson, M. L., Curlik, D. M.,2nd & Nokia, M. S. 2012. Use it or lose it: How neurogenesis keeps the brain fit for learning. Behavioural Brain Research 227 (2), 450-458.

Sirard, J. R. & Pate, R. R. 2001. Physical activity assessment in children and adolescents. Sports Medicine 31 (6), 439-54.

Sirard, J. R., Trost, S. G., Pfeiffer, K. A., Dowda, M. & Pate, R. R. 2005. Calibration and evaluation of an objective measure of physical activity in preschool children. Journal of Physical Activity and Health 2 (3), 345-357.

Smith, L., Fisher, A. & Hamer, M. 2015. Prospective association between objective measures of childhood motor coordination and sedentary behaviour in adolescence and adulthood. International Journal of Behavioral Nutrition and Physical Activity 12 (1), 75-75.

Smits-Engelsman, B. & Henderson, S. E. 1998. The assessment of children with developmental coordination disorders in the Netherlands: The relationship between the movement assessment battery for children and the körperkoordinations test fur kinder. Human Movement Science 17 (4-5), 699-709.

Soini, A. 2015. Always on the move? Measured physical activity of 3-year-old preschool children. University of Jyväskylä. Studies in sport, physical education and health 216.

Soini, A., Kettunen, T., Mehtälä, A., Sääkslahti, A., Tammelin, T., Villberg, J. & Poskiparta, M. 2012. Kolmevuotiaiden päiväkotilasten mitattu fyysinen aktiivisuus. Liikunta & Tiede 49 (1), 1-8.

Soini, A., Villberg, J., Sääkslahti, A., Gubbels, J., Mehtälä, A., Kettunen, T. & Poskiparta, M. 2014. Directly observed physical activity among 3-year-olds in finnish childcare. International Journal of Early Childhood 46 (2), 253-269.

Spittaels, H., Van Cauwenberghe, E., Verbestel, V., De Meester, F., Van Dyck, D., Verloigne, M., Haerens, L., Deforche, B., Cardon, G. & De Bourdeaudhuij, I. 2012. Objectively measured sedentary time and physical activity time across the lifespan: A cross-sectional study in four age groups. International Journal of Behavioral Nutrition and Physical Activity 9 (149), 1-12.

Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Roberton, M. A., Rudisill, M. E., Garcia, C. & Garcia, L. E. 2008. A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. Quest 60 (2), 290-306.

Stodden, D. F., True, L. K., Langendorfer, S. J. & Gao, Z. 2013. Associations among selected motor skills and health- related fitness: Indirect evidence for seefeldt's proficiency barrier in young adults? Research Quarterly for Exercise and Sport 84 (3), 397-403.

Storli, R. & Sandseter, E. B. H. 2015. Preschool teachers' perceptions of children's rough-and-tumble play (R&T) in indoor and outdoor environments. Early Child Development and Care , September 21, 2015-DOI:10.1080/03004430.2015.1028394.

Strong, W. B., Malina, R. M., Blimkie, C. J. R., Daniels, S. R., Dishman, R. K., Gutin, B., Hergenroeder, A. C., Must, A., Nixon, P. a., Pivarnik, J. M., Rowland, T., Trost, S. & Trudeau, F. 2005. Evidence based physical activity for school-age youth. The Journal of Pediatrics 146 (6), 732-737.

Syväoja, H. J., Kantomaa, M. T., Ahonen, T., Hakonen, H., Kankaanpää, A. & Tammelin, T. H. 2013. Physical activity, sedentary behavior, and academic performance in finnish children. Medicine and Science in Sports and Exercise 45 (11), 2098-2104.

Tandon, P. S., Zhou, C., Sallis, J. F., Cain, K. L., Frank, L. D. & Saelens, B. E. 2012. Home environment relationships with children's physical activity, sedentary time, and screen time by socioeconomic status. International Journal of Behavioral Nutrition and Physical Activity 9 (88), 1-9.

Tang, R., Lee, P., Chen, S., Hwang, B. & Chao, T. 2002. Cardiopulmonary response in obese children using treadmill exercise testing. Chinese Medical Journal 65 (2), 79-82.

Telama, R., Yang, X., Leskinen, E., Kankaanpää, A., Hirvensalo, M., Tammelin, T., Viikari, J. S. A. & Raitakari, O. T. 2014. Tracking of physical activity from early childhood through youth into adulthood. Medicine & Science in Sports & Exercise 46 (5), 955-962.

Telford, R. M., Telford, R. D., Cunningham, R. B., Cochrane, T., Davey, R. & Waddington, G. 2013. Longitudinal patterns of physical activity in children aged 8 to 12 years: The LOOK study. International Journal of Behavioral Nutrition and Physical Activity 10 (1), 1-12.

Thompson, A. M., Humbert, M. L. & Mirwald, R. L. 2003. A longitudinal study of the impact of childhood and adolescent physical activity experiences on adult physical activity perceptions and behaviors. Qualitative Health Research 13 (3), 358-377.

Thompson, J. L., Jago, R., Brockman, R., Cartwright, K., Page, A. S. & Fox, K. R. 2010. Physically active families - de-bunking the myth? A qualitative study of family participation in physical activity. Child: Care, Health and Development 36 (2), 265-274.

Timmons, B. W., Leblanc, A. G., Carson, V., Gorber, S. C., Dillman, C., Janssen, I., Kho, M. E., Spence, J. C., Stearns, J. A. & Tremblay, M. S. 2012. Systematic review of physical activity and health in the early years (aged 0-4 years). Applied Physiology, Nutrition, and Metabolism 37 (4), 773-792.

Tomporowski, P. D., McCullick, B. A. & Pesce, C. 2015. Enhancing children's cognition with physical activity games. Champaign IL: Human Kinetics.

Tomporowski, P. D., Davis, C. L., Miller, P. H. & Naglieri, J. A. 2008. Exercise and children's intelligence, cognition, and academic achievement. Educational Psychology Review 20 (2), 111-131.

Tomporowski, P. D., Lambourne, K. & Okumura, M. S. 2011. Physical activity interventions and children's mental function: An introduction and overview. Preventive Medicine 52 (supplement 1), 53-59.

Tremblay, M. S., Leblanc, A. G., Janssen, I., Kho, M. E., Hicks, A., Murumets, K., Colley, R. C. & Duggan, M. 2011. Canadian sedentary behaviour guidelines for children and youth. Applied Physiology, Nutrition, and Metabolism 36 (1), 59-64.

Trost, S. G., McDonald, S. & Cohen, A. 2013. Measurement of general and specific approaches to physical activity parenting: A systematic review. Childhood Obesity 9 (Suplement 1), s40-s50.

Tucker, P. 2008. The physical activity levels of preschool-aged children: A systematic review. Early Childhood Research Quarterly 23 (4), 547-558.

Twisk, J. W. 2001. Physical activity guidelines for children and adolescents: A critical review. Sports Medicine 31 (8), 617-27.

van Cauwenberghe, E., Labarque, V., Trost, S. G., de Bourdeaudhuij, I. & Cardon, G. 2011. Calibration and comparison of accelerometer cut points in preschool children. International Journal of Pediatric Obesity 6 (2-2), e582-e589.

van Cauwenberghe, E., Labarque, V., Gubbels, J., De Bourdeaudhuij, I. & Cardon, G. 2012. Preschooler's physical activity levels and associations with lesson context, teacher's behavior, and environment during preschool physical education. Early Childhood Research Quarterly 27 (2), 221-230.

van der Fels, I. M. J., te Wierike, S. C. M., Hartman, E., Elferink-Gemser, M. T., Smith, J. & Visscher, C. 2014. The relationship between motor skills and cognitive skills in 4–16 year old typically developing children: A systematic review. Journal of Science and Medicine in Sport , September 21, 2015-doi:10.1016/j.jsams.2014.09.007.

van Praag, H. 2009. Exercise and the brain: Something to chew on. Trends in Neurosciences 32 (5), 283-290.

van Praag, H., Christie, B. R., Sejnowski, T. J. & Gage, F. H. 1999. Running enhances neurogenesis, learning, and long-term potentiation in mice. Proceedings of the National Academy of Sciences 96 (23), 13427-13431.

van Sluijs, E.,M.F., Kriemler, S. & McMinn, A. M. 2011. The effect of community and family interventions on young people's physical activity levels: A review of reviews and updated systematic review. British Journal of Sports Medicine 45 (11), 914-922.

Van, D. H., Paw, M. J. C. a., Twisk, J. W. R. & Van Mechelen, W. 2007. A brief review on correlates of physical activity and sedentariness in youth. Medicine and Science in Sports and Exercise 39 (8), 1241-50.

Vandorpe, B., Vandendriessche, J., Lefevre, J., Pion, J., Vaeyens, R., Matthys, S., Philippaerts, R. & Lenoir, M. 2011. The KorperkoordinationsTest fur kinder: Reference values and suitability for 6-12-year-old children in flanders. Scandinavian Journal of Medicine & Science in Sports 21 (3), 378-388.

Vandorpe, B., Vandendriessche, J., Vaeyens, R., Pion, J., Matthys, S., Lefevre, J., Philippaerts, R. & Lenoir, M. 2012. Relationship between sports participation and the level of motor coordination in childhood: A longitudinal approach. Journal of Science and Medicine in Sport 15 (3), 220-225.

Vella, S. A., Cliff, D. P., Magee, C. A. & Okely, A. D. 2014. Sports participation and parent-reported health-related quality of life in children: Longitudinal associations. The Journal of Pediatrics 164 (6), 1469-1474.

Venetsanou, F., Kambas, A., Ellinoudis, T., Fatouros, I., Giannakidou, D. & Kourtessis, T. 2011. Can the movement assessment battery for children-test be the "gold standard" for the motor assessment of children with developmental coordination disorder? Research in Developmental Disabilities 32 (1), 1-10.

Weintraub, D. L., Tirumalai, E. C., Haydel, K., Fujimoto, M., Fulton, J. E. & Robinson, T. N. 2008. Team sports for overweight children: The stanford sports to prevent obesity randomized trial (SPORT). Archives of Pediatrics & Adolescent Medicine 162 (3), 232-237.

Welk, G. J., Corbin, C. B. & Dale, D. 2000. Measurement issues in the assessment of physical activity in children. Research Quarterly for Exercise and Sport 71 (2), S59-73.

Whitehead, J. R. & Corbin, C. B. 1997. Self-esteem in children and youth: the role of sport and physical education. In K. R. Fox (Ed.) The physical self: From motivation to well-being.Champaign, IL: Human Kinetics, 175-203.

Wilks, D. C., Sharp, S. J., Ekelund, U., Thompson, S. G., Mander, A. P., Turner, R. M., Jebb, S. A. & Lindroos, A. K. 2011. Objectively measured physical activity and fat mass in children: A bias-adjusted meta-analysis of prospective studies. PLoS ONE 6 (2), September 21, 2015-doi:10.1371/journal.pone.0017205.

Williams, H. G., Pfeiffer, K. a., O'Neill, J.,R., Dowda, M., McIver, K. L., Brown, W. H. & Pate, R. R. 2008. Motor skill performance and physical activity in preschool children. Obesity 16 (6), 1421-1426.
Wolf, G. 2007. Attention and motor skill learning. Champaign, IL: Human Kinetics.
Wood, A. C., Saudino, K. J., Rogers, H., Asherson, P. & Kuntsi, J. 2007. Genetic influences on mechanically-assessed activity level in children. Journal of Child Psychology and Psychiatry and Allied Disciplines 48 (7), 695-702.
Wrotniak, B. H., Epstein, L. H., Dorn, J. M., Jones, K. E. & Kondilis, V. A. 2006. The relationship between motor proficiency and physical activity in children. Pediatrics 118 (6), e1758-1765.
Yao, C. A. & Rhodes, R. E. 2015. Parental correlates in child and adolescent physical activity: a meta-analysis. International Journal of Behavioral Nutrition and Physical Activity 12 (10), September 21, 2015-doi:10.1186/s12966-015-0163-y.
Young, M. D., Plotnikoff, R. C., Collins, C. E., Callister, R. & Morgan, P. J. 2014. Social cognitive theory and physical activity: A systematic review and meta-analysis. Obesity Reviews 15 (13), 983-995.
Zask, A., Barnett, L. M., Rose, L., Brooks, L. O., Molyneux, M., Hughes, D., Adams, J. & Salmon, J. 2012. Three year follow-up of an early childhood intervention: Is movement skill sustained? The International Journal of Behavioral Nutrition and Physical Activity 9 (127), September 21, 2015-doi:10.1186/1479-5868-9-127.
Zhang, J., Shoham, D. a., Tesdahl, E. & Gesell, S. B. 2015. Network interventions on physical activity in an afterschool program: An agent-based social network study. American Journal of Public Health 105 (supplement 2), e1-e8.

APPENDICES

Appendix 1. Informed consent.

Perheiden arkiliikunta ja hyvinvointi

HUOLTAJIEN SUOSTUMUS LAPSEN OSALLISTUMISESTA TUTKIMUKSEEN

Lapsen huoltajana olen perehtynyt tutkimuksen tarkoitukseen ja lapseen kohdistuviin mittauksiin (liikunta-aktiivisuuden mittaus vyötärölle kiinnitettävällä kiihtyvyysanturilla viikon ajan ja mahdollinen shortseilla tapahtuva mittaus muutaman päivän aikana, kyselylomakkeet sekä liikuntataitoja mittaavat testit). Voin halutessani peruuttaa tai keskeyttää lapseni osallistumisen missä vaiheessa tahansa syitä ilmoittamatta ja ilman seuraamuksia.

Tutkimustuloksia saa käyttää tieteelliseen raportointiin (esim. julkaisuihin) sellaisessa muodossa, jossa yksittäistä tutkittavaa ei voi tunnistaa.

Tutkimukseen osallistuvien lasten nimet ja syntymäajat (ID:n täyttää tutkija)

Nimi________________________Syntymäaika_____________________ID___________

Nimi________________________Syntymäaika_____________________ID___________

Nimi________________________Syntymäaika_____________________ID___________

Osoite____

____

Päiväys Huoltajan1 allekirjoitus Nimen selvennys

____

Päiväys Huoltajan2 allekirjoitus Nimen selvennys

____

Päiväys Tutkijan allekirjoitus

Appendix 2. Lecture of the physical activity counseling.

PERHEIDEN ARKILIIKUNTA JA HYVINVOINTI-ILTA

TERVETULOA!

ESITEHTÄVÄ: Arvioikaa oikealle ”Reipas fyysinen aktiivisuus” -sarakkeeseen, kuinka paljon lapsellenne tulee reipasta fyysistä aktiivisuutta päivän eri kohdissa. Merkitkää minuuttimäärät ja laskekaa ne alas yhteen.

Klo	Mitä tapahtuu?	Reipas fyysinen aktiivisuus
7.00	Herätys	
7.30	Päiväkotimatka	
8.00	Aamupala	
8.30	Aamupiiri ja ohjattu toimintatuokio + vapaa leikki	
10.00	Ulkoilua	
11.15	Lounas	
12.00	Päivälepo	
14.00	Välipala ja vapaata leikkiä sisällä	
15.15	Ulkoilua ja pihaleikkejä	
16.00	Kotimatka	
	Vapaa-aika kotona ym.	
	Ilta-aika	
	Iltatoimet	
	Nukkumaan	
		Reipas fyysinen aktiivisuus yhteensä _____ tuntia _____ minuuttia

PÄIVITTÄIN REIPASTA LIIKUNTAA VÄHINTÄÄN 2 TUNTIA PÄIVÄKOTI-IKÄISILLÄ JA VÄHINTÄÄN 1½-2 TUNTIA EPPULUOKKALAISILLA

=

LASTEN LIIKUNTASUOSITUKSET SUOMESSA

Miten Sinä liikuit lapsuudessasi?

”Yleensä leikittiin yhdessä kaikki talon kakarat tai lähipiirin muksut. Tietysti puissa kiipeilyt ja temppuilut kuuluivat asiaan. Kesäisin uitiin ja pelattiin pallopelejä ja talvisin luisteltiin ja hiihdettiin ja laskettiin mäkeä ja tehtiin lumilinnoja.”

Tarinoita ja muistoja vanhempien kertomana
Lähde: Liikkumismuistoja, Suomen vanhempainliitto

Voiko lapsesi liikkua yhtä paljon?

Pienet valinnat ratkaisevat -video
https://www.youtube.com/watch?v=66t2HKG2f8w

ESIMERKKI PERUSTUEN OBJEKTIIVISESTI MITATTUUN TIETOON LASTEN LIIKUNTAMÄÄRÄSTÄ: Atte 5 vuotta. Päivähoidossa olevan lapsen fyysisesti passiivinen päivä.

Klo	Mitä tapahtuu?	Reipas fyysinen aktiivisuus
7.00	Herätys	
7.30	Autolla päiväkotiin	
8.00	Aamupala	
8.30	Aamupiiri ja ohjattu toimintatuokio + vapaa leikki	10 min
10.00	Ulkoilu: keinumista, kiipeilyä, leikkejä, pelejä, rakentelua…	30 min
11.15	Lounas	
12.00	Päivälepo	
14.00	Välipala ja vapaata leikkiä sisällä	
15.15	Ulkoilua ja pihaleikkejä	20 min
16.00	Autolla kotiin	
17.00	Päivällinen	

ESIMERKKI 2 PERUSTUEN OBJEKTIIVISESTI MITATTUUN TIETOON LASTEN LIIKUNTAMÄÄRÄSTÄ: Maija 5 vuotta. Päivähoidossa olevan lapsen fyysisesti aktiivinen päivä.

Klo	Mitä tapahtuu?	Reipas fyysinen aktiivisuus
7.00	Herätys	
7.30	Kävellen äidin tai isän kanssa päivähoitoon	15 min
8.00	Aamupala	
8.30	Aamupiiri ja ohjattu toimintatuokio + vapaa leikki	10 min
10.00	Ulkoilu: keinumista, kiipeilyä, leikkejä, pelejä, rakentelua…	30 min
11.15	Lounas	
12.00	Päivälepo	
14.00	Välipala ja vapaata leikkiä sisällä	
15.15	Ulkoilua ja pihaleikkejä	20 min
16.00	Kävellen äidin tai isän kanssa kotiin	15 min
17.00	Päivällinen	

MIHIN LIIKUNTASUOSITUKSET PERUSTUVAT?

Istumayhteiskunta sotii nykytietämystä vastaan

- Tiedetään, että useiden lasten suotuisa kasvu ja kehitys ovat uhattuina liikkumattomuuden vuoksi
- **Suositukset on hätähuuto:** meillä on kasvamassa ja kehittymässä passiivinen ja sairastava sukupolvi

KONKREETTISET TEKIJÄT: Miksi päivittäinen reipas liikkuminen on lapselle tärkeää?

Peruste 1: Liikunta vähentää sairastavuutta ja suojaa tapaturmilta

- Suoja ylimääräiseltä painonnousulta ja terveyden riskitekijöiltä, kuten diabetekselta, sydän- ja verisuonitaudeilta ja luuston heikolta kehittymiseltä
- Liikunta laskee vakavien tapaturmien alttiutta, kun kehon hahmotus ja -tuntemus kehittyvät ja opitaan tiedostamaan turvallisen ja vaarallisen rajat

Peruste 2: Liikkuminen kehittää kouluvalmiuksia

- Liikunta vähentää keskittymisvaikeuksia ja ylivilkkautta (toimii joskus myös kotona iltatoimien rauhoittumisena)
- Perusliikkumistaidot luovat pohjan käytännön kouluvalmiuksien kehittymiselle
- Näitä valmiuksia ovat mm. hienomotoriset taidot ja havaintotaidot (kuten lukeminen ja kirjoittaminen) ja sosiaaliset taidot
- Liikkuminen tutkitusti parantaa kognitiivisia kouluvalmiuksia aivoissa (muisti ja oppiminen)

MITEN LIIKKUMISTOTTUMUKSET SYNTYVÄT?

Jokapäiväisiä tilanteita ja valintoja

- Lapsi omaksuu **liikkumistottumukset** pääasiassa vanhemmiltaan ja sisaruksiltaan
  - eri asia kuin perinnöllinen aktiivisuustaso, joka on kullekin luontainen
- Esimerkiksi: hissi vai portaat, auto vai pyörä lyhyillä matkoilla, pelikonsoli vai lumilinnan rakennus, turhautunut äksyily sisällä vai paineiden purku ulkona temmeltämällä…

Jokapäiväiset tilanteet: merkitykset liikuntaa paljon moninaisemmat

- Perheen yhdessä viettämä aika liikkumisen parissa on lapselle erittäin merkityksellistä
  - Yhdessä tekemisen kokemukset, lapsi kokee voivansa osallistua ja olevansa tärkeä
- **Lapsen itsetunto** kaipaa kannustusta ja tukea
  - ”iskän avulla tämä onnistuu”, ”äiti keksi kuinka tämän voi tehdä” -> ”**minä osaan**!”
  - > positiivinen ja kannustava ilmapiiri

LASTEN LIIKUNTASUOSITUSTEN NÄKÖKULMASTA

HYVÄ: **Perheen yhteiset arkiliikkumistottumukset + rajat ruutuaikaan kohtuullisiksi**
(terveelliset tottumukset syntyvät)
Lapsen kannustaminen liikuntaan
(itsetunto vahvistuu)

TAVOITELTAVAA: **Arkiliikunnan lisäksi lapselle päivittäin MONIPUOLISEN REIPPAAN LIIKKUMISEN MAHDOLLISUUKSIA (ULKONA)!**
(parasta liikuntataitojen kehittymiselle)

EXTRAA: **samanikäisiä leikkikavereita** (into liikkua)

Appendix 3. Fidelity checklist of the face-to-face physical activity counseling

LIIKUNTANEUVONTAKESKUSTELU – TAVOITTEIDEN ASETTELU

Työmatka

1. TAUSTATIEDUSTELU: Miten yleensä kuljette työmatkanne ja viette lapsenne päiväkotiin?

2. MITÄ VAIHTOEHTOJA TEILLÄ ON aktiivisen työmatkaliikkumisen / päiväkotiin liikkumisen lisäämiseksi? (Koehenkilö miettii ensin itse vaihtoehtoja)

3. TAVOITE: Aktiivisen työmatkaliikunnan/päiväkotimatkustamisen lisääminen asteittain.

4. MITÄ KEINOJA LISÄTÄ AKTIIVISTA TYÖMATKALIIKUNTAA TEILLE ITSELLENNE TULEE MIELEEN?

NÄITÄ SUOSITELLAAN: asteittain etenemisen periaatteella

- Autoilun/julkisilla kulkemisen korvaaminen asteittain kävelyllä, pyöräilyllä tai muilla vastaavilla aktiivisilla liikkumistavoilla.
- Mikäli autoilun ym. passiivisen kulkemistavan korvaaminen ei ole mahdollista (johtuen esimerkiksi pitkästä työmatkasta), niin silloin suositellaan kulkuneuvon jättämistä asteittain kauemmaksi työpaikasta (parkkipaikan reunalle).

5. Kirjataan arkiliikuntasopimukseen työmatkaliikkumisen / päiväkotiin liikkumisen YHDESSÄ SOVITUT KONKREETTISET TAVOITTEET.

Kautta linjan tässä liikuntaneuvonnassa ”asteittain etenemisellä” tarkoitetaan tavoitteen mukaisten toistokertojen lisäämistä vähitellen, pienestä teosta vähitellen useammin toistuvaan ja vaativampaan muotoon. Esimerkiksi auton jättäminen aluksi kahdesti viikossa työpaikan parkkipaikan reunalle voi parhaimmillaan edetä vähitellen päivittäiseksi rutiiniksi. Samoin arki-iltojen ja viikonloppujen liikkumista pyritään lisäämään asteittain.

Työaika

1. TAUSTATIEDUSTELU: Kuvailkaa tyypillistä työpäiväänne; yhtämittaisten istumajaksojen pituudet, millaista liikettä sisältyy päiväänne?

2. MITÄ VAIHTOEHTOJA TEILLÄ ON työpäivän aikaisen aktiivisuuden lisäämiseksi? (Koehenkilö miettii ensin itse vaihtoehtoja)

3. TAVOITE: Pitkien istumajaksojen katkaiseminen ja passiivisten tottumusten korvaaminen asteittain aktiivisemmilla työpäivän aikana.

4. MITÄ KEINOJA LISÄTÄ TYÖPÄIVÄN AIKAISTA AKTIIVISUUTTA TEILLE ITSELLENNE TULEE MIELEEN?

NÄITÄ SUOSITELLAAN: asteittain etenemisen periaatteella

- Käytä portaita hissin sijaan
  - ➔ ei vie sen enempää aikaa, ei koskaan ruuhkaa ja on todella tehokasta
- Katkaise yhtämittainen pitkä istuminen nousemalla ylös tai kävelemällä
  - ➔ niskat, hartiat ja ranteet kiittävät lepotauosta ja mielikin virkistyy
- Kävele työkaverin luo soittamisen sijaan
  - ➔ Kävely käy erinomaisesta taukojumpasta ja kasvotusten asiat varmasti tulevat selväksi
- Kävele pieni lenkki ennen kahvia tai lounasta ja käy haukkaamassa raitista ilmaa
  - ➔ Aivot virkistyvät
- Ruokaile kauempana kuin normaalisti
  - ➔ Ota työkaverikin kaveriksi
- Tauolla seiso istumisen sijaan
- Nousen ylös tuolistani aina uuden tehtävän aloittaessani
- Papereiden lukeminen ja puhuminen puhelimeen seisten

5. Kirjataan arkiliikuntasopimukseen työpäivän aikaisen arkiliikkumisen lisäämisen YHDESSÄ SOVITUT KONKREETTISET TAVOITTEET.

ANNA TAUKOJUMPPA OHJEET JA LUPA LIIKKUA-PAPERI

Vapaa-aika arkisin

1. TAUSTATIEDUSTELU: Kuvailkaa tyypillistä perheenne arki-iltaa. Kerro myös, mitä säännöllistä liikuntaa harrastat.

2. MITÄ VAIHTOEHTOJA TEILLÄ ON lastenne reippaan liikkumisen mahdollisuuksien lisäämiseksi arki-iltoihin? (Koehenkilö miettii ensin itse vaihtoehtoja)

3. TAVOITE: Lasten reippaan liikkumisen määrän asteittainen lisääntyminen ja aikuisten yhtämittaisten istumisjaksojen lyhentyminen.

4. MITÄ KEINOJA LISÄTÄ LAPSEN REIPPAAN LIIKKUMISEN MÄÄRÄÄ ARKI-ILTOINA TEILLE ITSELLENNE TULEE MIELEEN?

NÄITÄ SUOSITELLAAN: asteittain etenemisen periaatteella

- Lasten reipasta ulkoliikuntaa <u>tunnin verran</u> hyvissä ajoin ennen nukkumaanmenoa (päiväkodin ja kodin välillä kulkeminen voidaan sisällyttää tähän)
- ➔ rauhoittaa iltatoimia ja helpottaa nukkumaanmenoa
- Lasten ikätovereiden seurassa liikkumisen mahdollisuuksien lisääminen
- ➔ leikkikaverit usein lisäävät lapsen kiinnostusta leikkiin ja tämä vähentää aikuisen tarvetta ”keksiä” tekemistä
- Lähiympäristön / luonnon liikuntamahdollisuuksien aktiivisempi hyödyntäminen
- ➔ kotipihassa liikkumisen lisäksi lapsi kaipaa silloin tällöin lisävirikkeitä ja haasteita uusista ympäristöistä
- Oman lapsen kiinnostuksenkohteiden kuuntelu, minkälaisesta tekemisestä lapsi on kiinnostunut
- ➔ aktiivisen tekemisen keksiminen esim. lukemisesta, askartelusta, tietokonepelaamisesta tai television katsomisesta kiinnostuneille
- Koko perheen arkiaktiivisuuden lisääminen pienillä teoilla: portaat hissin sijaan, pyörällä tai kävellen pienet kauppareissut
- ➔ lapset oppivat käyttäytymistavat vanhemmiltaan
- ENTÄ KUN SATAA, on pakkasta: saako teillä sisällä juosta, temppuratoja?
- AIKUISEN istumisen tauotus – lehden luku seisten, tiskaus yms.
- TV-TIETOKONE ajan istumisen tauotus.
-

5. Kirjataan arkiliikuntasopimukseen arki-iltojen arkiliikkumisen lisäämisen YHDESSÄ SOVITUT KONKREETTISET TAVOITTEET.

VIIKONLOPUT

1. TAUSTATIEDUSTELU: Kuvailkaa perheenne tyypillistä viikonloppupäivää.

2. MITÄ VAIHTOEHTOJA TEILLÄ ON lastenne reippaan liikkumisen mahdollisuuksien lisäämiseksi viikonloppuisin? (Koehenkilö miettii ensin itse vaihtoehtoja)

3. TAVOITE: Lasten liikuntasuosituksen mukaisen vähintään 2 tunnin reippaan liikkumisen määrän täyttyminen ja vanhempien yhtäjaksoisten istumajaksojen lyheneminen.

4. MITÄ KEINOJA LISÄTÄ LASTEN REIPPAAN LIIKUNNAN MÄÄRÄÄ VIIKONLOPPUISIN TEILLE ITSELLENNE TULEE MIELEEN?

NÄITÄ SUOSITELLAAN: asteittain etenemisen periaatteella

- viikonloppuaamujen lastenohjelmien jälkeen reippaan ulkoliikunnan ottaminen tavaksi
  ➔ selkeä tapa ja usein helppo toteuttaa
- erilaiset retket lähiluontoon ja ympäristöön
  ➔ luonnossa ja uusissa ympäristöissä riittää tutkittavaa ja leikkipaikkoja, joka riittää usein motivoimaan liikkumisen
- lapselle ikäisiään leikkikavereita, tuttavaperheet, leikkipuistot, sisarukset ym.
  ➔ leikkikaverit usein lisäävät lapsen kiinnostusta leikkiin ja tämä vähentää aikuisen tarvetta ”keksiä” tekemistä
- lapsille suunnattujen touhutapahtumien hyödyntäminen
  ➔ silloin tällöin ohjattu liikuntatoiminta antaa erilaisia virikkeitä ja on hyödyllistä taitojen kehitykselle
- myöhemmin annettavien sisäliikuntavinkkien hyödyntäminen (asetetaan tavoite puhelinseurantojen yhteydessä)
  ➔ sisälläkin lapsi voi liikkua, mutta näissä tapauksissa ohjeilta ja säännöiltä vaaditaan usein hieman enemmän

5. Kirjataan arkiliikuntasopimukseen viikonloppujen liikkumisen lisäämisen YHDESSÄ SOVITUT KONKREETTISET TAVOITTEET.

Appendix 4. Goal setting agreement document.

PERHEIDEN ARKILIIKUNTA JA HYVINVOINTI

Jyväskylän yliopisto / Liikuntabiologian laitos

Nimi_______________________________ ID ____________

Liikuntaneuvontakeskustelun perusteella olemme tänään ______________ sopineet:

TYÖMATKA

TAVOITE: AKTIIVISTEN KULKEMISTAPOJEN LISÄÄMINEN (pyöräillen, kävellen)
MERKINTÄ: EI KOSKAAN (**0**)SATUNNAISESTI (**1**). 1-2 KERTAA VIIKOSSA (**2**),
3-4 KERTAA VIIKOSSA (**3**), PÄIVITTÄIN (**4**).

Nykytilanteen kuvailu:	Nyky-tilanne (1-4)	Tavoite alussa (1-4)
Työpaikan ja kodin välillä		
Päiväkodin ja kodin välillä		
Auto parkkipaikan reunalle		
Bussilla liikkuminen: kävelymatkat pidemmiksi		

TYÖAIKA

TAVOITE: ARKILIIKUNNAN LISÄÄMINEN TYÖPÄIVÄN SISÄLLÄ
MERKINTÄ: EI KOSKAAN (**0**), SATUNNAISESTI (**1**), USEIMPINA PÄIVINÄ VIIKOSTA (**2**),
PÄIVITTÄIN (**3**), USEASTI PÄIVÄSSÄ (**4**).

TYÖPAIKKA-AKTIIVISUUDEN LISÄÄMISEN TAVAT. Nykytilanteen kuvailu:	Nyky-tilanne (1-4)	Tavoite alussa (1-4)
Hississä kulkemisen korvaaminen portaissa kulkemisella		
Pitkän yhtämittaisen istumisen katkaiseminen ylösnousemisella ja kävelyllä		
Kävely työkaverin luo soittamisen sijaan		
Tauolla seisominen istumisen sijaan		
Käy haukkaamassa raitista ilmaa ennen kahvia tai lounasta		
Ruokailu kauempana kuin normaalisti, kulkeminen kävellen		
Nouseminen tuolista ylös puhelimeen puhuessa		
Papereiden lukeminen seisten		
Jumppapallo		
Taukojumppa		

Vapaa-aika arkisin

TAVOITE: LAPSEN PÄIVÄKOTIPÄIVÄN JÄLKEISEN REIPPAAN LIIKKUMISAJAN LISÄÄMINEN VÄHINTÄÄN TUNTIIN PÄIVITTÄIN.
MERKINTÄ: EI KOSKAAN (**0**), SATUNNAISESTI (**1**), VIIKOITTAIN (**2**), USEIMPINA PÄIVINÄ VIIKOSTA (**3**), ARKIPÄIVITTÄIN (**4**).

ARKILIIKUNNAN LISÄÄMISEN TAVAT. Nykytilanteen kuvailu:	Nyky-tilanne (1-4)	Tavoite alussa (1-4)
Fyysisen aktiivisuuden yleismäärä: päiväkoti- tai koulupäivän ulkopuolella lapsi saa tunnin verran reipasta liikkumista (voi sisältää kulkemiset kauppaan tai kodin ja päiväkodin/koulun välillä, leikit ulkona/sisällä jne.)		
Kotiin tultua lapsi jää ulos leikkimään ruoanlaiton ajaksi		
Muuna aikana kotipihassa liikkuminen ja leikkiminen liikuntavälineillä ja leluilla		
Lähiympäristön liikuntapaikkojen hyödyntäminen (leikkipuistot, kentät ym.)		
Luontoympäristössä ulkoilu (myös lyhyet ja spontaanit käynnit)		
Lapsella ikäisiään leikkikavereita		
Kotona sisäliikunta (vinkkivihkot annetaan)		
Hyötyliikunta: pienet kauppamatkat, portaat yms. lihasvoimin		

Vapaa-aika viikonloppuisin

TAVOITE: LAPSEN VIIKONLOPPUPÄIVÄN REIPPAAN LIIKKUMISAJAN LISÄÄMINEN VÄHINTÄÄN KAHTEEN (2) TUNTIIN.
MERKINTÄ: EI KOSKAAN (**0**), SATUNNAISESTI (**1**), LÄHES JOKA VIIKONLOPPU (**2**), JOKA VIIKONLOPPUPÄIVÄ (**3**), USEASTI VIIKONLOPPUPÄIVÄSSÄ (**4**).

VIIKONLOPPULIIKKUMISEN LISÄÄMISEN TAVAT. Nykytilanteen kuvailu:	Nyky-tilanne (1-4)	Tavoite alussa (1-4)
Fyysisen aktiivisuuden yleismäärä: alle kouluikäiset vähintään 2 tuntia reipasta liikuntaa ja kouluikäiset vähintään 1-2 tuntia liikuntaa		
(Aamun) lastenohjelmien jälkeinen perheen yhteinen ulkoliikkuminen		
Muuna aikana kotipihassa liikkuminen ja leikkiminen liikuntavälineillä ja leluilla		
Lähiympäristön liikuntapaikkojen hyödyntäminen (leikkipuistot, kentät ym.)		
Luontoympäristössä ulkoilu (myös lyhyet ja spontaanit käynnit)		
Lapsella ikäisiään leikkikavereita		
Kotona sisäliikunta (vinkkivihkot annetaan)		
Hyötyliikunta: pienet kauppamatkat, portaat yms. lihasvoimin		

____________________ ____________________

Tutkijan allekirjoitus Tutkittavan allekirjoitus

Appendix 5. Feedback of the motor competence measurements

HYVÄT VANHEMMAT – PALAUTE LAPSENNE PERUSLIIKUNTATAIDOISTA
Lapsen nimi: Maija Mallioppilas

Olette olleet mukana vuoden ajan Perheen arkiliikunta- ja hyvinvointitutkimuksessa. Tänä aikana olemme tutkineet tutkimukseen osallistuvan lapsenne liikunta-aktiivisuuden ja liikuntataitojen kehittymistä. Tässä tiedotteessa kerromme, kuinka lapsenne liikuntataitotehtävät sujuivat tutkimuksen aikana.

Yleissääntönä voidaan pitää sitä, että kuka tahansa lapsi hyötyy taitojen harjoittelemisesta omalla taitotasollaan tai hieman sen yläpuolella. Ns. ”treenaaminen” tai ”valmentaminen” ei ole tarpeellista lapsuudessa, eikä siihen tässäkään kannusteta. Kuitenkin lapsen kehitys- ja taitotasolle sopivasti haastavien virikkeiden luomisessa vanhemmat voivat turvallisin mielin olla tukena, unohtamatta tietenkään myönteistä kannustusta. Virikkeellisyyden lisäksi toinen tärkeä asia on riittävän toiminta- ja liikkumisvapauden turvaaminen lapselle. Muistisääntö kuuluu, että *koulu- tai päiväkotipäivän ulkopuolisella ajalla lapsen olisi hyvä saada mahdollisuus noin yhteen tuntiin reipasta liikuntaa.*

Liikuntataitotehtävien arvioinnit esitetään kolmessa osa-alueessa: 1) tasapaino ja kehonhallintataidot, 2) voima, nopeus ja ketteryys sekä 3) välineenkäsittelytaidot. Nämä osa-alueet kattavat perusliikuntataitojen elementit. Arvioinnin apuna on käytetty samanikäisten suomalaislasten tuloksia vastaavissa taidoissa. Kunkin osa-alueen kohdalla olemme kirjanneet konkreettisia tapoja tukea näiden taitojen kehittymistä. Palaute- ja liikuntaneuvontatilaisuuden yhteydessä antamamme vinkkimateriaalit ja projektimme kotisivut ovat käytössänne (http://perheliikunta.nettisivu.org/).

1) Tasapaino- ja kehonhallintataitojen kehitys

(Yleispohja kaikkien liikuntataitojen kehittymiselle, mitataan kahdella tehtävällä)

ALKU	6KK	12KK	ARVIO
x	x+		Taitojen kehitys on vasta alullaan. Suotuisan jatkokehityksen kannalta päivittäisen reippaan ja monipuolisia haasteita sisältävän leikin ja liikkumisen lisääminen olisi suositeltavaa.
		x+	Taitojen kehitys on päässyt kohtuullisen hyvin alkuun. Suositusten mukainen päivittäinen reipas liikuntamäärä ja haasteita sisältävät leikit ja liikunta auttavat niiden kehittymistä edelleen
			Taidot ovat kehittyneet hyvin. Suositusten mukainen päivittäinen reipas liikunta mahdollistaa niiden kehittymisen edelleen

(+ positiivista kehitystä, - negatiivista kehitystä, +- sekä pos. että neg. kehitystä tapahtunut)

Vinkkejä tasapaino- ja kehonhallintataitojen harjaannuttamiseksi:
a) Kävely, hiipiminen, juokseminen ja vaikka piilosilla olo epätasaisille ja vaihtelevilla alustoilla ja ympäristöissä, kuten mäessä, ojassa, metsässä, pellolla, jäällä, hiekalla, heinikossa jne.
b) Yhdellä jalalla hyppelyä ja tasapainoilua, konttaamista, ryömimistä ja vaikka hiihtämistä aluksi tasamaalla ja sitten erilaisissa vaihtelevissa ympäristöissä.
c) Liikkuminen myös hämärällä (heikko valaistus) erilaisissa vaihtelevissa ympäristöissä, ei tarvitse olla vauhdikasta.
d) Kiipeämistä, roikkumista, keinumista ja tasapainoilua käsiä apuna käyttäen puissa, tangolla, telineillä, renkailla, köysillä, kiikussa jne.
e) Luistelu ja hiihto (erinomaisia liikuntamuotoja tasapaino- ja kehonhallintataitojen kehittymisen kannalta)

2) Hyppytaidon ja ketteryyden kehitys

(Tärkeä pohja liikunta- ja lajitaitojen kehittymiselle, mitataan kahdella tehtävällä)

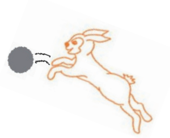
ALKU	6KK	12KK	ARVIO
x	x+-	x+-	Taitojen kehitys on vasta alullaan. Suotuisan jatkokehityksen kannalta päivittäisen reippaan ja monipuolisia haasteita sisältävän leikin ja liikkumisen lisääminen olisi suositeltavaa.
			Taitojen kehitys on päässyt kohtuullisen hyvin alkuun. Suositusten mukainen päivittäinen reipas liikuntamäärä ja haasteita sisältävät leikit ja liikunta auttavat niiden kehittymistä edelleen
			Taidot ovat kehittyneet hyvin. Suositusten mukainen päivittäinen reipas liikunta mahdollistaa niiden kehittymisen edelleen

(+ positiivista kehitystä, - negatiivista kehitystä, +- sekä pos. että neg. kehitystä tapahtunut)

Vinkkejä hyppytaidon ja ketteryyden harjaannuttamiseksi:
a) Ulkona ja sisällä erilaisten maastonkohteiden tai esineiden (kivet, kannot, lätäköt, ojat, tyynyt, patjat, korokkeet, telineet) hyödyntäminen: hypätään yli, hypätään päälle tai hypätään sieltä alas.
b) Nopeita pysähdyksiä vaativia leikkejä ja pelejä (liike pysähtyy kun musiikki loppuu, hyppy alas korokkeelta aivan paikalleen jääden)

c) Vauhdikas liikkuminen ja nopeat suunnanmuutokset (pallopelit, hipat)

3) Välineenkäsittelytaitojen kehitys (pallonkäsittelytaidot)
(Pohja havainnointitaitojen, käsien voimansäätelyn ja tarkan silmä-käsi työskentelyn kehittymiselle, mitataan yhdellä tehtävällä)



ALKU	6KK	12KK	ARVIO
			Taitojen kehitys on vasta alullaan. Suotuisan jatkokehityksen kannalta päivittäisen reippaan ja monipuolisia haasteita sisältävän leikin ja liikkumisen lisääminen olisi suositeltavaa.
x	x-	x+	Taitojen kehitys on päässyt kohtuullisen hyvin alkuun. Suositusten mukainen päivittäinen reipas liikuntamäärä ja haasteita sisältävät leikit ja liikunta auttavat niiden kehittymistä edelleen
			Taidot ovat kehittyneet hyvin. Suositusten mukainen päivittäinen reipas liikunta mahdollistaa niiden kehittymisen edelleen

(+ positiivista kehitystä, - negatiivista kehitystä, +- sekä pos. että neg. kehitystä tapahtunut)

Vinkkejä välineenkäsittelytaitojen harjaannuttamiseksi:
a) Kimmoisten ja ei-kimmoisten sekä erikokoisten ja -painoisten pallojen kopittelu seinää vasten, kaverin kanssa tai ryhmässä
b) Heittämistä, vierittämistä, kuljettamista, lyömistä ja pelaamista erilaisilla välineillä (kivet, kävyt, pallot, hernepussit, pelimailat…)
c) Pallon väistämistä ja tilassa liikkumista kehittävät palloleikit, kuten polttopallo

YLEINEN SANALLINEN PALAUTE:
LIIKUNNAN PERUSTAIDOT OLIVAT TUTKIMUKSEN ALUSSA HIEMAN IKÄTOVEREITA HEIKOMMAT TASAPAINOSSA JA HYPPYTAIDOISSA JA YHTÄ HYVÄT VÄLINEENKÄSITTELYTAIDOISSA. TUTKIMUSVUODEN AIKANA HYPPY- JA KETTERYYSTAIDOT SEKÄ VÄLINEENKÄSITTELYTAIDOT PYSYIVÄT MELKO ENNALLAAN. HIENOINEN POSITIIVINEN KEHITYSKULKU SEN SIJAAN NÄKYI TASAPAINO- JA KEHONHALLINTATAIDOISSA, HYVÄ MAIJA!

TÄSTÄ ON HYVÄ JATKAA. KANNUSTAN KIINNITTÄMÄÄN HUOMIOTA **RIITTÄVÄN JA MONIPUOLISEN** LIIKUNNAN SAAMISEEN PÄIVITTÄISESSÄ ELÄMÄSSÄ!

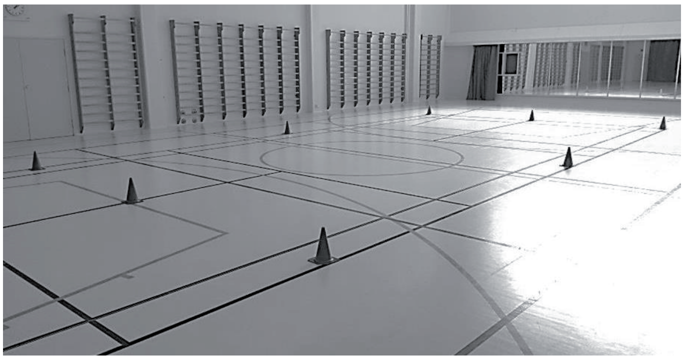
Ystävällisin terveisin ja reipasta arkiliikuntailoa toivottaen,

Arto Laukkanen
Perheen arkiliikunta- ja hyvinvointitutkimus
Liikuntabiologian laitos
Projektin kotisivut: http://perheliikunta.nettisivu.org/

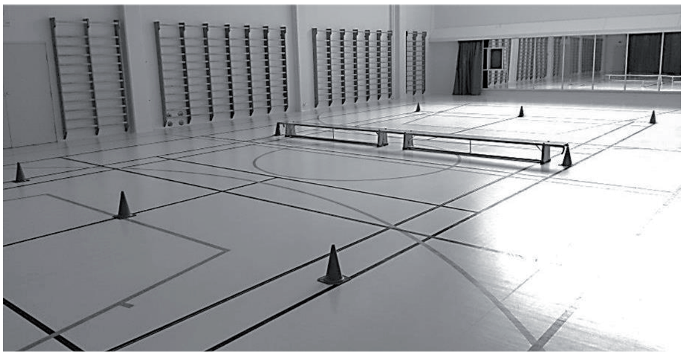
Appendix 6. Accelerometer in a firmly worn adjustable elastic belt.

Appendix 7. Physical activity task performance conditions.

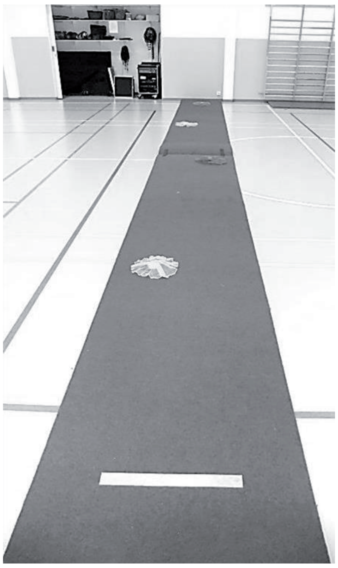
1. Tag



2. Ball game



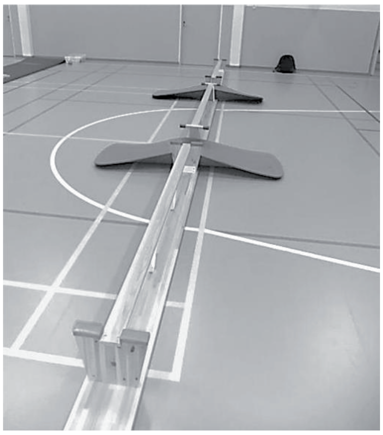
3. Crawl



4. Stair walking

5. Climbing on stall bars

6. Balance beam walking



Appendix 8. A measurement form of KTK and TCB

Lapsen nimi: **ID:**

1. Takaperin tasapainoilu
”Kävele takaperin puomilla niin pitkälle kuin pääset. Aloitetaan leveimmästä puomista”. Jokaisesta askeleesta piste, maksimi 8 pistettä / yritys. Huom! Ensimmäinen askel lasketaan siitä, kun toinenkin jalka asettuu puomille. Kokonaispistemäärä max 72.

Harjoittelu: kutakin palkkia voi harjoitella kävelemään kerran etu- ja takaperin.

Puomin leveys	1. yritys	2. yritys	3. yritys	Summa
6,0 cm (max 8pist./yritys)				
4,5 cm (max 8pist./yritys)				
3,0 cm (max 8pist./yritys)				

2. Yhdellä jalalla hyppely
”Ala hyppiä yhdellä jalalla tästä, hyppää vauhdilla yhdellä jalalla superlonien yli ja jatka vielä sen jälkeen vähintään 2 hyppyä samalla jalalla. Koko aikana et saa koskea toisella jalalla maahan, se katsotaan virheeksi.” 3 yritystä kummallakin jalalla / korkeus. Ylitys ensimmäisellä yrityksellä = 3 pist., toisella yrityksellä = 2 pist., viimeisellä yrityksellä = 1 pist. Jos pääsee yli vain vahvemmalla jalalla, niin jatketaan tällä jalalla pelkästään seuraavaan korkeuteen.

Harjoittelu: Kummallakin jalalla voi harjoitella 2 kertaa harjoituskorkeudelta. Suositus aloituskorkeudeksi: 5-6-vuotiaat 0cm (3 metriä yhdellä jallalla hyppelyä); 7-vuotiaat ja vanhemmat 10cm tai korkeampi.

Korkeus (cm)	0	5	10	15	20	25	30	35	40	45	50	55	60	Summa
Oikea jalka														
Vasen jalka														

3. Sivuttain hyppely
Molempien jalkojen on koskettava alustaa puuriman toisella puolella. Horjahtaminen ei keskeytä suoritusta, vaan lasta kehotetaan jatkamaan suoritusta. Harjoittelu: 5 hyppyä sivuttain alustalla.

	1. yritys	2. yritys	Summa
Hyppyaika 15 sekuntia			

4. Sivuttain siirtyminen
1 piste: puulevy on siirretty puolelta toiselle, 2. Piste: lapsi on siirtynyt puulevylle, 3 piste: puulevy on siirretty puolelta toiselle jne. Harjoittelu: 5 kertaa sivuttain siirtyminen

	1. yritys	2. yritys	Summa
Siirtymisaika 20 sekuntia			

5. Pallon heitto-kiinniotto
”Kokeile heittää pallo alakautta seinään tästä viivalta (2-3-metriä) ja yritä ottaa pallo kiinni yhden maastapompun jälkeen. Saat harjoitella 5 kertaa. Jatka samaa vielä 10-kertaa, niin lasken kuinka usein saat pallon kiinni.” Onnistuneet pallon heitto-kiinniottosuoritukset lasketaan yhteen.

PISTEET	/10

Appendix 9. Motor competence test conditions.

1. Walking backwards (Körperkoordinationstest für Kinder)

2. Hopping for height (Körperkoordinationstest für Kinder)

3. Jumping sideways (Körperkoordinationstest für Kinder)

4. Moving sideways
(Körperkoordinationstest
für Kinder)

5. Throwing and catching
(APM-inventory)

Appendix 10. Parental support questionnaire.

Koehenkilön nimikirjaimet: _______ ID: _____________

Tervetuloa täyttämään PERHEEN ARKILIIKUNTA JA HYVINVOINTI -projektin kyselyä.

Tämä kysely koskee perheen sosiaalista liikuntaympäristöä.

Lomake täytetään vain kerran perhettä kohti, eli vain toisen vanhemman/yksinhuoltajan on täytettävä sen kaikki kohdat. Mikäli perheestänne osallistuu useampi lapsi niin miettikää vastaukset nuorimman lapsen kohdalta.

Kyselyyn vastaaminen vie keskimäärin 4 minuuttia.

Vastaaja on

- ❍ äiti
- ❍ isä

Onko tutkimukseen osallistuvalla lapsellanne sisarusta tai sisaruksia?

- ❍ kyllä
- ❍ ei

Miettikää tutkimukseen osallistuvan lapsenne sisaruksista liikunnallisesti aktiivisinta. Mikä on hänen sukupuolensa ja ikänsä?

	Sukupuoli (tyttö = 1 / poika = 2)	ikä (0 - 30)
sisarus	☐☐	☐☐

Arvioikaa, kuinka usein tämä liikunnallisesti aktiivisin sisarus on liikunnallisesti aktiivinen (esim. kulkee jalan tai pyöräilee harrastuksiin tai kouluun, liikkuu kavereiden kanssa, harrastaa urheilua tai osallistuu ohjattuun liikuntaan).

- ❍ ei koskaan
- ❍ harvemmin kuin kerran viikossa
- ❍ 1-2 kertaa viikossa
- ❍ 3-4 kertaa viikossa
- ❍ 5-6 kertaa viikossa
- ❍ päivittäin

Arvioikaa, kuinka usein isä osallistuu yhdessä tutkimukseen osallistuvan lapsensa kanssa fyysisesti aktiiviseen toimintaan, kuten liikkumiseen leikkimiseen ja pelaamiseen.

- ❍ ei koskaan
- ❍ harvemmin kuin kerran viikossa
- ❍ 1-2 kertaa viikossa
- ❍ 3-4 kertaa viikossa
- ❍ 5-6 kertaa viikossa
- ❍ päivittäin

Arvioikaa, kuinka usein äiti osallistuu yhdessä tutkimukseen osallistuvan lapsensa kanssa fyysisesti aktiiviseen toimintaan, kuten liikkumiseen leikkimiseen ja pelaamiseen.

- ❍ ei koskaan
- ❍ harvemmin kuin kerran viikossa
- ❍ 1-2 kertaa viikossa
- ❍ 3-4 kertaa viikossa
- ❍ 5-6 kertaa viikossa
- ❍ päivittäin

Miettikää lapsistanne sitä, joka viettää eniten aikaa tutkimukseen osallistuvan lapsenne kanssa liikunnallisesti aktiivisen toiminnan parissa. Arvioikaa, kuinka usein hän osallistuu yhdessä tutkimukseen osallistuvan lapsenne kanssa fyysisesti aktiiviseen toimintaan, kuten liikkumiseen leikkimiseen ja pelaamiseen.

- ❍ ei koskaan
- ❍ harvemmin kuin kerran viikossa
- ❍ 1-2 kertaa viikossa
- ❍ 3-4 kertaa viikossa
- ❍ 5-6 kertaa viikossa
- ❍ päivittäin

Arvioikaa, kuinka usein perheenne harrastaa yhdessä liikkumista, kuten pyöräilyä, kävelyä, ulkona pelailua, retkeilyä, sisäliikuntaa, pelailua tai leikkimistä. Perheenä harrastamisella tarkoitetaan tässä sellaista toimintaa, johon osallistuu vähintään yksi aikuinen perheenjäsen ja jonka rooli ei rajoitu pelkkään valvomiseen vaan sisältää aktiivisen osallistumisen toimintaan.

- ❍ ei koskaan
- ❍ harvemmin kuin kerran viikossa
- ❍ 1-2 kertaa viikossa
- ❍ 3-4 kertaa viikossa
- ❍ 5-6 kertaa viikossa
- ❍ päivittäin

Minkä asioiden koette olevan esteenä lapsenne kanssa liikkumiselle

- ❑ ei ole kaveria/ryhmää liikkumaan yhdessä
- ❑ lääkärin tms asiantuntijan suositus
- ❑ joku vamma estää
- ❑ muut harrastukset, mitkä? : ____
- ❑ en tiedä missä voisimme liikkua
- ❑ liikuntapaikat ovat liian kaukana
- ❑ ei ole aikaa
- ❑ ei ole motivaatiota
- ❑ lapsien hoitaminen vie liikaa aikaa
- ❑ en ole liikunnallinen
- ❑ huonot kokemukset koululiikunnasta
- ❑ liikun jo mielestäni tarpeeksi lasteni kanssa yhdessä
- ❑ muu syy, mikä? : ____

Arvioikaa, kuinka usein isä osoittaa suoraa tukea tutkimukseen osallistuvan lapsenne liikunnalliselle aktiivisuudelle. Suoralla tuella tarkoitetaan tässä esimerkiksi seuraavia asioita: liikuntaharrastuksiin kyyditseminen, liikunnalliseen toimintaan osallistumisesta koituvien kulujen maksaminen sekä liikuntavälineiden tai -vaatteiden ostaminen.

- ei koskaan
- harvemmin kuin kerran viikossa
- 1-2 kertaa viikossa
- 3-4 kertaa viikossa
- 5-6 kertaa viikossa
- päivittäin

Arvioikaa, kuinka usein äiti osoittaa suoraa tukea tutkimukseen osallistuvan lapsenne liikunnalliselle aktiivisuudelle. Suoralla tuella tarkoitetaan tässä esimerkiksi seuraavia asioita: liikuntaharrastuksiin kyyditseminen, liikunnalliseen toimintaan osallistumisesta koituvien kulujen maksaminen, liikuntavälineiden tai -vaatteiden ostaminen.

- ei koskaan
- harvemmin kuin kerran viikossa
- 1-2 kertaa viikossa
- 3-4 kertaa viikossa
- 5-6 kertaa viikossa
- päivittäin

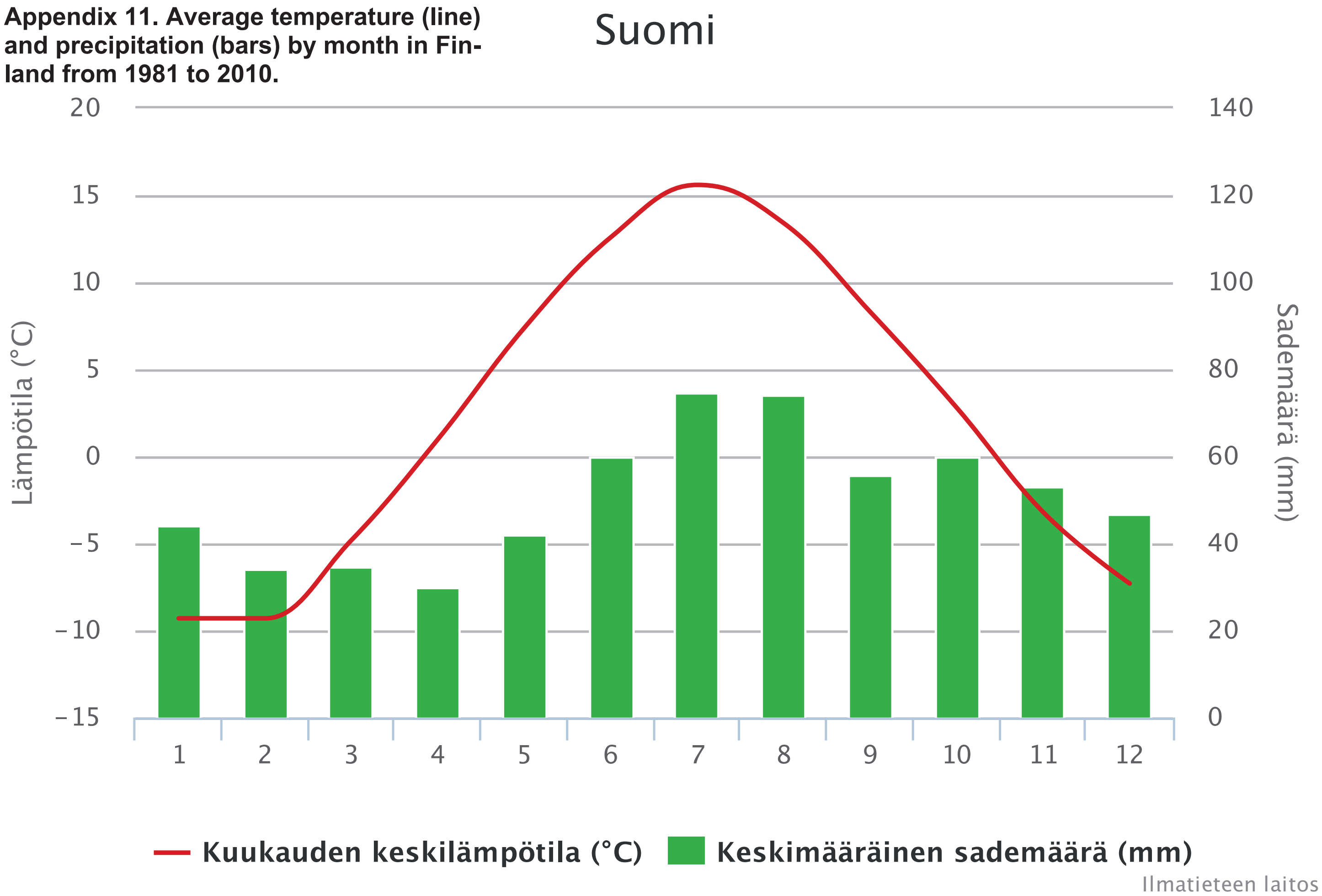
Arvioikaa, kuinka usein isä osoittaa kehuja tai kiitosta tutkimukseen osallistuvalle lapselle tämän liikunnallisen aktiivisuuden johdosta.

- ei koskaan
- harvemmin kuin kerran viikossa
- 1-2 kertaa viikossa
- 3-4 kertaa viikossa
- 5-6 kertaa viikossa
- päivittäin

Arvioikaa, kuinka usein äiti osoittaa kehuja tai kiitosta tutkimukseen osallistuvalle lapselle tämän liikunnallisen aktiivisuuden johdosta.

- ei koskaan
- harvemmin kuin kerran viikossa
- 1-2 kertaa viikossa
- 3-4 kertaa viikossa
- 5-6 kertaa viikossa
- päivittäin

Appendix 11. Average temperature (line) and precipitation (bars) by month in Finland from 1981 to 2010.



Appendix 12. A three-way interaction of study results.

TABLE 19 Changes in parental support and physical activity within and between intervention and control support tertiles when child's sex is treated as fixed variable. A three-way interaction of group × time × sex.

Outcome	Time (months)	Unadjusted mean (SD) Intervention	Control	p-value	MODEL 1 Adjusted change between groups (95% CI)	p-value	MODEL 2 Adjusted change between groups (95% CI)	p-value
Parental support								
All	0	3.63 (0.82)	3.42 (0.81)					
	6	3.46 (0.61)	3.31 (0.83)	.904	0.21 (-0.38 to 0.62)	.631	0.44 (-0.48 to 0.57)	.870
	12	3.45 (0.70)	**3.21 (0.80)**ǀ	.245	-0.32 (-0.97 to 0.34)	.339	-0.31 (-0.98 to 0.37)	.371
Lowest parental support tertile	0	2.77 (0.33)	2.74 (0.37)					
	6	3.04 (0.41)	2.90 (0.75)	.205	-0.14 (-0.77 to 0.50)	.661	-0.07 (-0.76 to 0.62)	.837
	12	2.95 (0.38)	**2.78 (0.77)**ǀ	.080	-0.61 (-1.51 to 0.30)	.183	-0.43 (-1.41 to 0.55)	.383
Highest parental support tertile	0	4.51 (0.46)	4.42 (0.55)					
	6	3.92 (0.56)	**4.20 (0.55)**ǁł	.114	0.85 (-0.15 to 1.84)	.093	1.06 (-0.15 to 2.26)	.084
	12	3.96 (0.74)	3.68 (0.71)	.696	-0.23 (-1.32 to 0.86)	.671	-0.31 (-1.48 to 0.85)	.590
Physical activity								
All	0	6.33 (0.32)	6.22 (0.26)					
	6	6.41 (0.40)	6.25 (0.28)	.419	0.11 (-0.20 to 0.42)	.493	0.14 (-0.18 to 0.45)	.387
	12	6.28 (0.29)	6.28 (0.33)	.200	0.11 (-0.25 to 0.47)	.534	0.19 (-0.16 to 0.55)	.284
Lowest parental support tertile	0	6.20 (0.30)	6.24 (0.28)					
	6	6.40 (0.47)	6.21 (0.34)	.780	0.08 (-0.42 to 0.57)	.758	0.22 (0.29 to 0.73)	.395
	12	6.24 (0.30)	6.22 (0.30)	.715	-0.23 (-0.91 to 0.44)	.495	0.09 (-0.60 to 0.78)	.793
Highest parental support tertile	0	6.33 (0.23)	6.27 (0.26)					
	6	6.37 (0.40)	6.37 (0.17)	.163	0.28 (-0.19 to 0.75)	.223	0.36 (-0.18 to 0.89)	.184
	12	6.29 (0.28)	6.42 (0.31)	.583	0.01 (-0.49 to 0.52)	.959	0.02 (-0.50 to 0.53)	.947

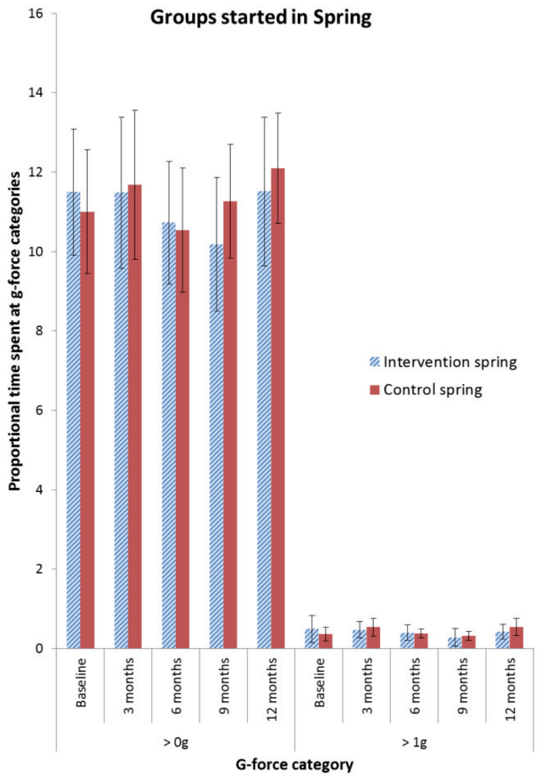
Note. Physical activity = logarithmically changed mean accelerometer counts per minute at leisure time. 0 months = baseline.

ǀ Within group change from baseline significant at the level of p < .05 and ǁ p < .01 (unadjusted model).

ł Within group change from baseline significant at the level of p < .05 (model 1).

ǂ Within group change from baseline significant at the level of p < .05 and ǂǂ p < .01 (model 2).

Appendix 13. Time spent at different g-force categories from baseline to 12 months in intervention and control groups.



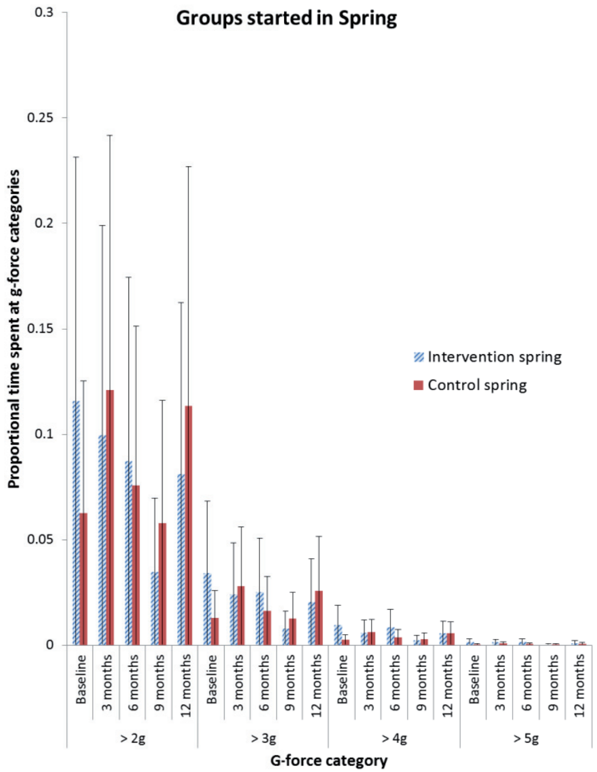


Figure 16 Means and standard deviations of time spent at different g-force categories from baseline to 12 months in intervention and control groups started in Spring.

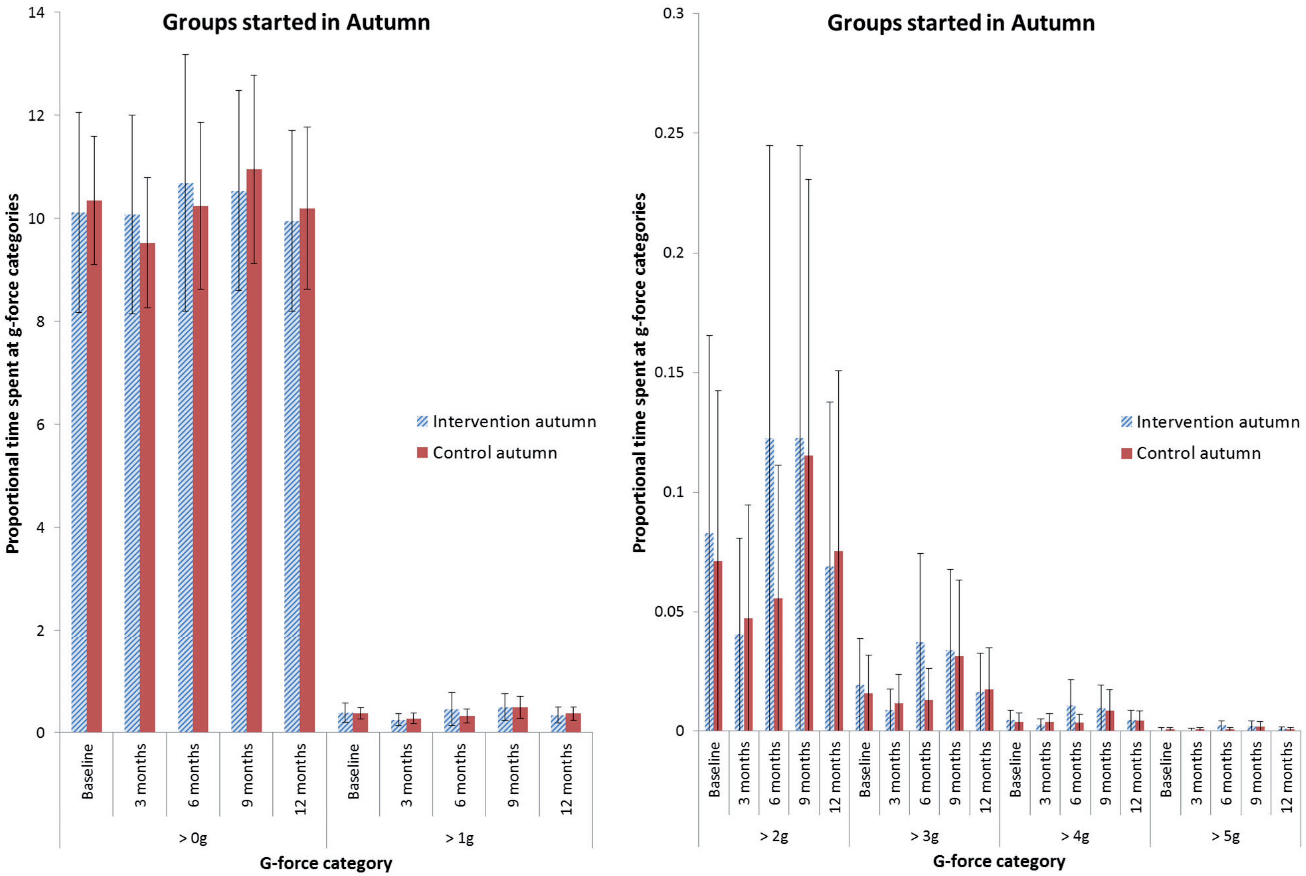


Figure 17 Means and standard deviations of time spent at different g-force categories from baseline to 12 months in intervention and control groups started in Autumn.

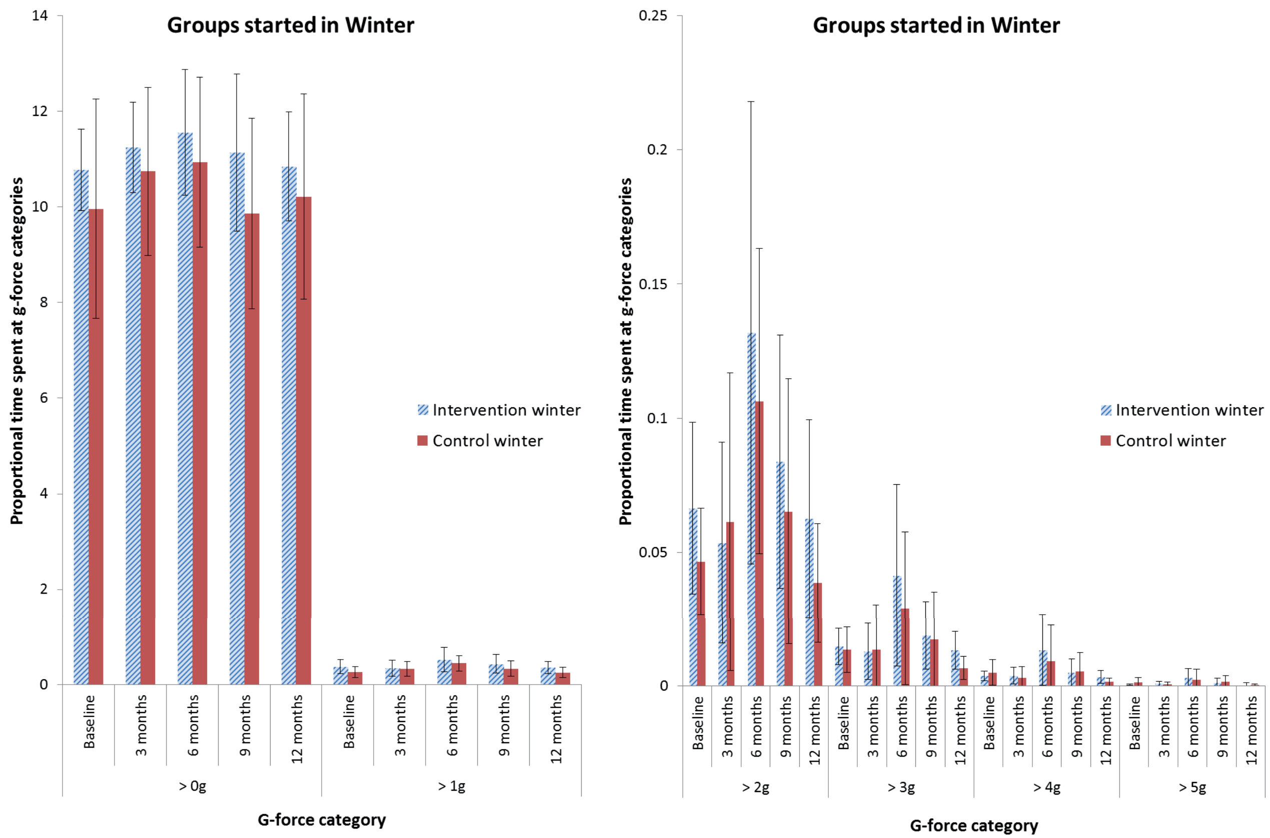


Figure 18 Means and standard deviations of time spent at different g-force categories from baseline to 12 months in intervenetion and control groups started in Winter.

ORIGINAL PUBLICATIONS

I

REIPAS LIIKUNTA TAKAA LASTEN MOTORISTEN PERUSTAI-TOJEN KEHITYKSEN – MUTTA KEVYTTÄKIN TARVITAAN!

by

Laukkanen, A., Finni, T., Pesola, A. & Sääkslahti, A. 2013

Liikunta & Tiede 50 (6), 47-51.

REIPAS LIIKUNTA TAKAA LASTEN MOTORISTEN PERUSTAITOJEN KEHITYKSEN – MUTTA KEVYTTÄKIN TARVITAAN!

ARTO LAUKKANEN, TAIJA FINNI, ARTO PESOLA, ARJA SÄÄKSLAHTI

Yhteyshenkilö: Arto Laukkanen, Liikuntabiologian laitos, Jyväskylän yliopisto, PL 35 (LL 175), 40014 Jyväskylän yliopisto. Puh. 040-684 6255, sähköposti: arto.i.laukkanen@jyu.fi

TIIVISTELMÄ

Laukkanen, A., Finni, T., Pesola, A.Sääkslahti, A. 2013. Reipas liikunta takaa lasten motoristen perustaitojen kehityksen – mutta kevyttäkin tarvitaan! Liikunta & Tiede 50 (6), 47–52.

■ Terveyshyötyjen ohjaamina kansainväliset liikuntasuositukset kehottavat, että yli 5-vuotiaiden lasten tulisi liikkua päivittäin vähintään yhden tunnin ajan intensiteetiltään keskiraskaasti tai raskaasti. Kansalliset liikuntasuositukset suosittelevat 7-vuotiaiden ja tätä nuorempien liikkuvan vähintään 2 tuntia intensiteetiltään ainakin osittain reippaasti. Toistaiseksi ei tiedetä, minkä tyyppinen liikunta olisi intensiteetiltään suositeltavaa lasten motoristen perustaitojen kehitykselle.

Tämän tutkimuksen tarkoitus oli selvittää lapsille tyypillisten ja motorisia perustaitoja kehittävien sisäliikuntamuotojen intensiteetit. Päiväkotilaiset (11 tyttöä ja 7 poikaa, keski-ikä 6,3 vuotta) ja ensimmäisen luokan oppilaat (3 tyttöä ja 8 poikaa, keski-ikä 7,6 vuotta) suorittivat yhden päivän aikana kuusi sisäliikuntatehtävää: hippa, pallopeli, konttaus, porraskävely, kiipeily ja tasapainokävely. Liikkumista mitattiin objektiivisesti vyötäröllä pidettävillä 3-suuntaisilla kiihtyvyysantureilla (GCDC), joilla analysoitiin liikkumisintensiteetti käyttäen counts- ja g-voimahistogrammi-menetelmiä. Sekä päiväkotilaisten että koululaisten liikkumisintensiteetti vaihteli tehtävien välillä erittäin kevyestä raskaaseen. Hippa, pallopeli, konttaaminen ja porraskävely olivat joko keskiraskaita tai raskaita ja toisaalta korkeita kiihtyvyyksiä aiheuttavia sisäliikuntamuotoja. Sen sijaan kiipeily ja tasapainokävely olivat pääasiassa kevyitä tai erittäin kevyitä ja matalia kiihtyvyyksiä aiheuttavia liikkumismuotoja.

Yhteenvetona voidaan todeta, että kiihtyvyysanturilla mitattuna raskaan ja keskiraskaan ohella myös hyvin kevyeksi luokiteltava fyysinen aktiivisuus voi sisältää motoristen perustaitojen kehityksen kannalta olennaisia liikkumismuotoja. Motoristen perustaitojen kehityksen kannalta on suositeltavaa, että intensiteetiltään kaikentyyppinen fyysinen aktiivisuus otetaan huomioon, kun lasten fyysistä aktiivisuutta mitataan tai annetaan fyysisen aktiivisuuden suosituksia.

Asiasanat: motoriset perustaidot, fyysinen aktiivisuus, lapset

ABSTRACT

Laukkanen, A., Finni, T., Pesola, A. & Sääkslahti, A. 2013. Brisk physical activity ensures the development of fundamental motor skills in children – but light is also needed! Liikunta & Tiede 50 (6), 47–52.

■ Based on health benefits, international physical activity (PA) guidelines recommend at least 60 minutes of moderate-to-vigorous intensity physical activity (MVPA) daily in children over 5-years-old. Finnish national guidelines recommend 7-years-old and younger children to be physically active at least 2 hours a day of which at least a part should contain MVPA. To date, there is no research-based evidence on which intensity of PA is of primary importance from the perspective of development of fundamental motor skills in children.

The purpose of this study was to examine the intensity of typical children's' indoor physical activities known to be important for fundamental motor development. Preschoolers (11 girls and 7 boys, mean age 6.3 years) and first-graders (3 girls and 8 boys, mean age 7.6 years) performed six indoor activities during a day: tag, ball game, crawling, stair walking, climbing and balance beam walking. Physical activity was measured objectively using three-dimensional accelerometers and intensity of PA was determined using counts- and g-force histogram methods. The intensity of different activities varied between activities from sedentary to vigorous in both preschoolers and first-graders. Tag, ball game, crawling and stair walking were classified as MVPA and contained high g-force impacts. In contrast, climbing and balance beam walking were mostly light or sedentary activity and accumulated low g-force impacts.

In conclusion, accelerometer-derived sedentary-to-light intensity PA, along with MVPA, can be essential for the development of fundamental motor skills in children. Therefore, PA of all intensities should be taken into consideration when PA in children is assessed or PA guidelines for children are administered.

Keywords: fundamental motor skills, physical activity, children

JOHDANTO

Poikkileikkaustutkimuksissa motoristen perustaitojen on osoitettu olevan yhteydessä fyysisen aktiivisuuden määrään: mitä paremmat motoriset perustaidot sitä fyysisesti aktiivisempia lapset ovat (Williams ym. 2008; Wrotniak ym. 2006). Toisaalta riittävän motoristen perustaitojen tason on havaittu tutkimuksissa olevan yksi fyysisen aktiivisuuden vähenemistä hidastava tekijä siirryttäessä lapsuudesta nuoruuteen (Lopes ym. 2011; Barnett ym. 2009). Heikkojen motoristen perustaitojen on puolestaan todettu olevan yhteydessä terveyttä kuvaaviin muuttujiin, kuten kohonneeseen kehon painoindeksiin ja vyötärönympärysmittaan (D'Hondt ym., 2012; Okely ym., 2004), huonompaan terveyskuntoon (Hands ym. 2009) sekä heikompaan akateemiseen suoriutumiseen (Kantomaa ym. 2013). Motoristen perustaitojen kehittyminen lapsuudessa on yhtäältä seurausta hermostollisten järjestelmien kypsymisestä, kehon fyysisten ominaisuuksien kehittymisestä ja motorisesta harjoittelusta (Malina ym. 2004).

Aikaisemmissa tutkimuksissa sekä motoristen perustaitojen kehitys (Fisher ym. 2005; Williams ym. 2008) että terveydellisten tekijöiden suotuisa muutos (Timmons ym. 2012; Sääkslahti ym.2004) on liitetty intensiteeteiltään rasittavan tai kohtuullisesti rasittavan fyysisen aktiivisuuden määrään. Osittain tällaisiin aikaisempiin tutkimustuloksiin pohjautuen kansainväliset liikuntasuositukset kehottavat yli 5-vuotiaita liikkumaan päivittäin vähintään 60 minuuttia, ja tämän ajan suositellaan koostuvan joko kokonaan (Australia's Physical Activity Recommendations 2005; UK physical activity guidelines 2011) tai ainakin osittain rasittavasta tai kohtuullisen rasittavasta liikunnasta (Physical Activity for Children 2004). Kohtuullisesti rasittavalla ja rasittavalla liikunnalla (moderate-to-vigorous physical activity) tarkoitetaan sykettä kohottavaa ja hikoilua aiheuttavaa, niin sanottua reipasta liikuntaa ja leikkiä. Kansallisissa liikuntasuosituksissa päivittäisen liikkumisen kokonaismääräksi suositellaan 7-vuotiailla ja tätä nuoremmilla vähintään 2 tuntia, ja niissä painottuvat hieman kansainvälisiä suosituksia vahvemmin liikunnan kasvattava rooli ja toisaalta liikuntaan kasvamisen merkitys (Fyysisen aktiivisuuden suositus kouluikäisille 7–18-vuotiaille 2008; Varhaiskasvatuksen liikunnan suositus 2005).

Suomalaisten lasten fyysisestä aktiivisuudesta on olemassa sekä kyselyihin (kuten Kansallinen liikuntatutkimus 2009–2010), kyselyihin ja päiväkirjoihin (Nupponen ym., 2010) että objektiiviseen kiihtyvyysanturimittaamiseen perustuvaa tietoa (Soini ym. 2012). Reliaabeli ja suuretkin otokset kustannustehokkaasti mahdollistava kiihtyvyysanturimittaaminen perustuu liikkumisesta aiheutuvien kiihtyvyyksien määrän ja voimakkuuden eli intensiteetin rekisteröimiseen. Toistaiseksi ei ole kuitenkaan vielä tutkittua tietoa siitä, miten nämä yhä yleisemmin käytettävät kiihtyvyysanturit tulkitsevat nuorille lapsille tyypilliset liikkumismuodot rasittavuuden eli intensiteetin suhteen. Toisin sanoen tähän mennessä ei ole selvää käsitystä siitä, minkä intensiteettisiä ovat lasten tyypilliset ja motorisia perustaitoja kehittävät liikuntamuodot kiihtyvyysanturilla mitattuna.

Tämän tutkimuksen tarkoituksena oli selvittää, kuinka intensiivistä päiväkotilaisten ja ensimmäisen luokan oppilaiden tyypilliset ja perusliikuntataitoja kehittävät sisäliikuntamuodot ovat kiihtyvyysanturimittausten perusteella. Kiihtyvyysanturimittareiden tuottamasta datasta analysoitiin aktiivisuusluvut eri liikunta-aktiivisuuden intensiteeteille (counts-analyysi) ja lisäksi kiihtyvyysvoimat (g-voima) analysoitiin reaaliaikaisesti ja esitettiin histogrammina. Käyttämällä kahta rinnakkaista analysointimenetelmää pyrittiin saamaan tyypillisten sisäliikuntamuotojen intensiteetistä mahdollisimman kattava kuva.

TUTKIMUSAINEISTO JA MENETELMÄT

Tutkimuksen aineisto kerättiin yhdestä Jyväskylän seudulla sijaitsevasta päiväkoti-koulusta osana vuosina 2011–2013 toteutettavaa "Istumisen vähentämisen ja arkiliikunnan lisäämisen vaikutukset aikuisten ja heidän pienten lastensa liikkumiseen ja terveyteen (InPact)" -hanketta. Tutkimuksen suostumuslomake fyysisen aktiivisuuden mittauksiin osallistumisesta lähetettiin 30:lle 5–6-vuotiaan päiväkotilaisen ja 12 ensimmäisen luokan oppilaan huoltajalle. Suostumus osallistumisesta saatiin yhteensä 20 päiväkotilaisen ja 11 ensimmäisen luokan oppilaan huoltajalta. Tutkimukseen suostumuksensa antaneiden huoltajien lapsista kaksi oli poissa päiväkodista ja yksi koulusta tutkimuspäivänä. Tutkimusjoukko (n=29) koostui näin ollen 11 päiväkoti-tytöstä (ikä 6,26 ± 0,64 vuotta) ja seitsemästä pojasta (ikä 6,29 ± 0,54 vuotta) sekä kolmesta ensimmäisen luokan tytöstä (ikä 7,76 ± 0,29 vuotta) ja kahdeksasta pojasta (ikä 7,48 ± 0,24 vuotta).

Tyypilliset sisäliikuntamuodot

Päiväkotilaisten ja ensimmäisen luokan oppilaiden mitattaviksi sisäliikuntamuodoiksi pyrittiin valitsemaan lapsille entuudestaan tuttuja ja selkeitä sekä yksilö- että yhteistoiminnallisia tehtäviä. Selkeydellä ja yksiselitteisyyden periaatteella haettiin sitä, että tehtävien suoritustapa olisi suhteellisen vakio. Tällä pyrittiin mahdollisimman korkeaan tehtävien toistettavuuteen. Tehtävän suorittamisessa jää tällöin pienempään osaan toiminnan suunnittelu ja suuntaaminen, ja keskittyminen voidaan kohdistaa tehtävän vaatimaan motoriseen säätelyyn (Wolf 2007). Lisäksi tehtävien haluttiin olevan kaikenikäisille tutkimukseen osallistuville lapsille soveltuvia, jotta tuloksia voitaisiin käsitellä yhteismitallisina koko tutkimusjoukolle. Näillä perusteilla tutkittaviksi sisäliikuntamuodoiksi valikoituivat seuraavat yhteistoiminnalliset (1 ja 2) ja yksilötehtävät (3, 4, 5 ja 6):

1) Pelastushippa. Lapset leikkivät "banaani-hippaa" 6 oppilaan ryhmissä (alue 10,9 m × 6,1 m) niin, että kullakin lapsella oli 30 sekunnin hippa-vastuu. Hippa-leikin yhteiskesto oli 3 minuuttia ja vaihtoihin kulunut aika. Lapsia kehotettiin mahdollisimman nopeasti pelastamaan hipan kiinni ottamat pelaajat. Mikäli hippa sai kiinni kaikki pelaajat ennen 30 sekunnin täyttymistä, niin peli aloitettiin alusta uudelleen.

2) Pallopeli "oma puoli puhtaaksi". Lapset jaettiin 3 hengen joukkueisiin, joiden tavoitteena oli erän aikana puhdistaa oma kenttäpuolisko (10,9 m × 6,1 m) hernepusseista. Puhdistaminen tapahtui nostamalla omalle kenttäpuoliskolle jäänyt hernepussi yksi kerrallaan maasta ja heittämällä se vastapuolen kenttäpuoliskolle. Pelissä oli 3 yhden minuutin erää, joiden välissä oli lyhyet tauot. Taukojen aikana kenttäpuoliskoille jääneet hernepussit laskettiin ja jaettiin uudelleen tasapuolisesti seuraavaa erää varten.

3) Konttaus. Salin halki kulkevaan voimistelumattoon (12,3 m pitkä, 90 cm leveä, 4 cm paksu) oli merkattu pujottelurata niin, että lasten tuli konttaamalla pujotella rata päädystä toiseen yhden kerran ilman keskeytyksiä. Konttausvauhtia ei ohjeistettu erikseen, vaan lapset saivat kontata itse määräämällään vauhdilla.

4) Porraskävely. Tehtävänä oli kuljettaa viisi hernepussia, yksi kerrallaan, portaiden (yhden portaan korkeus 5,9 cm, portaikon korkeus yhteensä 3,5 m) alatasolta ylätasolle. Portaissa ei saanut juosta, muuten kävelytyyli oli vapaa. Kaiteesta sai tarvittaessa ottaa tukea, mikäli lapsi koki sen tarpeelliseksi.

5) Kiipeily. Seinään kiinteästi asennetuille neljälle vierekkäiselle puolapuulle (leveys yhteensä 304 cm, puolapuiden ylin puola 250 cm korkeudella) oli merkitty kahdenvärisillä hernepusseilla kiipeilyrata. Kiipeilyrata oli kaksivaiheinen: Kiipeäminen alhaalta ylös ja yksiväristen hernepussien pudottaminen vuorollaan kunkin vierekkäisen puolapuun ylimmältä puolalta. Kiipeilyradan lopuksi lasten oli siirryttävä sivuttain oikealle, halki kaikkien neljän puolapuun ja

pudotettava kunkin puolapuun ylimmällä puolalla oleva raidallinen hernepussi. Lapset saivat ennen mittaamista harjoitella kiipeilyä puolapuilla. Kiipeilytyyli oli vapaa.

6) Tasapainokävely. Tehtävänä oli etuperin kävellen tasapainoilla yhden kerran edestakaisin kolmea perättäin asetettua käännettyä penkkiä pitkin. Penkkien väliin jäävä aukko (n. 50 cm) oli sallittua ylittää joko pitkällä askeleella tai tukiaskeleella penkkien väliin jäävälle alueelle. Yhden käännetyn penkin pituus oli 240 cm, leveys 9 cm ja korkeus 35 cm, jolloin käännetyillä penkeillä käveltäväksi matkaksi kertyi yhteensä 14,4 m.

Yhteistoiminnallisissa tehtävissä lapsiryhmien koko oli 6 henkeä. Yksilötehtävissä yksi lapsi suoritti tehtävää kerrallaan. Yksilötehtävien mahdollista sosiaalista suoriutumispainetta pyrittiin vähentämään ottamalla mukaan kerrallaan vain tehtävien lukumäärää vastaava määrä lapsia. Näin myös odotusajat jäivät lyhyiksi. Jokaisella yksilötehtäväpisteellä oli yksi aikuinen antamassa suulliset suoritusohjeet ja valvomassa annetun tehtävän suorittamista. Yhteistoiminnalliset tehtävät suoritettiin aina samassa järjestyksessä. Aikataulullisista syistä johtuen yksilötehtävien suoritusjärjestys ei ollut sama kaikilla, vaan tehtävien tekeminen aloitettiin joko tehtävästä 3, 4, 5 tai 6.

Fyysinen aktiivisuus

Lasten fyysistä aktiivisuutta mitattiin kaikkien tehtävien ajan kolmisuuntaisilla X6–1a -mallin kiihtyvyysantureilla, jotka mittaavat kiihtyvyyttä dynaamisesti ±6 g:n alueelta (Gulf Coast Data ConceptsInc, USA). Kiihtyvyysanturi asetettiin tukevasti keskelle lapsen vyötärön etuosaa, säädettävään ja joustavaan vyöhön kiinnitettynä.

Kiihtyvyysanturien keräämä data analysoitiin counts-pohjaisella analyysimenetelmällä käyttäen lapsilla määritettyjä fyysisen aktiivisuuden intensiteetin raja-arvoja. Yleisesti kiihtyvyysanturimittaaminen perustuu siihen, että liikahtelun tuottamien kiihtyvyyksien määrä ja niiden voimakkuus tallentuvat mittarin muistiin. Tässä tutkimuksessa kiihtyvyyksistä laskettiin 15:n sekunnin aikavälein (englanniksi epoch time) keskiarvo, jonka mukaan fyysinen aktiivisuus määriteltiin intensiteetiltään kyseisellä aikavälillä joko erittäin kevyeksi (sedentary—alle 373 sykäystä), kevyeksi (light—373–585 sykäystä), keskiraskaaksi (moderate—585–881 sykäystä) tai raskaaksi (vigorous—yli 881 sykäystä) (Van Cauwenberghe et al 2010).

Fyysisen aktiivisuuden intensiteetin määrittämiseksi kiihtyvyysanturidata analysoitiin lisäksi Jyväskylän yliopistossa kehitetyn reaaliaikaisen kiihtyvyyksien tallentamiseen perustuvan g-voimahistogrammin avulla. G-voimahistogrammi kykenee säilyttämään fyysisen aktiivisuuden tosiaikaisen intensiteettitiedon ilman keskiarvoistamista. Histogrammianalyysissä kiihtyvyysvoimat analysoitiin seuraaviin luokkiin: 0–0,05 g, 0,05–0,2 g, 0,2–0,4 g, …, 5,6–5,8 g ja 5,8–6,0 g. Sekä counts- että g-voimahistogrammi-analyysin tulokset laskettiin suhteellisina osuuksina kuhunkin tehtävään keskimäärin kokonaisuudessaan käytetystä ajasta (prosenttiosuus tehtävään keskimäärin kuluneesta kokonaisajasta). Lisäksi keskimääräisistä prosenttiosuuksista laskettiin kaikissa tapauksissa keskihajonnat.

Antropometria

Lasten pituus (seinään kiinnitetty mittanauha) ja paino (Soehnle Digital -henkilövaaka) mitattiin sisäliikuntatehtävien suorittamisen yhteydessä. Mittaustilanne toteutettiin niin, että kerrallaan vain yksi lapsi oli aikuisen ohjaajan mitattavana erillisessä pukuhuonetilassa. Kehon painoindeksistä (BMI, kg/m²) laskettiin keskiarvo ja keskihajonta kummankin tutkimusryhmän sisällä.

TULOKSET

Päiväkotilaisten keskimääräinen kehon painoindeksi oli 16,3 ± 1,0 (pituus 117 cm ± 7,2 cm; paino 22,3 kg ± 3 kg) ja koululaisten 17,6 ± 1,9 (pituus 125,5 cm ± 5,1 cm; paino 27,7 kg ± 4,2 kg). Keskimäärin koululaiset suoriutuivat yksilötehtävistä selvästi päiväkotilaisia lyhyemmässä ajassa (Taulukko 1). Lisäksi ensimmäisen luokan oppilaiden suoritusten kestot olivat yksilötehtävissä selvästi yhdenmukaisemmat kuin päiväkotilaisilla, joiden ajankäytössä oli keskihajontojen perusteella huomattavasti suurempia yksilöiden välisiä eroja. Odotetusti yhteistoiminnallisten tehtävien kestoissa ei havaittu eroja yksilöiden välillä.

Sekä päiväkotilaiset että koululaiset liikkuivat hipassa, pallopelissä ja konttaamisessa suurimman osan ajasta (vaihteluväli 65,2–100 prosenttia) raskaaksi määritellyllä fyysisen aktiivisuuden intensiteettitasolla (Taulukot 2 ja 3). Lisäksi koululaisten portaissa kävely oli suurimmaksi osaksi raskaaksi ja päiväkotilaisilla kohtuullisen raskaaksi luokiteltavaa. Kummallakin ikäryhmällä konttaaminen aiheutti yli 10 prosenttia suoritusajasta suureksi luokiteltavia, yli 1 g:n, kiihtyvyyksiä (Taulukot 4 ja 5). Seuraavaksi eniten suuria kiihtyvyyksiä aiheuttivat hippa ja pallopeli sekä porraskävely.

Muista tehtävistä poiketen, kiipeily ja tasapainokävely olivat fyysisen aktiivisuuden intensiteetiltään pääosin kevyttä tai erittäin kevyttä liikkumista erityisesti päiväkotilaisilla (Taulukko 2). Koululaisilla kii-

TAULUKKO 1. Yhteistoiminnallisiin ja yksilötehtäviin käytetty aika keskimäärin sekunteina (± keskihajonta).

Tehtävä	Päiväkotilaiset (*n* = 18)	1. luokan oppilaat (*n* = 11)
Hippa	179,8 ± 0,8	179,9 ± 0,4
Pallopeli	180,0 ± 1,6	180,0 ± 0,5
Konttaus	23,0 ± 5,6	18,8 ± 2,8
Kiipeily	116,1 ± 40,5	64,7 ± 14,0
Porraskävely	154,9 ± 53,3	119,2 ± 14,6
Tasapainoilu	62,9 ± 18,7	50,6 ± 10,2

TAULUKKO 2. Päiväkotilaisten käyttämä suhteellinen osuus ajasta fyysisen aktiivisuuden intensiteettitasoilla eri sisäliikuntamuodoissa (keskiarvo ± keskihajonta). Counts-analyysi. Kutakin sisäliikkumismuotoa parhaiten kuvaava intensiteettiluokka on lihavoitu.

Intensiteetti	Hippa	Pallopeli	Konttaus	Porraskävely	Kiipeily	Tasapainokävely
Erittäinkevyt	2,3 ± 3,9	6,5 ± 6,7	0,0 ± 0, 0	7,9 ± 23,9	**73,5 ± 22,5**	50,9 ± 40,5
Kevyt	11,5 ± 13,2	9,6 ± 8,2	0,0 ± 0, 0	9,6 ± 22,7	22,5 ± 21,3	**51,7 ± 40,3**
Keskiraskas	7,1 ± 7,2	9,2 ± 13,0	5,9 ± 24,4	**43,6 ± 36,0**	5,4 ± 9,7	1,9 ± 7,9
Raskas	**84,0 ± 18,1**	**88,5 ± 16,2**	**96,5 ± 25,0**	39,2 ± 36,3	0,0 ± 0,0	0,0 ± 0,0

TAULUKKO 3. Koululaisten suhteellisesti käyttämä osuus ajasta fyysisen aktiivisuuden intensiteettitasoilla eri sisäliikuntamuodoissa (keskiarvo ± keskihajonta). Counts-analyysi. Kutakin sisäliikkumismuotoa parhaiten kuvaava intensiteettiluokka on lihavoitu.

Intensiteetti	Hippa	Pallopeli	Konttaus	Porraskävely	Kiipeily	Tasapainokävely
Erittäinkevyt	2,3 ± 3.9	8,3 ± 11.9	0,0 ± 0,0	0,0 ± 0,0	**38,0 ± 28,0**	30,7 ± 44,8
Kevyt	13,1 ± 7.9	5,3 ± 10.3	0,0 ± 0,0	10,0 ± 18,2	30,8 ± 28,7	**44,5 ± 42,2**
Keskiraskas	8,3 ± 11.8	9,1 ± 17.5	0,0 ± 0,0	39,7 ± 33,3	30,4 ± 35,1	30,7 ± 41,9
Raskas	**65,2 ± 16.7**	**89,4 ± 19.8**	**103 ± 2,8**	**50,8 ± 40,3**	3,1 ± 10,3	0,0 ± 0,0

TAULUKKO 4. Päiväkotilaisten käyttämä suhteellinen osuus ajasta fyysisen aktiivisuuden intensiteettitasoilla eri sisäliikuntamuodoissa (keskiarvo ± keskihajonta). G-voimahistogrammianalyysi. Kutakin sisäliikkumismuotoa parhaiten kuvaava kiihtyvyysluokka on lihavoitu.

Intensiteetti	Hippa	Pallopeli	Konttaus	Porraskävely	Kiipeily	Tasapainokävely
0 g	65,7 ± 3,3	62,4 ± 2,4	61,4 ± 4,2	66,1 ± 3,5	72,5 ± 4,1	69,8 ± 3,0
0,05–0,2 g	**9,8 ± 1,4**	**10,9 ± 1,8**	6,7 ± 2,2	**12,3 ± 2,4**	**20,4 ± 1,7**	**19,1 ± 2,7**
0,2–0,4 g	6,6 ± 1,1	9,3 ± 1,2	6,5 ± 2,1	8,7 ± 1,6	4,7 ± 2,0	6,9 ± 1,8
0,4–0,6 g	4,6 ± 1,1	5,9 ± 1,0	5,1 ± 1,3	4,8 ± 1,1	1,1 ± 0,7	2,3 ± 1,3
0,6–0,8 g	3,3 ± 0,8	3,7 ± 0,7	4,0 ± 1,2	2,8 ± 1,0	0,5 ± 0,3	0,8 ± 0,6
0,8–1 g	2,5 ± 0,6	2,4 ± 0,6	3,6 ± 1,1	1,6 ± 0,7	0,3 ± 0,2	0,4 ± 0,3
summa 1–2 g	6,0 ± 1,6	4,4 ± 1,4	**10,2 ± 3,4**	2,9 ± 1,6	0,4 ± 0,4	0,5 ± 0,3
summa 2–3 g	1,3 ± 0,8	0,7 ± 0,6	2,3 ± 1,5	0,6 ± 0,7	0,1 ± 0,1	0,1 ± 0,1
summa 3–4 g	0,2 ± 0,2	0,1 ± 0,2	0,3 ± 0,4	0,1 ± 0,3	0,0 ± 0,0	0,0 ± 0,1
summa 4–5 g	0,0 ± 0,1	0,1 ± 0,2	0,0 ± 0,1	0,0 ± 0,1	0,0 ± 0,0	0,0 ± 0,0
summa 5–6 g	0,0 ± 0,0	0,0 ± 0,0	0,0 ± 0,0	0,0 ± 0,0	0,0 ± 0,0	0,0 ± 0,0

TAULUKKO 5. Koululaisten suhteellisesti käyttämä osuus ajasta fyysisen aktiivisuuden intensiteettitasoilla eri sisäliikuntamuodoissa (keskiarvo ± keskihajonta). G-voimahistogrammi-analyysi. Kutakin sisäliikkumismuotoa parhaiten kuvaava kiihtyvyysluokka on lihavoitu.

Intensiteetti	Hippa	Pallopeli	Konttaus	Porraskävely	Kiipeily	Tasapainokävely
0 g	65,2 ± 3,0	61,2 ± 2,3	59,8± 4,1	63,0 ± 1,6	68,8 ± 2,9	66,8 ± 2,6
0,05–0,2 g	**10,1 ± 1,5**	**11,0 ± 2,0**	6,2 ± 2,0	**11,6 ± 3,4**	**19,0 ± 1,8**	**18,7 ± 3,3**
0,2–0,4 g	7,3 ± 1,3	10,1 ± 1,0	7,5 ± 1,8	9,5 ± 1,4	6,9 ± 1,8	8,6 ± 1,7
0,4–0,6 g	5,0 ± 0,9	6,3 ± 1,1	5,6 ± 1,9	5,5 ± 1,2	2,2 ± 0,9	3,0 ± 1,5
0,6–0,8 g	3,5 ± 0,7	4,0 ± 0,7	4,7 ± 1,5	3,4 ± 1,2	1,0 ± 0,4	1,2 ± 0,8
0,8–1 g	2,5 ± 0,5	2,6 ± 0,7	3,5 ± 1,1	2,0 ± 1,0	0,7 ± 0,3	0,6 ± 0,5
summa 1–2 g	5,4 ± 1,5	4,3 ± 1,4	**9,8 ± 2,9**	3,9 ± 2,5	1,1 ± 0,7	0,8 ± 0,7
summa 2–3 g	0,9 ± 0,6	0,5 ± 0,4	2,5 ± 1,3	1,0 ± 1,0	0,2 ± 0,1	0,2 ± 0,2
summa 3–4 g	0,1 ± 0,1	0,1 ± 0,1	0,4 ± 0,9	0,1 ± 0,2	0,1 ± 0,1	0,1 ± 0,1
summa 4–5 g	0,0 ± 0,0	0,0 ± 0,0	0,0 ± 0,1	0,0 ± 0,0	0,1 ± 0,1	0,0 ± 0,0
summa 5–6 g	0,0 ± 0,0	0,0 ± 0,0	0,0 ± 0,0	0,0 ± 0,0	0,0 ± 0,1	0,0 ± 0,0

peily ja tasapainokävely jakautuivat melko tasaisesti erittäin kevyen, kevyen ja kohtuullisen raskaan intensiteetin piiriin, painottuen kuitenkin kiipeilyssä erittäin kevyeen ja tasapainokävelyssä kevyeen intensiteettiluokkaan. Kyseisissä yksilötehtävissä matalaintensiteettisyys ilmeni molemmissa ikäryhmissä myös alhaisten kiihtyvyyksien suurena osuutena ja toisaalta suurien kiihtyvyyksien pienenä osuutena käytetystä ajasta (taulukot 4 ja 5).

POHDINTA JA JOHTOPÄÄTÖKSET

Tämän tutkimuksen tulokset osoittivat, että päiväkotilaisten ja ensimmäisen luokan oppilaiden tyypilliset sisäliikuntamuodot vaihtelivat kiihtyvyysanturimittausten perusteella intensiteetiltään koko käytetyn luokitteluasteikon alueella, erittäin kevyestä raskaaseen liikkumiseen. Sekä hippa, pallopeli, konttaaminen että porraskävely olivat käytettyjen analyysimenetelmien pohjalta keskiraskasta tai raskasta liikkumista ja sisälsivät suureksi luokiteltavia kiihtyvyysvoimia. Sen sijaan kiipeily ja tasapainokävely luokiteltiin pääasiassa kevyeksi tai erittäin kevyeksi liikkumiseksi ja näiden liikuntamuotojen aiheuttamat kiihtyvyysvoimat olivat pääosin alhaisia. Tarkasteltaessa lasten fyysistä aktiivisuutta havaittiin siis, että eräät motorisen kehityksen kannalta olennaiset liikkumismuodot voivat olla kiihtyvyysanturilla määritettynä intensiteetiltään erittäin kevyttä, jopa paikoillaan olemiseen verrattavaa, aktiivisuutta.

Tasapainon katsotaan muodostavan liikkumisen perustaitojen osa-alueen, jonka pohjalle liikkumis-, välineenkäsittely- ja myöhemmin myös spesifimmät lajitaidot rakentuvat (Gallahue & Ozmun 2002). Vaikka tasapaino on tärkeä osa kaikentyyppistä hallittua liikkumista ja asennon säilyttämistä ajatellen (Kauranen 2011, 180–197), niin tässä tutkimuksessa erityisesti tasapainokävely käännetyillä penkeillä edustaa selkeimmin tasapainonhallintaa vaativaa aktiivisuutta. Kiipeämistä puolestaan pidetään erinomaisen tärkeänä liikkumismuotona, koska se harjaannuttaa kehon oikean ja vasemman puolen vuoroittaista liikuttamista. Sen lisäksi se on tärkeää ns. kehon keskilinjan ylittämisestä ja ylipäätään kehonhahmotuksesta saatavien kokemusten kannalta. (Ayres 2008.) Näiden kokemusten merkitys on ilmeisen tärkeä motoristen perustaitojen kehitykselle, mutta ne on liitetty viime aikoina yhä vahvemmin myös kognitiiviseen toimintakykyyn, kuten koulumenestykseen (Westendorp ym. 2011).

On tärkeää huomata, että tasapainoa ja monipuolista kehonhahmotusta ja -hallintaa harjoittavissa liikkumismuodoissa vaaditaan suuriakin isometrisiä eli staattisia lihasaktiivisuuksia, jotka rasittavat kehon hermolihasjärjestelmää ja kuluttavat energiaa. Liikkeen ollessa vähäistä kiihtyvyysanturi kuitenkin rekisteröi tällaisen aktiivisuuden intensiteetiltään kevyeksi sen vaatimaan lihasaktiivisuuteen verrattuna (Mikkonen & Juutinen 2012). On oletettavaa, että useat motoriset perusliikkeet ovat senlaatuisia, että intensiivinen, vauhdikas suorittaminen todennäköisesti jopa haittaa näiden taitojen oppimista. Motorisen kehityksen näkökulmasta kiihtyvyysanturein määritettyä fyysistä aktiivisuutta tulisikin näin ollen tarkastella koko käytössä olevan intensiteettiskaalan alueella, aina kevyestä liikkumisesta vauhdikkaaseen. Ihannetilanteessa fyysisen aktiivisuuden mittaamisen tulisi pohjautua objektiivisen ja esimerkiksi havainnointiin perustuvan subjektiivisen menetelmän yhdistelmään, jolloin liikunnan määrästä ja laadusta saataisiin tarkempi kokonaiskuva.

Mielenkiintoisena yksittäistapauksena tutkimuksessa nousi esiin intensiteetiltään erittäin raskaaksi osoittautunut ja huomattavan paljon suuria kiihtyvyyksiä aiheuttanut konttaus. Sekä objektiivisen mittarin että tutkimustilanteen havaintojen perusteella konttaamisrata innosti lapsia erityisen rankkaan fyysiseen aktiivisuuteen. Tämän mahdollisti osaltaan radan melko lyhyt mitta. Toisaalta radan suorittamisen rivakkuuteen ei millään lailla ohjeistettu esimerkiksi kannustamalla ikätovereiden väliseen kilpailuun tai mittaamalla suoritusaikaa. Tavoitteena tehtävissä oli ylipäänsä se, että lapset voivat liikkua itselleen totutunlaisella ja mieluisalla tavalla. Lapset saivat suorittaa konttaamistehtävän niin omaehtoisesti kuin se tilanteessa oli ylipäänsä mahdollista. On mahdollista, että kiihtyvyysanturiin kohdistui konttaamisessa ylimääräistä heiluntaa ja tärähtelyä, mikäli esimerkiksi raajat osuivat suorituksen aikana mittariin. Toisaalta on huomattava, että tutkimusjoukko oli kooltaan kohtalainen (18 päiväkotilaista ja 11 koululaista), jolloin yksittäistapaukset eivät todennäköisesti riitä merkittävästi vinouttamaan ryhmien keskiarvoja.

Yksilötehtäviin käytetyn ajan hajonnat erosivat huomattavasti päiväkotilaisten ja koululaisten välillä. Tämä kertonee osaksi siitä, että yksilötehtävien suorittamiseen vaadittavat motoriset taidot olivat koululaisilla melko hyvin hallinnassa. Toisaalta päiväkotilaisten huomattavasti suurempi hajonta käytetyssä ajassa viitannee siihen, että tehtävistä suoriutumiseen vaadittavat taidot ja toiminnan säätely olivat vielä usealla kehittymässä, jolloin yksilöiden väliset erotkin olivat suuremmat (Jaakkola 2010, 104). Tämä havainto tukee olettamusta siitä, että liikkumisen perustaitojen kypsä taso saavutetaan keskimäärin vasta kouluiän kynnyksellä (Gallahue & Ozmun 2002, 182).

Tutkimukseen sisältyy muutamia rajoittavia tekijöitä. Tutkimuksessa lapsille ohjeistettujen yksilötehtävien kestot olivat osin sen verran lyhyitä, että se aiheutti counts-analyysin intensiteetin luokittelussa epätarkkuutta. Counts-analyysissä käytettiin intensiteettiluokan määrittämiseen 15 sekunnin tarkasteluväliä. Joissain tapauksissa tehtävään käytetty viimeinen tarkasteluväli kuitenkin kesti todellisuudessa alle 15 sekuntia. Tästä johtuen counts-analyysin intensiteettiluokkien yhteenlaskettu suhteellinen osuus käytetystä ajasta ylitti joissain tapauksissa 100 prosenttia. Toistettavuuden näkökulmasta suoritusten kesto ei toisaalta voi olla kovin pitkä, sillä lasten liikkuminen ja leikkiminen on luonnostaan pyrähdyksenomaista ja lyhytkestoista (Bailey ym. 1995). On lisäksi syytä huomata, että leikkien ja yksilöliikkumisen kokonaiskesto voi tosielämässä erota tässä tutkimuksessa niihin käytetystä ajasta. Oletettavasti lapsille tyypillisten ja tuttujen liikkumismuotojen intensiteetti voi muuttua, mitä kauemmin niitä yhtäjaksoisesti jatketaan. Tällöin kiihtyvyysanturin määrittelemä fyysisen aktiivisuuden keskimääräinen intensiteetti voi erota tämän tutkimuksen tuloksissa raportoiduista arvoista.

Kirjoittajien tiedossa ei ole aiemmin julkaistuja tutkimusartikkeleita, jotka olisivat keskittyneet selvittämään lapsille tyypillisten liikuntamuotojen intensiteettiä objektiivisesti mittaamalla. Fyysisen aktiivisuuden objektiivinen mittaaminen lapsilla on yleistyvä trendi, jonka pohjalta saadaan luotettavaa tietoa kokonaisaktiivisuudesta ja sen intensiteetistä. Tämän tutkimuksen tulokset viittaavat siihen, että kiihtyvyysanturi rekisteröi eräät motorisen kehityksen kannalta tärkeät liikkumismuodot intensiteetiltään kevyeksi tai jopa erittäin kevyeksi. Tämä johtuu kyseisten liikemuotojen vähäisestä liikemäärästä ja alhaisesta liikeintensiteetistä, vaikka niissä kuormitettaisiinkin esimerkiksi kehon hermolihasjärjestelmää huomattavasti. Intensiteetiltään rauhallisen liikkumisen ja leikkimisen rooli tulisikin tarkoin huomioida, kun tutkitaan lasten fyysistä aktiivisuutta ja sen yhteyksiä motorisen perustaitojen kehitykseen. Liikuntaviestinnässä, kuten liikuntasuosituksissa, olisi tulevaisuudessa suotavaa tuoda esiin entistä konkreettisemmin ja perustellummin liikkumisen erilaisia merkityksiä lapsen kehityksen kannalta. Reipas liikunta on tutkitusti yhteydessä terveyteen ja motorisiin perustaitoihin ja lisäksi kiihtyvyysanturien rauhalliseksi rekisteröimällä liikkumisella on oma tärkeä roolinsa motorisessa kehityksessä.

Fyysisen aktiivisuuden laskevan trendin myötä riittävien liikkumisen perustaitojen hankkiminen lapsuudessa voi muuttua aiempaa haastavammaksi. Jatkotutkimuksissa tulisikin keskittyä aiempaa tarkemmin siihen, millaista nykylasten fyysinen aktiivisuus on määrän lisäksi laadultaan. Sekä määrää että laatua tarkastelemalla voitaisiin kartoittaa monipuolisesti motoristen perustaitojen kehityksen kannalta suotuisia kehityspolkuja. Suotuisten kehityspolkujen esimerkit ja mallit antaisivat tärkeitä työkaluja sekä interventiotutkimusten suunnittelulle että käytännön kenttätyötä tekeville liikuntakasvattajille ja -vaikuttajille.

Kirjoittajat haluavat kiittää Piia Haakanaa, Martti Meliniä sekä Aarni Kimmoa tutkimuksen kenttämittausten yhteydessä saamastaan avusta.

LÄHTEET

Australia's Physical Activity Recommendations for 5–12 Year olds. 2005. Australian Government Department of Health and Ageing. www.health.gov.au/internet/main/publishing.nsf/content/health-pubhlth-strateg-phys-act-guidelines (Viitattu 11.4.2013)

Ayres, A.J. 2008. Aistimusten aallokossa. Sensorisen integraation häiriö ja terapia. Jyväskylä: PS-kustannus.

Bailey, R.C., Olson, J., Pepper, S.L., Porszasz, J., Barstow, T.J. & Cooper, D.M. 1995. The level and tempo of children's physical activities: and observational study. Medicine & Science in Sports & Exercise 27 (7), 1033–1041.

Barnett, L.M., Van Beurden, E., Morgan, P.J., Brooks, L.O. & Beard, J.R. 2009. Childhood motor skill proficiency as a predictor of adolescent physical activity. The Journal of Adolescent Health: Official Publication of the Society for Adolescent Medicine 44 (3), 252–259.

D'Hondt, E., Deforche, B., Gentier, I., De Bourdeaudhuij, I., Vaeyens, R., Philippaerts, R. & Lenoir M. 2012. A longitudinal analysis of gross motor coordination in overweight and obese children versus normal-weight peers. International Journal of Obesity 37 (1), 61–67.

Fisher, A., Reilly, J.J., Kelly, L.A., Montgomery, C., Williamson, A., Paton, J.Y. & Grant, S. 2005. Fundamental movement skills and habitual physical activity in young children. Medicine and Science in Sports and Exercise 37 (4), 684–688.

Fyysisen aktiivisuuden suositus kouluikäisille 7–18-vuotiaille. 2008. Helsinki: Opetusministeriö ja Nuori Suomi ry.

Gallahue, D. &Ozmun, J. C. 2002.Understanding motor development: infants, children, adolescents, adults. (5th ed.) Boston: McGraw-Hill.

Hands, B., Larkin, D., Parker, H., Straker, L. & Perry, M. 2009. The relationship among physical activity, motor competence and health-related fitness in 14-year-old adolescents. Scandinavian Journal of Medicine & Science in Sports 19 (5), 655–63.

Jaakkola, T. 2010. Liikuntataitojen oppiminen ja taitoharjoittelu. Jyväskylä: PS-kustannus.

Kansallinen liikuntatutkimus 2009–2010. 2010. Helsinki: Opetus- ja kulttuuriministeriö.

Kantomaa, M.T., Stamatakis, E., Kankaanpaa, A., Kaakinen, M., Rodriguez, A., Taanila, A., Ahonen, T., Jarvelin, M.R. & Tammelin, T. 2013. Physical activity and obesity mediate the association between childhood motor function and adolescents' academic achievement. Proceedings of the National Academy of Sciences of the United States of America 110 (5), 1917–1922

Kauranen, K. 2011. Motoriikan säätely ja motorinen oppiminen. Helsinki: Liikuntatieteellisen seuran julkaisuja nro 167.

Lopes, V.P., Rodrigues, L.P., Maia, J.A.R. & Malina, R.M. 2011. Motor coordination as predictor of physical activity in childhood. Scandinavian Journal of Medicine & Science in Sports 21 (5), 663–9.

Malina, R., Bouchard, C. & Bar-Or, O. 2004. Growth, maturation and physical activity. Growth, maturation and physical activity (2nd ed.) Champaign, IL.: Human Kinetics

Mikkonen, M. & Juutinen, T. 2012. Vipinää pieniinkin kinttuihin.Viitattu 4.9.2013. www.wikiliikkuja.com.

Nupponen, H., Halme, T., Parkkisenniemi, S., Pehkonen, M. & Tammelin, T. 2010. LAPS SUOMEN -tutkimus. 3–12-vuotiaiden lasten liikunta-aktiivisuus. Yhteenveto vuosien 2001–2003 menetelmistä ja tuloksista. Liikunnan ja kansanterveyden julkaisuja 239. Liikunnan ja kansanterveyden edistämissäätiö LIKES.

Okely, A.D., Booth, M.L. & Chey, T. 2004. Relationships between body composition and fundamental movement skills among children and adolescents. Research quarterly for exercise and sport 75 (3), 238–247.

Physical Activity for Children: A Statement of Guidelines for Children Ages 5–12, second edition. 2004. National Association for Sport and Physical Education, NASPE.http://www.aahperd.org/naspe/standards/nationalGuidelines/PA-Children-5–12.cfm (Viitattu 11.4.2013).

Soini, A., Kettunen, T., Mehtälä, A., Sääkslahti, A., Tammelin, T., Villberg, J. & Poskiparta, M. 2012. Kolmevuotiaiden päiväkotilasten mitattu fyysinen aktiivisuus. Liikunta ja Tiede 49 (1), 2–8.

Sääkslahti, A., Numminen, P., Varstala, A., Helenius, H., Tammi, A., Viikari, J. & Välimäki, I. 2004. Physical activity as a preventive measure for coronary heart disease risk factors in early childhood. Scandinavian Journal of Medicine and Science in Sports 14 (3), 143–149.

Timmons, B.W., Leblanc, A.G., Carson, V., Gorber, S.C., Dillman, C., Janssen, I., Kho, M.E., Spence, J.C., Stearns, J.A. & Tremblay, M.S. 2012. Systematic review of physical activity and health in the early years (aged 0–4 years). Applied Physiological Nutrition and Metabolism 37 (4), 773–792.

UK physical activity guidelines for children and young people 5–18 years. 2011. UK Government. Department of Health.https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/135115/dh_128144.pdf.pdf(Viitattu 11.4.2013)

Van Cauwenberghe, E., Labarque, V., Trost, S.G., De Bourdeaudhuij, I. &Cardon, G. 2011. Calibration and comparison of accelerometer cut points in preschool children. International Journal of Pediatric Obesity 15 (6), e582–9.

Varhaiskasvatuksen liikunnan suositukset. 2005. Helsinki: Sosiaali- ja terveysministeriön oppaita 17, Yliopistopaino Oy.

Westendorp, M., Hartman, E., Houwen, S., Smith, J. & Visscher, C.. 2011. The relationship between gross motor skills and academic achievement in children with learning disabilities. Research in developmental disabilities 32 (6), 2773–9.

Williams, H.G., Pfeiffer, K.A., O'Neill, J.R., Dowda, M., McIver, K.L., Brown, W.H. & Pate, R.R. 2008. Motor skill performance and physical activity in preschool children. Obesity 16 (6), 1421–6.

Wolf, G. 2007. Attention and motor skill learning. Champaign, IL: Human Kinetics.

Wrotniak, B.H., Epstein, L.H., Dorn, J.M., Jones, K.E. & Kondilis, V.A. 2006: The relationship between motor proficiency and physical activity in children. Pediatrics 118 (6), e1758–65.

II

RELATIONSHIP BETWEEN HABITUAL PHYSICAL ACTIVITY AND GROSS MOTOR SKILLS IS MULTIFACETED IN 5- TO 8-YEAR-OLD CHILDREN

by

Laukkanen, A., Pesola, A., Havu, M., Sääkslahti, A. & Finni, T. 2014

Scandinavian Journal of Medicine & Science in Sports 24 (2), e102-e110

Scand J Med Sci Sports 2014: 24: e102–e110
doi: 10.1111/sms.12116

SCANDINAVIAN JOURNAL OF
MEDICINE & SCIENCE
IN SPORTS

Relationship between habitual physical activity and gross motor skills is multifaceted in 5- to 8-year-old children

A. Laukkanen[1], A. Pesola[1], M. Havu[1], A. Sääkslahti[2], T. Finni[1]

[1]*Neuromuscular Research Center, Department of Biology of Physical Activity, University of Jyväskylä, Jyväskylä, Finland,*
[2]*Department of Sport Sciences, University of Jyväskylä, Jyväskylä, Finland*
Corresponding author: Arto Laukkanen, MSc/PhD student, Department of Biology of Physical Activity, University of Jyväskylä, 40014 University of Jyväskylä, Finland. Tel: +358 40 6846255, Fax: +35814617423, E-mail: arto.i.laukkanen@jyu.fi

Accepted for publication 27 July 2013

Adequate motor skills are essential for children participating in age-related physical activities, and gross motor skills may play an important role for maintaining sufficient level of physical activity (PA) during life course. The purpose of this study was to examine the relationship between gross motor skills and PA in children when PA was analyzed by both metabolic- and neuromuscular-based methods. Gross motor skills (KTK – Körperkoordinationstest für Kinder and APM inventory – manipulative skill test) of 84 children aged 5–8 years (53 preschoolers, 28 girls; 31 primary schoolers, 18 girls) were measured, and accelerometer-derived PA was analyzed using in parallel metabolic counts and neuromuscular impact methods. The gross motor skills were associated with moderate-to-high neuromuscular impacts, PA of vigorous metabolic intensity, and mean level of PA in primary school girls ($0.5 < r < 0.7$, $P < 0.05$), and with high impacts in preschool girls ($0.3 < r < 0.5$, $P < 0.05$). In preschool boys, moderate impacts, light-to-vigorous PA, and mean level of PA were associated with gross motor skills ($0.4 < r < 0.7$, $P < 0.05$). In conclusion, the result emphasizes an important relationship between gross motor skills and PA stressing both metabolic and neuromuscular systems in children. Furthermore, PA highly stressing neuromuscular system interacts with gross motor proficiency in girls especially.

The acquisition of adequate motor skills is an essential developmental task in childhood. Exploration of the environment and new tasks require a wide scale of gross and fine motor skills (Shumway-Cook & Woollacott, 2012), and delays in the development of motor skills have been linked to lower perceived physical competence (Robinson, 2011) and weaker academic achievement (Kantomaa et al., 2013). Also, motor skills have been associated to health-related measures such as body mass index (BMI) and waist circumference (Okely et al., 2004; D'Hondt et al., 2011; Lopes et al., 2012b), and fitness (Hands et al., 2009).

In previous studies, the total amount of physical activity (PA) and moderate-to-vigorous PA (MVPA) have typically correlated positively and sedentariness negatively with the level of gross motor skills in children (Fisher et al., 2005; Wrotniak et al., 2006; Williams et al., 2008; Burgi et al., 2011). In longitudinal designs, the level of gross motor skills has weakly or moderately predicted relationship with the level of PA (Barnett et al., 2009; Lopes et al., 2011). In these previous studies, examining the relationship between objectively measured habitual PA and gross motor skills in children, PA has been primarily assessed by metabolic basis. This is due to the fact that the accelerometer data have been categorized into different PA intensities using counts cutoff points typically defined on the basis of energy consumption (Evenson et al., 2008).

A major contributor to the enhancement of motor performance, fitness, as well as proficiency of gross motor skills, is the ongoing neuromuscular development. Neuromuscular development refers to the maturation of both neural and muscular systems and includes the integration of these systems (Kellis & Hatzitaki, 2012, p. 50). The neuromuscular efficiency is expressed as greater force production, which along with other domains of growth and maturation, can be seen as an essential prerequisite for skill acquisition (Haywood & Getchell, 2009). Therefore, the assessment of PA in relation to gross motor development should take into consideration the amount and quality of neuromuscular loading, i.e., forces acting on the body.

The neuromuscular loading can be examined via real-time assessment of acceleration forces caused by bodily movements. The use of real–time-based accelerometer signal has been previously recommended for bone studies in children (Rowlands, 2007) and it could be considered to supplement the typical metabolic-based analysis of habitual PA also in studies regarding the relations between PA and gross motor skills in children. This is especially important because habitual PA in children is known to be transitory in nature (Baquet et al., 2007), and about 95% of PAs last less than 15 s (Bailey et al., 1995).

Consequently, we hypothesized the parallel analysis of both metabolic and neuromuscular loading of PA would enable more comprehensive evaluation of the association between gross motor skills and habitual PA in children. Therefore, the purpose of this study was to examine the relationship between habitual PA and gross motor skills in 5–8-year-old children when the accelerometer signal was processed by both (a) metabolic counts and (b) neuromuscular impact-based methods.

Materials and methods

This report utilizes midline measurements from a parallel group randomized controlled intervention trial (ISRCTN28668090; Finni et al., 2011) examining daily PA and motor skills in children. PA level was assessed during 6 days using three-dimensional (3-D) accelerometer measurements, and gross motor skills were tested using KTK, Körperkoordinationstest für Kinder (Kiphard & Schilling, 2007), and the modified APM inventory, manipulative skill test (Numminen, 1995). An ethics approval for the project was received from the Ethics Committee of the Central Finland Health Care District.

Subjects

An invitation to participate to the study was sent to parents of 601 children who were attending all-day day care in 22 kindergartens and to parents of 454 primary schoolers attending nine different primary schools between April 2011 and April 2012. A total of 103 children (66 preschoolers of 19 kindergartens and 37 primary schoolers of eight primary schools) and their parents accepted the invitation. Ninety-five children participated in the midline measurements. Of them 11 children were excluded because of missing PA measurement (2), refusing to take part to the gross motor skill tests (1), no required PA data from weekday or weekend days (6), and the age of under 5 years (2). In the end, the study group ($n = 84$) consisted of 28 preschool girls (age 5.95 ± 0.47 years) and 25 preschool boys (5.92 ± 0.45 years), and 18 first-grade girls (8.06 ± 0.15 years) and 13 first-grade boys (7.93 ± 0.34 years).

Anthropometry

In the laboratory, height and body weight were measured and BMI (kg/m^2) was calculated for each subject. Approximately 11% of the sample was found overweight on the basis of international cutoff points (Cole, 2000).

PA

PA was measured for an average of 5.47 days (11.60 ± 0.91 h/d) in preschoolers and 5.35 days (12.42 ± 1.28 h/d) in primary schoolers using triaxial X6-1a accelerometers with a dynamic range of $\pm 6\ g$ (Gulf Coast Data Concepts Inc, Waveland, MS, USA). Subjects with recordings longer than 500 min on at least 3 days (2 weekdays and 1 weekend day) were accepted for further analysis (Penpraze et al., 2006). On average 3.72 (11.72 ± 1.10 h/d) and 3.68 (12.57 ± 0.85 h/d) of measured days were weekdays, and 1.75 (11.45 ± 1.06 h/d) and 1.74 (11.53 ± 1.41 h/d) weekend days in preschoolers and primary schoolers, respectively. The device was carried on the anterior waistline in a firmly worn adjustable elastic belt during waking hours, with the exception of water-based activities and bathing. Verbal and written instructions for accelerometry measurement in children were given individually to parents and teachers at the kindergarten.

Motor skills

Gross motor skills were tested in the laboratory, in kindergarten, or at primary school depending on which suited the children and their parents the best. In each case, the testing circumstances were set as similar as possible regarding distractions, floor material, space, and equipment needed in the measurement. Children were tested alone or in small groups of two or three children, and the tasks were performed one child at a time. An oral instruction and a model performance were given for every task, and the tasks were performed in the same order for every child. The same trained researcher (A. L.) assessed all the tests. A pilot study for testing gross motor skills by this protocol was conducted in preschoolers ($n = 7$), separate to this study group. In the pilot, testing sessions were videotaped and analyzed afterward for appropriate arrangement and assessment practices with two senior researchers in the field.

From the KTK test battery, the children performed all the four items:

1. Walking backwards (WB) on balance beams (length 3 m; height 5 cm) with different widths of 6.0, 4.5, and 3.0 cm, starting from the widest one. A maximum test score possible was 72 steps, which accumulated from three trials per each beam, and a maximum of eight successful steps for each trial.
2. Hopping for height (HH), one foot at a time, over an increasing pile of soft mattresses (width 60 cm; depth 20 cm; height 5 cm each). The first, second, or third trial of each height was awarded by three, two, or one point(s), respectively. A maximum test score was 39 points (ground level + 12 mattresses) for each leg, summed to the maximum of 78 points with both legs.
3. Jumping sideways (JS) from side to side over a thin wooden lath ($60 \times 4 \times 2$ cm) on the jumping base (100×60 cm). Two trials of 15 s were performed and a total of successful jumps were summed.
4. Moving sideways (MS). The children had two identical wooden plates (size 25×25 cm; height 5.7 cm) and after stepping to one, they had to transfer another one sideways for the next transition. The total of transitions was summed over two 20-s trials. Transitions were performed to the same direction on both trials.

The reliability of the KTK has been shown to be high (Kiphard & Schilling, 2007). The raw test scores of the KTK test items were transformed into gender- and age-standardized values and into a measure indicating overall gross motor coordination (MC) according to the KTK manual. The MC is classified as follows: "not possible" (values under 56), "severe motor disorder" (values 56–70), "moderate motor disorder" (values 71–85), "normal" (86–115), "good" (116–130), and "high" (131–145).

In addition, manipulative skills were measured by underarm throw and catch a ball (TCB) test of an APM inventory. APM inventory has been validated in 1800 Finnish children of 1–7 years of age and shown to be highly reliable (Numminen, 1995). In TCB for preschoolers, a softball (circumference 65.4 cm; weight 228 g) was thrown underarm 10 times to a target (10-cm wide piece of distinguishable tape) at a height of 1.30 m on the wall from a distance of 2 m and caught after a bounce on the floor. TCB was modified for primary schoolers so that it was performed in two separate parts with a higher degree of difficulty. In the first part, the ball was thrown 10 times from a distance of 3 m and caught after a bounce on the floor. Additionally, hits that rose over the marked upper limit of a height of 2 m on the wall were failed. In the second part, the ball was thrown 10 times from a distance of 3 m and caught without a bounce on the floor. No marked upper limit on the wall existed on the second part. The number of catches (maximum of 10 in preschoolers and 20 in primary schoolers) was summed (marked as TCB_raw). Finally, the TCB_raw was transformed into age-standardized value (TCB) by the averaged sum scores of the age groups (5-, 6-, and 7–8-year-olds) in this study sample. Performing the KTK and TCB took approximately 20–30 min per child.

Data analysis

A resultant vector $(x^2 + y^2 + z^2)^{0.5}$ of the 3-D accelerometer signal was composed, band-pass filtered (0.25–11 Hz), and values below 0.05 *g* were threshold filtered. All these phases of analysis are similar as in typical Actigraph analysis. The neuromuscular loading of PA was assessed via real-time g-force impacts that were recorded up to 6 *g*. The percentage of measurement time and accumulated minutes per day spent at different g-force impact categories were analyzed in the intervals as follows: 0–0.05, 0.05–0.2, 0.2–0.4, . . . , 5.6–5.8, and 5.8–6.0 *g*. For assessing the metabolic loading, PA counts were calculated by summing over 15-s epochs and multiplying by a device-specific factor that was derived from simultaneous recordings with the X6-1a and ActiGraph GT3X (Actigraph LCC, Pensacola, FL, USA) in three children during normal daily living. Additionally, mean counts per minute (CPM) values, referring to the mean level of PA, were calculated.

In this study, the time spent at counts intensity categories was analyzed using the following cutoff points: sedentary, under 373; light, 373–585; moderate, 585–881; and vigorous, over 881 (Van Cauwenberghe et al., 2011). While Van Cauwenberghe et al. used uniaxial accelerometer and in the present study a triaxial device was used, there is an agreement between uniaxial and triaxial accelerometers to classify PA into intensity categories in children (Robusto & Trost, 2012).

Non-wearing time was defined as 20 min or longer continuous zero signal and was cut out. In addition, midday nap time was cut out from further analysis in children attending kindergarten. Nap times were marked to the diary by the kindergarten teachers.

Statistical analysis

All analyses were conducted separately for both sexes in preschoolers and primary schoolers in the Statistical Package for the Social Sciences (SPSS) Statistics software (IBM SPSS Statistics 20, SPSS Finland, Espoo, Finland). Descriptives of PA analyzed by neuromuscular- and metabolic-based methods include means and standard deviations of percentage of measurement time and minutes per day spent at different categories. Moreover, means, standard deviations, and ranges of age, height, weight, BMI, and gross motor skill test scores were calculated. The skewed distributions in percentage of time spent at g-force impact categories in preschool girls and boys, and primary school boys were logarithmically transformed. Independent samples *t*-tests were used to examine the differences between boys and girls, and differences between preschoolers and primary schoolers in PA analyzed by neuromuscular- and metabolic-based methods and in anthropometrics and gross motor skill scores. Partial correlation coefficients were calculated between the time spent at g-force impact categories and standardized gross motor skills values and MC, and between the time spent at counts intensity categories and standardized gross motor skill scores and MC. The effect of BMI and age was controlled in all correlational analyses. Because all participants did not display accelerations up to 6 *g*, the correlations were done only up to the g-force category in which every subject within given group had data. Consequently, the upper boundary for g-forces was set to 5.6 *g* in preschool girls, 5.4 *g* in preschool boys, and 6 *g* in primary schoolers. Level of significance was set to $P < 0.05$.

Results

Descriptives for PA analyzed by neuromuscular-based g-force impact method are summarized in Table 1 and by metabolic-based counts intensity method in Table 2. Boys accumulated more time than girls at g-force impact categories ($2.48 < t < 3.64$, $P < 0.05$) and less time at zero g-force (primary schoolers, $t = 2.31$, $P < 0.05$). Similarly, boys spent more time at counts intensity categories ($2.26 < t < 3.33$, $P < 0.05$) and less time at sedentary ($2.79 < t < 2.92$, $P < 0.01$). In general, primary schoolers spent more time at g-force impact categories ($2.15 < t < 3.38$, $P < 0.05$) and counts intensity categories ($2.06 < t < 3.48$, $P < 0.05$) and were less sedentary ($t = 3.09$, $P < 0.01$) than preschoolers. Additionally, mean CPM values, referring to the mean level of PA, were higher among primary schoolers (652 ± 200/min; $t = 3.20$, $P < 0.01$) than preschoolers (532 ± 142/min). The mean CPM was higher in primary school boys (boys: 742 ± 225/min; $t = 2.27$, $P < 0.5$) compared with primary school girls (587 ± 156/min), but no significant difference was found between sexes in preschoolers (girls: 502 ± 115/min; boys: 567 ± 162/min).

As expected, primary schoolers on average were heavier and taller than preschoolers, but there was no difference in BMI (Table 3). No significant sex differences were found in age, height, weight, or BMI in preschoolers or primary schoolers. Gross motor skills were identified both in preschoolers and primary schoolers as normally developed (scores between 86 and 115), and in primary school boys as well developed in JS and MS (scores between 116 and 130) on the basis of KTK classification. In general, primary schoolers performed significantly better in WB, HH, JS and MS, and in MC than preschoolers, regardless of age standardization. Further, preschool boys performed better than preschool girls in MC ($t = 2.44$, $P < 0.05$), HH ($t = 3.22$, $P < 0.01$), and JS ($t = 2.59$, $P < 0.05$). Similarly, primary

Table 1. Percentage of physical activity measurement time (mean ± standard deviation) and accumulated minutes spent per day (mean in parenthesis) in neuromuscular impact-based g-force categories

G-force impact category (*g*)	Preschoolers (5–6-year-olds)		Primary schoolers (7–8-year-olds)	
	Girls (*n* = 28)	Boys (*n* = 25)	Girls (*n* = 18)	Boys (*n* = 13)
0	89.86 ± 1.66 (621.05)	89.27 ± 1.55 (627.50)	89.66 ± 1.92 (658.84)*	88.01 ± 1.94 (672.55)
0.05–0.20	6.73 ± 1.00 (46.39)	6.80 ± 0.87 (47.80)	6.46 ± 1.06 (47.39)	6.94 ± 0.93 (52.78)
0.2–0.4	1.90 ± 0.35 (13.11)*	2.16 ± 0.40 (15.20)††	2.19 ± 0.51 (16.06)*	2.64 ± 0.49 (19.80)
0.4–0.6	0.69 ± 0.16 (4.78)*	0.82 ± 0.18 (5.76)†	0.79 ± 0.24 (5.82)**	1.09 ± 0.29 (8.12)
0.6–0.8	0.32 ± 0.09 (2.18)	0.36 ± 0.10 (2.57)	0.33 ± 0.12 (2.41)**	0.49 ± 0.15 (3.60)
0.8–1.0	0.17 ± 0.06 (1.19)	0.19 ± 0.06 (1.37)	0.17 ± 0.05 (1.26)**	0.25 ± 0.09 (1.87)
1–2	0.30 ± 0.20 (1.86)	0.30 ± 0.20 (2.26)	0.30 ± 0.11 (2.22)*	0.43 ± 0.19 (3.16)
2–3	0.05 ± 0.02 (0.33)	0.06 ± 0.06 (0.45)†	0.07 ± 0.04 (0.53)	0.10 ± 0.07 (0.72)
3–4	0.01 ± 0.01 (0.08)	0.16 ± 0.02 (0.12)†	0.02 ± 0.02 (0.15)	0.03 ± 0.03 (0.21)
4–5	0.00 ± 0.00 (0.03)	0.01 ± 0.01 (0.04)	0.01 ± 0.01 (0.05)	0.01 ± 0.01 (0.07)
5–6	0.00 ± 0.00 (0.01)	0.00 ± 0.00 (0.01)	0.00 ± 0.00 (0.01)	0.00 ± 0.00 (0.02)

Significant difference between sexes in percentage of measurement time in g-force categories *$P < 0.05$, **$P < 0.01$ and between preschool and primary schoolers †$P < 0.05$, ††$P < 0.01$.

Table 2. Percentage of physical activity measurement time (mean ± standard deviation) and accumulated minutes spent per day (mean in parenthesis) in metabolic counts intensity categories

Intensity category	Preschoolers (5–6-year-olds)		Primary schoolers (7–8-year-olds)	
	Girls (*n* = 28)	Boys (*n* = 25)	Girls (*n* = 18)	Boys (*n* = 13)
Sedentary	90.19 ± 2.60 (623.41)**	87.84 ± 3.52 (617.01)††	88.07 ± 3.48 (646.92)**	83.12 ± 4.76 (638.39)
Light	4.65 ± 1.05 (32.01)**	5.73 ± 1.33 (40.13)†	5.18 ± 1.46 (37.87)**	6.84 ± 1.38 (51.66)
Moderate	2.74 ± 0.82 (18.84)*	3.41 ± 1.05 (24.23)††	3.49 ± 1.06 (25.70)**	5.22 ± 1.74 (38.03)
Vigorous	2.44 ± 1.18 (16.92)	3.05 ± 1.93 (21.91)††	3.28 ± 1.45 (24.39)	4.85 ± 2.53 (34.98)

Significant difference between genders in percentage of measurement time in counts intensity categories *$P < 0.05$, **$P < 0.01$ and between preschoolers and primary schoolers †$P < 0.05$, ††$P < 0.01$.

Table 3. Means, standard deviations, and ranges (in parentheses) of age, height (in cm), weight (in kg), body mass index (BMI), standardized scores on the four items of the KTK, overall gross motor coordination according to the KTK, manipulative skill test raw score (TCB_raw), and standardized score (TCB)

Measures	Preschoolers (5–6-year-olds)		Primary schoolers (7–8-year-olds)	
	Girls (n = 28)	Boys (*n* = 25)	Girls (*n* = 18)	Boys (*n* = 13)
Age (years)	5.95 ± 0.47 (1.91)	5.92 ± 0.45 (1.63)	8.06 ± 0.51 (0.56)	7.93 ± 0.34 (1.04)
Height (cm)	115.41 ± 6.09 (28.10)	117.40 ± 4.97 (17.80)††	128.25 ± 5.85 (25.30)	127.83 ± 4.18 (16.10)
Weight (kg)	20.70 ± 2.72 (10.40)	21.69 ± 2.42 (8.80)††	25.49 ± 4.23 (12.40)	26.70 ± 3.56 (10.20)
BMI	15.49 ± 1.04 (4.29)	15.70 ± 0.89 (3.77)	15.47 ± 2.14 (8.31)	16.28 ± 1.45 (4.61)
WB	91.07 ± 14.27 (64)	86.0 ± 12.77 (48)†	102.22 ± 13.69 (46)**	86.2 ± 14.42 (53)
HH	92.93 ± 16.63 (85)**	108.04 ± 16.87 (55)††	108.56 ± 11.59 (43)	110.67 ± 7.63 (22)
JS	101.00 ± 13.83 (57)*	112.69 ± 18.63 (71)†	109.33 ± 15.95 (59)*	122.92 ± 11.66 (36)
MS	103.25 ± 14.12 (53)	108.81 ± 15.63 (60)†	110.67 ± 11.68 (40)	115.92 ± 15.35 (47)
MC	94.86 ± 13.52 (55)*	104.92 ± 16.69 (57)††	109.72 ± 13.83 (60)	111.42 ± 11.92 (39)
TCB_raw	5.61 ± 2.63 (10)	6.46 ± 3.01 (10)	13.17 ± 3.81 (15)	14.83 ± 4.15 (13)
TCB	0.92 ± 0.43 (1.63)	1.06 ± 0.49 (1.66)	0.95 ± 0.28 (1.09)	1.07 ± 0.30 (0.94)

Significant difference between sexes *$P < 0.05$, **$P < 0.01$ and between preschool and primary schoolers †$P < 0.05$, ††$P < 0.01$.
HH, hopping for height; JS, jumping sideways; KTK, KörperkoordinationsTest für Kinder; MC, overall gross motor coordination according to the KTK; MS, moving sideways; TCB, standardized value of the manipulative skill test score; TCB_raw, throwing and catching a ball manipulative skill test raw score; WB, walking backwards.

school boys were better than girls in JS ($t = 2.45$, $P < 0.05$), although girls outperformed boys in WB ($t = 3.24$, $P < 0.01$).

After controlling for BMI and age, correlations between gross motor skills and PA revealed multifaceted trends (Fig. 1). MC correlated with the time spent sustaining impacts between 0.6 and 1.2 *g* ($0.42 < r < 0.51$, $P < 0.05$) and with the time spent at PA of light ($r = 0.51$, $P < 0.05$) and moderate metabolic intensity ($r = 0.55$, $P < 0.01$), and negatively with sedentary time ($r = -0.52$, $P < 0.05$) in preschool boys. Additionally, mean CPM was associated with MC ($r = 0.45$, $P < 0.05$) in

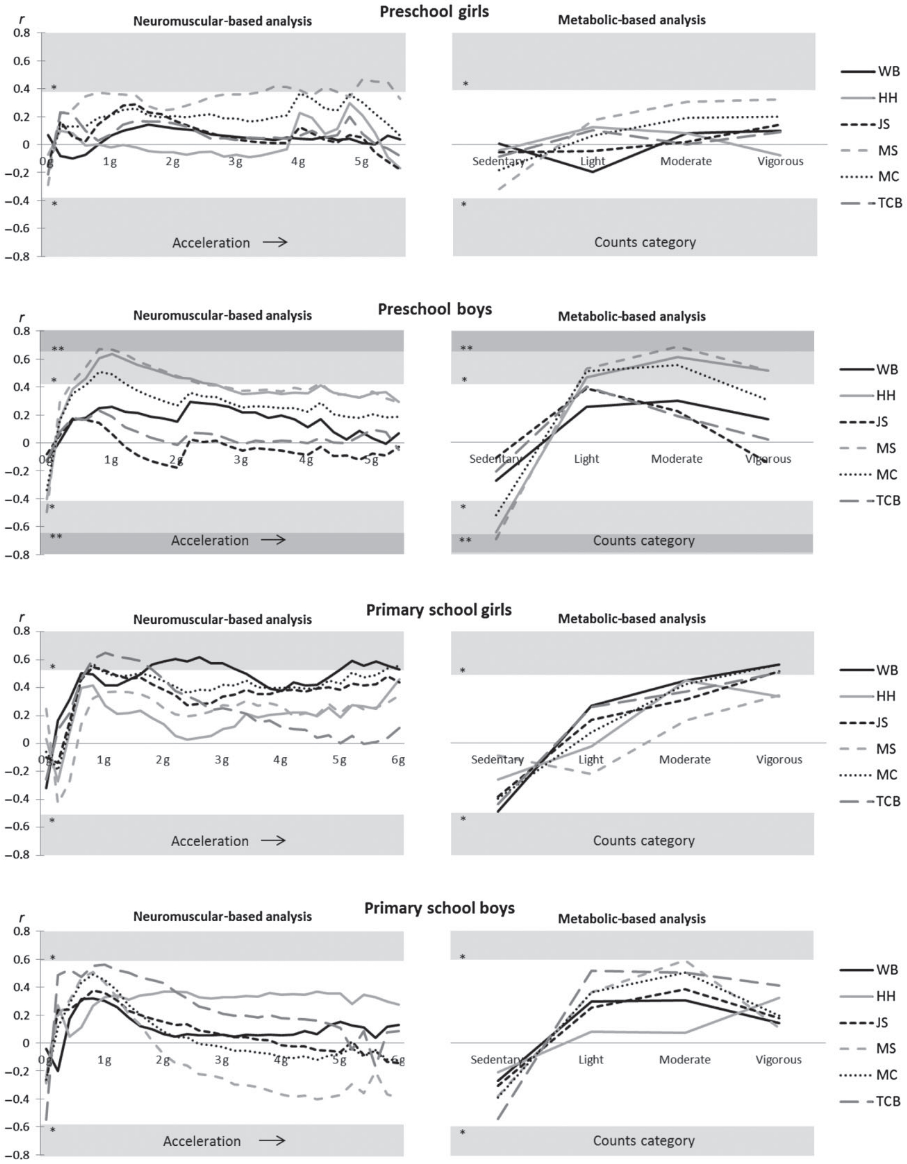


Fig. 1. Display of relations of gross motor skills and the time spent at neuromuscular impact-based g-force categories and metabolic-based counts intensity categories after controlling the effect of body mass index and age. The time spent at g-force categories and counts categories are plotted in the *x*-axis, and Pearson's correlation coefficients (two-tailed) in the *y*-axis. HH, hopping for height; JS, jumping sideways; KTK, Körperkoordinationstest für Kinder; MC, overall gross motor coordination according to the KTK; MS, moving sideways; TCB, throwing and catching a ball; WB, walking backwards. Significant correlation $*P < 0.05$ and $**P < 0.001$.

preschool boys. In primary school girls, MC was in association with the time spent at 0.6–1.0, 1.4–1.6, and 5.6–6.0 *g* impacts ($0.50 < r < 0.57$, $P < 0.05$) and with the time spent at vigorous intensity ($r = 0.56$, $P < 0.05$).

Of specific gross motor skill test items, MS correlated with the time spent sustaining impacts of 0.6–0.8 *g* ($r = 0.67$, $P < 0.001$), 0.2–0.6 *g*, and 0.8–2.4 *g* ($0.43 < r < 0.67$, $P < 0.05$), 0 *g* ($r = –0.50$, $P < 0.05$) and with the time spent at light ($r = 0.53$, $P < 0.05$), moderate ($r = 0.69$, $P < 0.001$), vigorous ($r = 0.52$, $P < 0.05$), and inversely with sedentary ($r = –0.69$, $P < 0.001$) categories in preschool boys (Fig. 1). HH correlated with the time spent sustaining impacts between 0.4 and 2.6 *g* ($0.41 < r < 0.64$, $P < 0.05$) and with the time spent at light ($r = 0.47$, $P < 0.05$), moderate ($r = –0.64$, $P < 0.001$), vigorous ($r = 0.51$, $P < 0.05$), and negatively with sedentary ($r = –0.65$, $P < 0.01$) categories in preschool boys. Both MS and HH were significantly in association with mean CPM ($0.60 < r < 0.66$, $P < 0.01$) in preschool boys.

In preschool girls, MS was associated with the time spent sustaining impacts of 3.4–4.0, 4.2–4.4, and 4.8–5.4 *g* ($0.39 < r < 0.47$, $P < 0.05$), but not with the time spent at any counts intensity category or with mean CPM. In primary school girls, TCB was associated with the time spent sustaining impacts of 0.8–1 *g* ($r = 0.65$, $P < 0.01$), WB with 1.6–3.4 and 4.8–6.0 *g* ($0.50 < r <$ 61, $P < 0.05$) and JS with 0.6–1.0 *g* ($0.52 < r < 0.55$, $P < 0.05$). TCB, WB, and JS correlated with vigorous-intensity category ($0.50 < r <$ 57, $P < 0.05$) and WB with mean CPM ($r = 0.52$, $P < 0.05$) in primary school girls. On the whole, in primary school boys, no significant association was found between gross motor skills and the PA analyzed by neuromuscular or metabolic methods, or between gross motor skills and mean CPM.

Discussion

This study indicated that gross motor skills are positively in association with habitual PA and negatively associated with sedentary time in 5–8-year-old children. However, the metabolic and neuromuscular methods, which were used in parallel for analyzing PA, present a novel insight for evaluating this relationship. In primary school girls the MC, referring to the overall gross MC, correlated significantly with moderate-to-high neuromuscular impacts and with PA of vigorous metabolic intensity. On the other hand, in preschool boys, MC correlated positively with the mean level of PA, moderate neuromuscular impacts, PA of light-to-moderate metabolic intensity, and negatively with sedentariness. In addition, there was a weak, but significant association between a gross motor skill and high neuromuscular impacts in preschool girls. These findings suggest that the gross motor skills are in relation to the mean level of PA in boys especially, but to high neuromuscular impacts in girls only.

The novel finding of the present study give support to the assumption that the tendency to perform activities inducing high neuromuscular impacts, i.e., forces, could significantly support the development of gross motor skills, and the limited capacity to perform movements of high neuromuscular impacts could mediate the lack of motor proficiency (Payne & Isaacs, 2007). Moreover, it has been shown that muscular strength could also attenuate the accumulation of subcutaneous adipose tissue during childhood (Lopes et al., 2012a). However, when interpreted the other way round, the limited capacity to perform movements of high neuromuscular impacts and to move vigorously could be caused by the lack of motor proficiency. This assumption is supported by a previous study (Chia et al., 2010) indicating the proficiency of gross motor skills to enable one to move with more easiness and for longer durations at a time because of lower perceived exertion of PA. Nevertheless, because of the cross-sectional design of the present study, the direction of the causality remains unknown.

The present results are in line with previous studies indicating the relationship between gross motor skills and the total amount of PA, MVPA, and sedentariness assessed on metabolic basis (e.g., Fisher et al., 2005; Wrotniak et al., 2006). On the other hand, the present study also revealed weak, but significant correlation between the PA of light metabolic intensity and gross motor skills in preschool boys. In general, the mean CPM of preschoolers at the present sample was substantially lower than previously reported in Dutch preschoolers (Cardon & De Bourdeaudhuij, 2008), and this fact could possibly explain the association between the light PA and gross motor skills. It could be that if the mean level of PA is low, even the increase of light PA could facilitate the development of gross motor skills in preschool-aged children.

The previous studies have reported stronger positive correlations among boys (Williams et al., 2008; Cliff et al., 2009) or no sex difference (Fisher et al., 2005; Wrotniak et al., 2006) when examining the relationship between gross motor skills and PA. Comparison between studies is difficult because of heterogeneity in methodologies used for assessing PA and gross motor abilities. The relationship is presumably also affected by multiple individual and environmental factors and therefore causing inconsistency between studies. For instance, perceived motor competence may play an important role when it comes to the relation between actual motor competence and PA (Barnett et al., 2008a; Stodden et al., 2008). In the present study, the varied correlations between gross motor skills and PA in girls could be an indication of more complex relationship between these factors. The finding gives support to the assumption that ongoing interaction between gross motor development and ability to perform greater force allows children to take part to physical activities typical to their developmental level (Haywood & Getchell, 2009). It is worth specifying in this connection that even though the motor performance has interrelationship with biological growth and maturation rate (Payne & Isaacs, 2007), it has been shown that the KTK, primarily used for assessing the gross motor proficiency at the present study, is not related to biological maturity (Vandendriessche et al., 2012).

When examining the relationship between gross motor skills and habitual PA in children, there are some potential advantages with the use of real-time acceleration forces for analyzing PA. The results revealed a weak, but significant relationship between the time spent at high g-forces and MS in preschool girls. The reason why only PA analyzed by neuromuscular-based method was associated with gross motor skills in some cases of this study may be the fact that real–time-based method is able to distinguish intermittent and short-term PA typical to children (Baquet et al., 2007). Moreover, although the relationship between gross motor skills and vigorous PA in primary school girls was revealed by the metabolic-based counts method, the significance of PA of high impacts in this relation was reinforced by neuromuscular method. Further, the selection of cutoff points and epoch time for analyzing accelerometer-derived PA may significantly affect the outcome of PA (Bornstein et al., 2011) and especially the amount of MVPA (Cliff & Okely, 2007), and thereby also the relationship between gross motor skills and PA. In contrast, the neuromuscular-based method as used in the present study examines the raw data in real time in a simple histogram style. Together, the two analysis methods can provide comprehensive interpretation of the amount and quality of objectively measured PA.

In this study, PA measurements were administered at different times of the year and seasonal differences in Finland may affect the total amount of PA (Sääkslahti, 2005), although the methodological comparisons presented remain unaffected. While the gross motor skills measured in this study encompass only a part of the spectrum of coordinative capabilities, both KTK and TCB have been used extensively for assessing gross motor skills in children (Iivonen et al., 2011; Vandorpe et al., 2011). Also, the sample used in the present study was limited. However, the purpose of the research was to examine the relations between habitual PA and gross motor skills in children from a neuromuscular perspective parallel to metabolic perspective, and further research is needed for generalizing the results found by this novel approach.

In conclusion, our study indicates that gross motor skills and accelerometer-derived PA are related in 5–8-year-old children. The result is in line with previous studies examining this relationship based on valid and reliable gross motor assessment and objective PA monitoring (Fisher et al., 2005; Wrotniak et al., 2006; Williams et al., 2008; Burgi et al., 2011). The novel neuromuscular-based accelerometer signal analysis method found significant relations between high neuromuscular impacts and gross motor skills in preschool and primary school girls. The results of the present study suggest that in addition to the mean level of PA, even short activities inducing high loads may be important for enhancing gross motor proficiency in children, and in girls especially.

Perspectives

The decline of habitual PA from childhood to adolescence requires understanding of factors attenuating this trend. Motor skills in children have been shown to play an important role in encouraging and enabling maintenance of PA (Barnett et al., 2009; Lopes et al., 2011) and health-related fitness level later in life (Barnett et al., 2008b). Adequate motor skills are needed for participating in age-related physical activities, and thereby forming a positive circle to healthy lifestyle (Stodden et al., 2008; Hands et al., 2009). The present data support the evidence of association between gross motor skills and habitual PA in children, and also give a novel insight of this relationship. In the light of gross motor development, girls could especially benefit from PA including high neuromuscular impacts, even if they were transitory in nature. The neuromuscular perspective of gross motor development should be considered when PA recommendations for children are given. By taking the features of motor development comprehensively into account, practitioners and educators can have more concrete foundation to support growth and maturation through physical education.

Key words: physical activity, motor abilities, motor skill assessment, young children, elementary school children, accelerometry.

Acknowledgements

This study was funded by the Finnish Ministry of Education and Culture. The first author (A. L.) would like to address special thanks to Juho Vainio foundation and Ellen and Artturi Nyyssönen foundation for personal funding for the research and publication work. The authors would also like to express their appreciation for Center for Scientific Computing Espoo, Finland, for ample computer resources.

References

Bailey RC, Olson J, Pepper SL, Porszasz J, Barstow TJ, Cooper DM. The level and tempo of children's physical activities: and observational study. Med Sci Sports Exerc 1995: 27: 1033–1041.

Baquet G, Stratton G, Van Praagh E, Berthoin S. Improving physical activity assessment in prepubertal children with high-frequency accelerometry monitoring: a methodological issue. Prev Med 2007: 44: 143–147.

Barnett LM, Morgan P, Van Beurden E, Beard JR. Perceived sports competence mediates the relationship between childhood motor skill proficiency and adolescent physical activity and fitness: a longitudinal assessment. Int J Behav Nutr Phys Act 2008a: 5: 40.

Barnett LM, Van Beurden E, Morgan PJ, Brooks LO, Beard JR. Does childhood motor skill proficiency predict adolescent fitness? Med Sci Sports Exerc 2008b: 40: 2137–2144.

Barnett LM, Van Beurden E, Morgan PJ, Brooks LO, Beard JR. Childhood motor skill proficiency as a predictor of adolescent physical activity. J Adolesc Health 2009: 44: 252–259.

Bornstein DB, Beets MW, Byun W, McIver K. Accelerometer-derived physical activity levels of preschoolers: a meta-analysis. J Sci Med Sport 2011: 14: 504–511.

Burgi F, Meyer U, Granacher U, Schindler C, Marques-Vidal P, Kriemler S, Puder JJ, Bürgi F. Relationship of physical activity with motor skills, aerobic fitness and body fat in preschool children: a cross-sectional and longitudinal study (Ballabeina). Int J Obes 2011: 35: 937–944.

Cardon GM, De Bourdeaudhuij IMM. Are preschool children active enough? Objectively measured physical activity levels. Res Q Exerc Sport 2008: 79: 326–332.

Chia LC, Guelfi KJ, Licari MK. A comparison of the oxygen cost of locomotion in children with and without developmental coordination disorder. Dev Med Child Neurol 2010: 52: 251–255.

Cliff DP, Okely AD. Comparison of two sets of accelerometer cut-off points for calculating moderate-to-vigorous physical activity in young children. J Phys Act Health 2007: 4: 509–513.

Cliff DP, Okely AD, Smith LM, McKeen K. Relationships between fundamental movement skills and objectively measured physical activity in preschool children. Pediatr Exerc Sci 2009: 21: 436–449.

Cole TJ. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000: 320: 1240–1240.

D'Hondt E, Deforche B, Vaeyens R, Vandorpe B, Vandendriessche J, Pion J, Philippaerts R, De Bourdeaudhuij I, Lenoir M. Gross motor coordination in relation to weight status and age in 5- to 12-year-old boys and girls: a cross-sectional study. Int J Pediatr Obes 2011: 6: e556–e564.

Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG. Calibration of two objective measures of physical activity for children. J Sports Sci 2008: 26: 1557–1565.

Finni T, Sääkslahti A, Laukkanen A, Pesola A, Sipilä S. A family based tailored counselling to increase non-exercise physical activity in adults with a sedentary job and physical activity in their young children: design and methods of a year-long randomized controlled trial. BMC Public Health 2011: 11: 1–8.

Fisher A, Reilly JJ, Kelly L, Montgomery C, Williamson A, Paton JY, Grant S. Fundamental movement skills and habitual physical activity in young children. Med Sci Sports Exerc 2005: 37: 684–688.

Hands B, Larkin D, Parker H, Straker L, Perry M. The relationship among physical activity, motor competence and health-related fitness in 14-year-old adolescents. Scand J Med Sci Sports 2009: 19: 655–663.

Haywood K, Getchell N. Life span motor development. 5th edn. Champaign, IL: Human Kinetics, 2009.

Iivonen S, Sääkslahti A, Nissinen K. The development of fundamental motor skills of four- to five-year-old preschool children and the effects of a preschool physical education curriculum. Early Child Dev Care 2011: 181: 335–343.

Kantomaa MT, Stamatakis E, Kankaanpaa A, Kaakinen M, Rodriguez A, Taanila A, Ahonen T, Jarvelin MR, Tammelin T, Kankaanpää A, Järvelin M-R. Physical activity and obesity mediate the association between childhood motor function and adolescents' academic achievement. Proc Natl Acad Sci U S A 2013: 110: 1917–1922.

Kellis E, Hatzitaki V. Development of neuromuscular coordination with implications in motor control. In: De Ste Croix M, Korff T, eds. Paediatric biomechanics and motor control. Theory and application. Abingdon, Oxon: Routledge, 2012: 50–69.

Kiphard E, Schilling F. Körperkoordinationtest für Kinder. 2. Überarbeitete und ergänzte Auflage. Weinheim: Beltz Test GmbH, 2007.

Lopes VP, Rodrigues LP, Maia JAR, Malina RM. Motor coordination as predictor of physical activity in childhood. Scand J Med Sci Sports 2011: 21: 663–669.

Lopes VP, Maia JAR, Rodrigues LP, Malina RM. Motor coordination, physical activity and fitness as predictors of longitudinal change in adiposity during childhood. Eur J Sport Sci 2012a: 12: 384–391.

Lopes VP, Stodden DF, Bianchi MM, Maia JAR, Rodrigues LP. Correlation between BMI and motor coordination in children. J Sci Med Sport 2012b: 15: 38–43.

Numminen P. APM inventory: manual and test booklet for assessing pre-school childrens's perceptual and basic motor skills. Jyväskylä, Finland: LIKES, 1995.

Okely AD, Booth ML, Chey T. Relationships between body composition and fundamental movement skills among children and adolescents. Res Q Exerc Sport 2004: 75: 238–247.

Payne V, Isaacs L. Human motor development. A lifespan approach. 7th edn. McGraw-Hill, NY: McGraw-Hill Companies, Inc, 2007.

Penpraze V, Reilly JJ, Maclean CM, Montgomery C, Kelly LA, Paton JY, Aitchison T, Grant S. Monitoring of physical activity in young children: how much is enough. Pediatr Exerc Sci 2006: 18: 483–491.

Robinson LE. The relationship between perceived physical competence and fundamental motor skills in preschool children. Child Care Health Dev 2011: 37: 589–596.

Robusto KM, Trost SG. Comparison of three generations of ActiGraph™ activity monitors in children and adolescents. J Sports Sci 2012: 30: 1429–1435.

Rowlands AV. Accelerometer assessment of physical activity in children: an update. Pediatr Exerc Sci 2007: 19: 252–266.

Sääkslahti A. Effects of physical activity intervention on physical activity and motor skills and relationships between physical activity and coronary heart disease risk factors in 3–7-years-old children. Jyväskylä, Finland: University of Jyväskylä. Studies in Sport, Physical Education and Health 104, 2005.

Shumway-Cook A, Woollacott MH. Motor control. Translating research into clinical practice. 4th edn. Philadelphia, PA: Lippincott Williams & Wilkins, 2012.

Stodden DF, Goodway JD, Langendorfer SJ, Roberton MA, Rudisill ME, Garcia C, Garcia LE. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. Quest 2008: 60: 290–306.

Van Cauwenberghe E, Labarque V, Trost SG, De Bourdeaudhuij I, Cardon GM. Calibration and comparison of accelerometer cut points in preschool children. Int J Pediatr Obeb 2011: 6: e582–e589.

Vandendriessche JB, Vaeyens R, Vandorpe B, Lenoir M, Lefevre J, Philippaerts RM. Biological maturation, morphology, fitness, and motor coordination as part of a selection strategy in the search for international youth soccer players. J Sports Sci 2012: 30: 1695–1703.

Vandorpe B, Vandendriessche J, Lefevre J, Pion J, Vaeyens R, Matthys S, Philippaerts R, Lenoir M. The Korperkoordinations Test fur Kinder: reference values and suitability for 6–12-year-old children in Flanders. Scand J Med Sci Sports 2011: 21: 378–388.

Williams HG, Pfeiffer KA, O'Neill JR, Dowda M, McIver KL, Brown WH, Pate RR. Motor skill performance and physical activity in preschool children. Obesity 2008: 16: 1421–1426.

Wrotniak BH, Epstein LH, Dorn JM, Jones KE, Kondilis VA. The relationship between motor proficiency and physical activity in children. Pediatrics 2006: 118: e1758–e1765.

III

FAMILY-BASED CLUSTER RANDOMIZED CONTROLLED TRIAL ENHANCING PHYSICAL ACTIVITY AND MOTOR COMPETENCE IN 4–7-YEAR-OLD CHILDREN

by

Laukkanen, A., Pesola, AJ., Heikkinen, R., Sääkslahti, A. & Finni, T. 2015

Plos One 10 (11), e0143987

PLOS | ONE

RESEARCH ARTICLE

Family-Based Cluster Randomized Controlled Trial Enhancing Physical Activity and Motor Competence in 4–7-Year-Old Children

Arto Laukkanen[1,2]*, Arto Juhani Pesola[1], Risto Heikkinen[1], Arja Kaarina Sääkslahti[2], Taija Finni[1]

1 Neuromuscular Research Center, Department of Biology of Physical Activity, University of Jyväskylä, Jyväskylä, Finland, **2** Department of Sport Sciences, University of Jyväskylä, Jyväskylä, Finland

* arto.i.laukkanen@jyu.fi

Citation: Laukkanen A, Pesola AJ, Heikkinen R, Sääkslahti AK, Finni T (2015) Family-Based Cluster Randomized Controlled Trial Enhancing Physical Activity and Motor Competence in 4–7-Year-Old Children. PLoS ONE 10(10): e0141124. doi:10.1371/journal.pone.0141124

Editor: Robert K Hills, Cardiff University, UNITED KINGDOM

Received: April 10, 2015

Accepted: October 4, 2015

Published: October 26, 2015

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Funding: This study was funded by the Finnish Ministry of Education and Culture (DNRO42/627/2010) (TF), the Juho Vainio foundation (201210015, 201310207 and 201410158) (AL) and the Ellen and Artturi Nyyssönen Foundation (5/10/2012) (AL). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Abstract

Little is known of how to involve families in physical activity (PA) interventions for children. In this cluster randomized controlled trial, we recruited families with four- to seven-year-old children to participate in a year-long study where parents in the intervention group families (n = 46) received tailored counseling to increase children's PA. Structured PA was not served. Control group families (n = 45) did not receive any counseling. PA in all children (n = 91; mean age 6.16 ± 1.13 years at the baseline) was measured by accelerometers at the baseline and after three, six, nine and 12 months. Motor competence (MC) (n = 89) was measured at the baseline and after six and 12 months by a KTK (KörperkoordinationsTest für Kinder) and throwing and catching a ball (TCB) protocols. The effect of parental counseling on study outcomes was analyzed by a linear mixed-effects model fit by REML and by a Mann-Whitney U test in the case of the TCB. As season was hypothesized to affect counseling effect, an interaction of season on the study outcomes was examined. The results show significant decrease of MVPA in the intervention group when compared to the control group (p < .05). The TCB showed a nearly significant improvement at six months in the intervention group compared to the controls (p = .051), but not at 12 months. The intervention group had a steadier development of the KTK when the interaction of season was taken into account. In conclusion, more knowledge of family constructs associating with the effectiveness of counseling is needed for understanding how to enhance PA in children by parents. However, a hypothesis may be put forward that family-based counseling during an inactive season rather than an active season may provide a more lasting effect on the development of KTK in children.

Trial Registration

Controlled-Trials.com ISRCTN28668090

Competing Interests: The authors have declared that no competing interests exist.

Introduction

Studies on objectively measured physical activity (PA) indicate that an inactive lifestyle is very common among children and youths [1]. However, an adequate level of PA is vital for normal bone growth [2], developing motor competence [3] and healthy self-esteem [4], and it may play an important role in mental function via psychosocial, physical fitness and general health factors [5]. PA has also been linked with higher cognition [6] and academic achievement [7]. On the other hand, insufficient PA has been shown to be associated with cardiometabolic risk factors [8], as well as decreased psychosocial health in children [9].

PA interventions for children and adolescents with family, school and community involvement have shown small to moderate effects [10–13] or no effects [14] on objectively measured PA levels. While the majority of studies have employed multicomponent intervention methods (i.e. involvement of schools and families simultaneously), there is a lack of knowledge about how best to involve families themselves in PA interventions for children [15,16]. Some evidence of effectiveness has been suggested by interventions with educational and training programs for parents. For instance, "The Healthy Dads, Healthy Kids" [17] educational program with eight face-to-face education sessions for fathers over a period of three months was found to be effective in decreasing the fathers' weight and increasing the PA of the children. Therefore, more research on effective and feasible family PA intervention strategies would be of great value; parental support of a child's PA, for example, has consistently been shown to be associated with PA levels in children [18–21].

Because PA behavior has been seen as complex in nature and challenging to change, it is important to research mediative paths supporting an active lifestyle. Development of gross motor competence (MC) has emerged as one major interest in this context. While MC has multifaceted associations with PA [3,22], it also predicts the level of PA [23,24] and fitness [25], and it is associated with perceived sports competence, which mediates the level of PA later in life [26]. It has also been shown that acquired MC itself may act as a mediator for increased PA [27]. On the other hand, low MC is hypothesized to be one factor predisposing a physically inactive lifestyle and accumulation of health risk factors [28]. Although behavioral theories (e.g. social cognitive theory [29]) and some evidence consider the influence of the home environment to be important on the development of MC in children [30–32], little is known about whether not only habitual PA patterns, but also the development of MC could be influenced by family-based intervention. At best, a home or parental component has comprised only a minor area of study in efforts to enhance PA and MC in children [33,34], making it difficult to interpret the effect of family on the outcomes.

The present cluster randomized controlled trial addressed this gap by testing 1) whether family-based tailored counseling aimed at increasing PA in children is an effective way to enhance objectively measured PA in children. The secondary goal was to examine 2) whether family-based counseling is effective in contributing to the development of MC in children. Additionally, it has been shown that seasonal variation may significantly affect PA behavior and fitness in children [35,36]. Because this study was conducted in a northern country with great seasonal variation and possible effects (e.g. frequency of outdoor PA), we also examined 3) whether seasonal variation played a role in the effects of counseling on changes in PA and MC in children. The advantages, challenges and limitations of family-based PA counseling are discussed on the basis of the findings of this unique study and previous literature on PA interventions with children. Also, an interaction between season and the study effect on KTK performance is proposed as one means of strengthening the effect of family-based PA counseling on MC development in children.

Materials and Methods

This study was conducted as part of a year-long randomized controlled trial "A family-based tailored counseling to increase non-exercise physical activity in adults with a sedentary job and physical activity in their young children" (InPact, ISRCTN28668090) [37]. Overall, the InPact study was aimed at increasing non-exercise PA in adults and PA in their young children via individually tailored PA counseling. In this paper, the counseling process and main outcomes regarding the children are reported. The authors confirm that all ongoing and related trials for this study are registered. A delay in the registration of the trial was due to time constraints in the study implementation. Ethical approval for the project was received from the Ethics Committee of the Central Finland Health Care District on March 25, 2011 (Dnro 6U/2011) and we obtained written informed consent from all of the parents for their own and their children's involvement in the study. Reporting of the methods and findings of this trial was guided by a checklist of the CONSORT 2010 Statement for reporting randomized trials [38].

Cluster randomization and recruitment

The study was performed in a city of Central Finland with approximately 133,000 inhabitants living in a relatively small city center and topographically and socioeconomically varied suburbs. Balanced regions in the city (henceforth referred to as "clusters") were identified in terms of population, daycare centers and school facilities, socioeconomic characteristics (education) and outdoor PA possibilities. Seven balanced counterpart clusters were formed (from one to four daycare centers or schools in each cluster) and randomization into either intervention or control clusters was done by researchers (AL, TF) for each of these counterparts. As a result, there were seven intervention clusters and seven control clusters. Recruitment of families for the intervention group was then performed from the intervention clusters and families for the control group from the control clusters. The allocation ratio was around 10%, with 1055 recruitment letters sent to parents via children attending 21 daycare centers and eight primary schools. Altogether 101 children were allocated to the study. The researchers (AL, AP, TF) performed randomization, enrolled participants, and assigned participants to the study. The flow of participants through the cluster randomized controlled trial is illustrated in Fig 1. Children attending daycare less than 10 days a month, children with a developmental disorder or other disorders delaying motor development, children whose parents sat less than 50% of their work time or had a chronic disease, and children with a pregnant parent were excluded. At least one parent and a child were required for the family to be included in the study. The recruitment of participants was performed between the 1st of April, 2011 and the 30th of April, 2012. The baseline measurements took place between the 2nd of May, 2011 and the 2nd of May, 2012 in a balanced manner for the intervention and control group families. All parents were given the possibility to receive PA counseling: intervention families after the baseline measurements and control families after the final measurements.

Tailored counseling

Tailored counseling to support parents in changing behavior to increase PA in their children was based on social cognitive theory (SCT) [29] and the theory of planned behavior (TPB) [39]. The TPB was added to the study design after commencement of the trial in order to complement the tailored counseling process. The behavior change techniques used in this study were based on nine items conducted in one or several parts of the counseling process: 1) a lecture, 2) individual face-to-face counseling and goal setting, and 3) counseling by phone (Table 1). The lecture and individual discussions were led by researchers (AL, AP, TF) who had all undergone an orientation in best practices in behavior change counseling before the

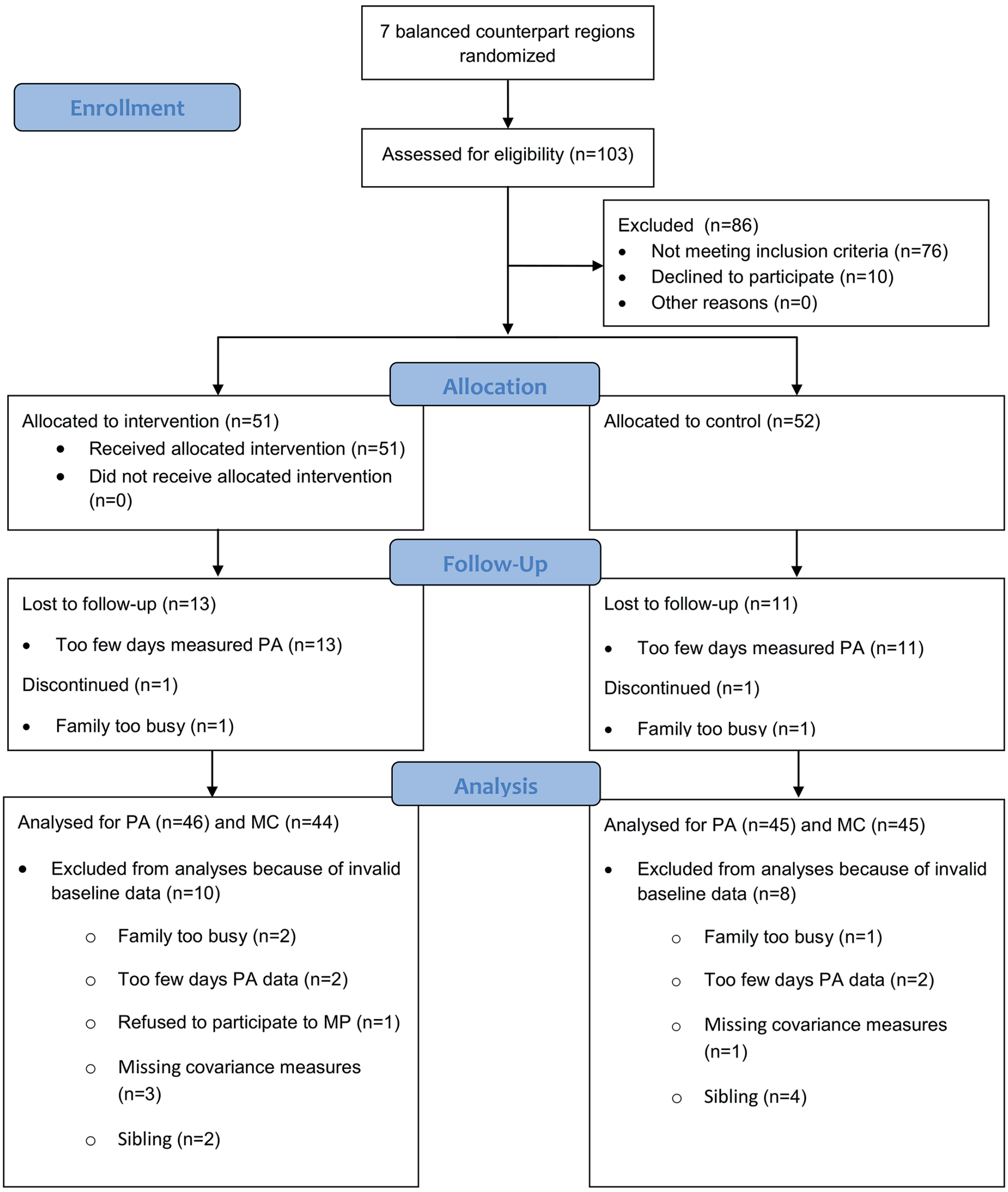


Fig 1. Flow chart of the study. PA, physical activity; MC, motor competence.

doi:10.1371/journal.pone.0141124.g001

Table 1. Description of the techniques used in the family-based PA counseling.

Technique item (theoretical framework)	Counseling	Description	Example of implementation
1 Provide instruction (SCT)	Lecture, face-to-face, phone counseling	Providing scientific-based ways to increase PA in children	"Outdoor PA, PA with peers, PA with parents, active ways of commuting"
2 Provide information on consequences (SCT, TPB)	Lecture	Information about how physical activity enhances health, development of gross and fine motor coordination, and therefore academic readiness	"PA is associated with lower cardiometabolic risk factors in children, and lack of gross motor coordination may hamper development of fine motor coordination."
3 Prompting identification as a role model (SCT)	Lecture	Information of concrete situations where parents act as physically active role models for their children	"Consider if you could choose stairs instead of a lift and walking instead of taking a car."
4 Provide general encouragement (SCT)	Lecture, face-to-face, phone counseling	Justifying concrete benefits from the intended behavior change	"Adequate PA during the day helps children to go to sleep."
5 Provide information about others approval (TPB).	Lecture	Information about other parents' and authorities' opinions/rules about restricting PA that is natural for children	Discussion of typical restrictions with other parents (e.g. restricting children from running up stairs, playing ball outdoors in rainy weather and climbing on trees).
6 Prompting intention formation (SCT, TPB)	Face-to-face	Encouragement for enabling behavior change	"Consider if prohibiting children from jumping indoors would be unnecessary."
7 Progressive goal setting (SCT)	Face-to-face, phone counseling	Encouragement to set target frequency for goal implementation, prompting for considering progressive increase of the target frequency	"I aim to provide my children with weekly opportunities for outdoor play during leisure time."
8 Prompting barrier identification (SCT)	Phone counseling	Prompting parents to identify barriers of PA in children and implementing the goals set in the counseling session	"What are the reasons your child was not able to play outdoors on the weekend?"
9 Self-evaluation	Phone counseling	Parents were asked to self-evaluate the implementation of goals that were set	"On a scale of 1–5, how well did you do in achieving the set goal?"

PA = physical activity; SCT = Social Cognitive Theory; TPB = Theory of Planned Behavior; Face-to-face = face-to-face discussion between parent and counselor.

doi:10.1371/journal.pone.0141124.t001

study. The phone counseling sessions were conducted by two researchers (AL, AP). In the lecture, parents were instructed that outside the daycare or school context, one hour of moderate-to-vigorous PA (MVPA) during weekdays and two hours of MVPA during the weekend days was the target level of PA (Table 1: item 1). This general target was justified by the gap between national PA guidelines and preliminary research findings about the current level of PA in children [40] and by the assumed consequences of (not) achieving the recommended PA. Specifically, the close relationship between PA and health, the development of MC, and school readiness were explained to parents (Table 1: item 2). Scientific-based, concrete strategies for enhancing PA in children were discussed. The key message was to enable PA in a way natural for children (e.g. running around and climbing, not restricting them unnecessarily) and also to offer possibilities for PA in non-constructed environments–such as heaths, forests and hills–as time spent outdoors associates with PA and PA in natural environments may contribute the development of balance and motor coordination [41,42]. Seasonal variation, and especially the decline of PA in late autumn and winter, was emphasized as a key challenge for PA in children (Table 1: item 1). The role of parents as an important model for their children's PA behavior in everyday life, and not only regarding exercise habits, was emphasized. Parents were encouraged in PA-friendly role modeling (Table 1: item 3). Typical restrictions put against PA in children's everyday life were discussed by parents and researchers during the counseling session (Table 1: item 5).

Following a fidelity checklist of the individual face-to-face discussion, parents were first asked to describe the PA habits of the family during leisure time, and then encouraged to consider and set small, gradual goals for increasing the children's PA to reach the target level. Physical activities common to the entire family were also encouraged (Table 1: items 4 and 6). The goals that parents set were rated on a scale of 1 to 4, depending on the frequency of intended implementation (1 = randomly, 2 = once or twice a week, 3 = three to four times a week, 4 = daily) (Table 1: item 7). The goals set by the parent him/herself were written as an agreement that was signed by the parent and the researcher.

To promote compliance with implementation of the goals, phone discussions were held at two and five months after the counseling and goal setting. During the phone calls, compliance with the goals set, possible modifications to the goals, and perceived barriers to implementation of the goals were discussed (Table 1: item 8). Additionally, the parents were asked to self-evaluate the implementation of goals by answering the question "Did you do your best to achieve the goal?" on a scale of 1 to 5 (1 = not at all, 2 = a little, 3 = moderately, 4 = relatively well, 5 = fully) (Table 1: item 9). Implementation was supported by monthly e-mails which contained seasonal tips and illustrative videos about how to increase PA and develop MC in their children. Feedback about the progress of a child's MC in comparison to age-related peers was given to parents shortly after the six-month measurements. The feedback form also included practical advice for improving MC (e.g. moving on varied terrain enhances the development of balance and coordination). The last six months of the study were the same for the intervention and control groups, including only nine- and 12-month assessments but no other contact with the researchers.

Assessment of PA, MC and anthropometrics

PA was measured using triaxial X6-1a accelerometers with a dynamic range of ±6 g (Gulf Coast Data Concepts Inc., Waveland, MS, USA) at the baseline and three, six, nine and 12 months for six consecutive days at a time. Recordings longer than 7 hours (420 minutes) on at least 3 days (2 weekdays and 1 weekend day) [43] were accepted for analysis. Proportional values of time spent at different PA intensities of sedentary, light and MVPA [44] were calculated in relation to the total measurement time and by weighting weekdays by 5/7 and weekend days by 2/7. Three control children were lost for PA follow-up at three months, five intervention and three control children at six months, six intervention and five control children at nine months, and two intervention and one control children at 12 months because of too few days measured PA (Fig 1). Missing PA values were imputed by using a predictive model on the condition that the subject had successfully performed the baseline and at least one other measurement point. Variation in school timetable, teacher support for PA, etc. may cause bias on the study effects; therefore, PA during school time, imputed when needed, was used as a covariate when explaining the change in MC due to counseling. The imputed PA was not used as a dependent variable itself, but only as a predictive covariate.

MC was measured at the baseline, six and 12 months, using the Körperkoordinationstest für Kinder (KTK), standardized in Germany in 1974, which has been shown to be highly reliable [45]. The KTK consists of four different test items: walking backwards (WB), hopping for height (HH), jumping sideways (JS) and moving sideways (MS). The means of the raw scores of the four KTK items at each measurement point were calculated and used as a secondary outcome measure. Additionally, a throwing and catching a ball test (TCB) from an APM inventory was used for measuring ball-handling skills. The APM inventory has been validated in 1800 Finnish children of under eight years of age, and it has been shown to be highly reliable (test-retest $r = 0.86–0.94$) [46]. In this study, the TCB for preschool children (aged four to six) utilized a soft ball (circumference 65.4 cm; weight 228 g), which was thrown underarm 10 times towards a target (10-cm wide piece of distinguishable tape) at a height of 1.3 m on the wall from a distance of two meters and caught after a bounce on the floor. The TCB was modified for primary schoolers (aged seven) so that it was performed in two separate parts with a higher degree of difficulty. In the first part, the ball was thrown 10 times from a distance of three meters and caught after a bounce on the floor. Additionally, hits on the wall above the marked two-meter upper limit were counted as fails. In the second part, the ball was thrown 10 times from a distance of three meters and caught without a bounce on the floor. No upper limit was marked on the wall for the second part. The number of catches was summed for preschoolers, and for primary schoolers the average number of catches in the two parts was calculated. Performing the KTK and TCB took approximately 20–30 minutes per child, and testing sessions took place either in the laboratory, in daycare center, or at school in groups of one to three children. The testing conditions were as similar as possible in every case regarding distractions, floor material and space needed for the measurements.

Height and body weight were measured in the laboratory at six and 12 months, and BMI (kg/m^2) was calculated. The BMI did not significantly change over time and thus the six-month BMI was used in statistical analyses. Based on international cutoff points [47], approximately 11% of children in this study were overweight.

Statistical analysis

Differences between groups (intervention and control) and gender in terms of background characteristics were tested by independent samples T- and chi-square (X^2) tests. The effect of counseling on PA and the KTK was analyzed with a linear mixed-effects model fit by REML using statistical programming language R (R 3.0.1, NLME package, the R foundation for Statistical Computing). An autoregressive covariance model (AR1) was also used in the analyses considering changes in the KTK.

Analysis of the counseling effect was initially based on a three-level hierarchy where children (n = 97) were nested within families (n = 91) and families were nested within randomized clusters (n = 14). The children, families and clustered samples were considered in the models as random grouping effects. However, the models were inestimable with the family-level hierarchy because of the great number of families in comparison to the total number of children. Therefore, in five cases where more than one child per family was participating to this study, only one child from the family was randomly included to the final analyses. Consequently, the final counseling effect analysis based on a two-level hierarchy where children (n = 91) were nested within randomized clusters.

The Group × Time interaction formed a base model for examining the effects of counseling on the proportional change of time spent in different PA intensities and the KTK between the baseline and the 12-month follow-up. Based on this interaction, the mean change from the baseline to six months and the baseline to 12 months, and the mean difference between groups in these time intervals, were calculated. In the second phase, the interaction of gender was added to the base model and the three-way interaction of Group × Time × Gender was tested with the Likelihood ratio test. The models with and without the three-way interaction term were compared. The same procedure was applied for the three-way interaction of Group × Time × Season in order to examine the influence of seasonal variation on the study effects. Subjects were divided into three groups based on the season when they were tested at the baseline: *spring* (n = 30) (March, April, May and June), *autumn* (n = 42) (August, September, October and November) and *winter* (n = 22) (December, January and February). The influence of seasonal variation was illustrated by plotting the proportion of time spent in MVPA at the baseline, three, six, nine and 12 months, and the mean of KTK and TCB at the baseline, six and 12 months among intervention and control groups, starting in spring, autumn and winter. Following the intention-to-treat principle, all subjects with acceptable baseline data from outcome measurements and covariances were included in the analyses of study effect. From the total of 101 children, the effect of counseling on PA (Group × Time; Group × Time × Gender; Group × Time × Season) was analyzed with 48 intervention and 49 control children with the intended treatment, and the study effect on the KTK (Group × Time; Group × Time × Gender; Group × Time × Season) with 46 intervention and 49 control children.

All mixed models were adjusted for theory-based confounding variables (in order of statistical importance, with PA as dependent variable: average monthly temperature, participation in extracurricular PA, gender, age and season at baseline measurement; with KTK as dependent variable: age, BMI, proportion of time spent in MVPA during school time, participation in extracurricular PA, and testing environment). Average temperatures were retrieved from climate statistics by the Finnish Meteorological Institute. Sedentary time was LOGIT-transformed, while light PA and MVPA were LOG-transformed due to skewed distributions. Furthermore, distribution of the TCB was not normal at the baseline because of several zero-point performances ($n = 13$) in the youngest participants. Therefore, a related samples Wilcoxon signed rank test (W) was used to examine the development of TCB by time in general. Non-parametric Mann-Whitney U test was used for testing differences between the groups in changes of the TCB: first, in all children, and secondly, in girls and boys separately A logistic regression analysis was performed for revealing possible systematic explanations (e.g. parents' education level) for dropping out of the study. The level of significance was set to $p < .05$ in all analyses.

Results

Participant characteristics and measurement flow

The proportion of overweight children included in this study (11%) was within the national average for five-year-olds (9.8–17.7%) [48]. Intervention group accumulated significantly less sedentary time ($t = 2.23$, p = .028) and more MVPA ($t = 2.52$, p = .013) at baseline (Table 2). Boys cumulated significantly less sedentary time ($t = 2.78$, p = .007) and more light PA ($t = 3.64$, $p < .001$) and MVPA ($t = 2.02$, p = .047) compared to girls at the baseline, but MC was similar between genders. Parents in the intervention group were significantly older than in the control group ($t = 3.37$, p = .001). When compared to the mean of the whole recruitment region, parents in this study were more highly educated (i.e. they were more likely to have a university or polytechnic degree (71% / 35%) and less often single parents (4% / 27%). There were no other significant differences between gender or the intervention and control groups in terms of background characteristics or baseline assessments.

On average, PA was measured for 5.04 days (11.79 ± 0.93 h/d), 5.17 days (11.74 ± 0.93 h/d), 5.22 days (11.84 ± 0.98 h/d), 5.15 days (11.59 ± 0.85 h/d) and 5.27 days (11.68 ± 0.90 h/d) at the baseline, three, six, nine and 12 months, respectively. A total of 3 intervention and 4 control children discontinued the study after enrollment because of a busy life situation in the family or parents participating in another study (Fig 1). Four children (three intervention and one control) were excluded from the analysis of study effects on the KTK because of one or more missing covariance measurements. Six children (two intervention and four control) were dropped out from all intervention effect analysis because of a sibling(s) taking part to the study. Study dropouts did not statistically differ from other subjects involved in the study.

Effect of the study on PA

Group × Time interaction indicated a significant decline of MVPA ($D = 10.45$, $df = 4$, p = .033) in the intervention group when compared to the control group (Table 3). Group × Time ×

Gender interaction indicated no significant gender differences in the treatment effect on the proportion of time spent at different PA intensities.

Effect of the study on MC

The mean score of KTK ($F = 154.5$, $p < .001$) and TCB ($W = 7.46$, $p < .001$) increased significantly with time (Table 3, Fig 2). Group × Time interaction showed no study effect for the development of the KTK. There were no significant differences between genders in the study effect for the development of the KTK. The TCB indicated a slightly greater, although not quite significant, improvement among intervention group (increase of 2.25 ± 2.34 points) compared to the control group (increase of 1.34 ± 2.40 points) between the baseline and six months ($U = 753.5$, $p = .051$). The change of the TCB did not differ between groups from the baseline to 12 months ($U = 987.5$, $p = .984$). When genders were analyzed separately, there were no significant differences between groups in the development of the TCB (data not shown).

Influence of the season on study effects

Group × Time × Season interaction in the KTK ($D = 23.97$, $df = 10$, $p = .009$) indicated a significant study effect on the KTK when taking the influence of season into account (Table 3). More

Table 2. Background characteristics of the children and parents for analysis.

Characteristics	Intervention	Control
Children (*n*)	46	45
Girls (n)	25	24
Age (years)	6.07 ± 1.12 (3.65)	6.20 ± 1.13 (3.60)
Height (cm)	121.10 ± 7.53 (34.20)	120.21 ± 7.83 (29.70)
Weight (kg)	23.31 ± 3.46 (15.0)	22.66 ± 4.06 (16.6)
BMI	15.84 ± 1.18 (5.90)	15.58 ± 1.50 (8.89)
Season enrolled in the study		
Spring (n)	18	13
Autumn (n)	17	22
Winter (n)	11	10
Physical activity (n)	46	45
Sedentary (%)	87.51 ± 4.05 (17.95)*##	89.25 ±3.33 (14.93)
Light (%)	5.44 ± 2.44 (8.12)###	5.08 ± 1.40 (6.84)
MVPA (%)	7.11 ± 2.94 (13.31)*#	5.73 ± 2.21 (10.11)
Motor competence (n)	44	45
KTK	30.09 ± 12.80 (48.0)	31.02 ± 11.50 (41.75)
TCB	4.47 ± 3.04 (10)	4.72 ± 2.91 (10)
Parents involved in the study (n)	64	58
Age	36.34 ± 4.88 (25)**	39.48 ± 5.40 (22)
Females (n)	40	30
Higher-level education (%)	67.04 (%)	67.78 (%)
Household income ≥ 60 000€ (%)	62.79 (%)	58.14 (%)
Single parent (%)	2.22 (%)	4.65 (%)

Data are presented as mean ± SD and range (in parentheses) from the baseline measurements, except height, weight and BMI (kg/m^2) for children, which are presented from the midline measurements.

Season, season when enrolled in this study; KTK, mean value of all four items of the KörperkoordinationsTest fur Kindern; TCB, mean score of throwing and catching a ball.

Significant difference between intervention and control groups, p < .05 (*), p < .01 (**) and between genders, p < .05 (#), p < .01 (##), p < .001 (###).

doi:10.1371/journal.pone.0141124.t002

Table 3. Change in physical activity and motor competence for intervention and control groups at 6 and 12 months.

Outcome	Period of change in months	Mean change (95% Confidence Interval)		Mean difference between groups (95% Confidence Interval)	P-value			
		Intervention	Control	Intervention–Control	Time	Group × Time	Group × Time × Gender	Group × Time × Season
Physical activity								
Sedentary (%)	0–6	0.04 (-0.07 to 0.16)	-0.07 (-0.18 to 0.04)	0.11 (-0.03 to 0.26)				
	0–12	0.02 (-0.11 to 0.15)	-0.10 (-0.22 to 0.03)	0.11 (-0.02 to 0.25)	.506	.106	.642	.171
Light (%)	0–6	0.02 (-0.07 to 0.11)	0.04 (-0.05 to 0.13)	-0.02 (-0.14 to 0.10)				
	0–12	0.04 (-0.06 to 0.15)	0.06 (-0.04 to 0.17)	-0.02 (-0.13 to 0.09)	.775	.285	.511	.200
MVPA (%)	0–6	-0.11 (-0.24 to 0.02)	0.08 (-0.05 to 0.21)	-0.19 (-0.35 to 0.02)				
	0–12	-0.08 (-0.24 to 0.08)	0.08 (-0.08 to 0.24)	-0.16 (-0.32 to 0.001)	.172	**.033**	.507	.212
Gross motor coordination								
KTK	0–6	18.80 (13.74 to 23.86)***	17.39 (12.22 to 22.56)***	1.41 (-5.89 to 8.71)				
	0–12	35.28 (29.6 to 41.0)***	36.76 (30.97 to 42.54)***	-1.47 (-9.52 to 6.58)	**< .001**	.737	.930	**.008**

*** Significant change within group, p < .001.

doi:10.1371/journal.pone.0141124.t003

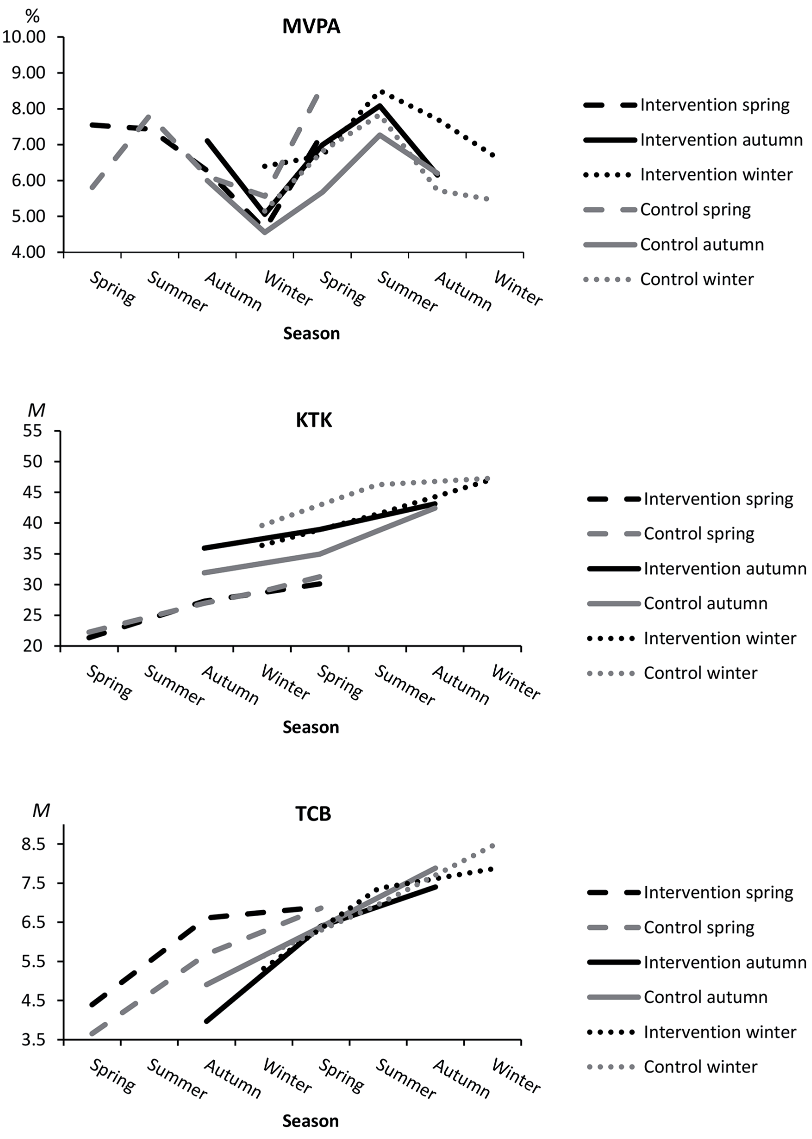


Fig 2. Seasonal variation in intervention and control groups starting in spring, autumn and winter in relation to proportional time spent at MVPA, and the development of the mean of the KTK and TCB. Season is plotted on the x-axis and the response variable on the y-axis. MVPA, moderate to vigorous physical activity; KTK, Körperkoordinationstest für Kinder; TCB, throwing and catching a ball.

doi:10.1371/journal.pone.0141124.g002

specifically, intervention and control groups who started the study during winter differed in the progress of the KTK during the transition from an active to inactive season in the latter half of the follow-up (from six to 12 months, difference of 11 percent points and seven raw points) (Fig 2). Season had no significant interaction effect on the changes of PA between groups.

Study evaluation

Every parent (n = 69) in the intervention group received a lecture (~ 30 minutes) and face-to-face counseling with goal setting (~ 30–60 minutes). Of those, 64 (93%) and 51 (74%) were reached for phone discussions at 2 and 5 months, respectively (Fig 1). During the counseling session, parents set an average of 3.5 goals intended to increase their child's PA. The most common goals were: PA with the family (28%), PA outdoors (25%), PA in the backyard or in the neighboring area (22%), PA with peers (18%) and PA indoors (6%). The parents who were reached once or twice for phone counseling perceived the most common weekday barriers to goal implementation to be weather (38%), hurry and needing to do other tasks (30%), and either their own or the child's tiredness (17%). On weekends, hurry and needing to do other tasks (35%), weather (21%) and tiredness (10%) were the most common barriers. Both mothers and fathers in the intervention group rated individual discussion as the most important study tool used in this project (~ 32% of the parents), followed by feedback from measurement results (~ 19%), the lecture (~ 18%), phone discussions (~ 3%), printed material (~ 4%), emails (~ 4%) and project web pages (0%).

Discussion

The current year-long RCT showed that a single counseling session given to parents and accompanied by reinforcing phone calls and e-mail contacts could not increase but rather showed decrease in objectively measured MVPA in children aged 4–7 years. On the other hand, although ways to influence development of children's MC was not primarily targeted in the present family based PA counseling, a greater development of KTK was found in the intervention group when the interaction of season was taken into account. Furthermore, a positive change in ball-handling skills, even though just below the level of significance, was observed in the intervention group (TCB) during the reinforced counseling period (0–6 months). Results suggest that family-based PA counseling may have distinct influences on PA behavior and on the development of MC.

The results of the present study parallel previous interventions employing parents as promoters for PA and MC in their own children. In the study of Hamilton et al. [49], children at risk of developmental delay significantly outperformed their control peers in ball-handling skills after an investigator-led and mother-assisted eight-week motor skill program. Similarly, Cliff et al. [34] recruited obese children to participate in structured PA sessions led by qualified PE teachers over ten weeks. Families were educated to enhance social support for PA, to monitor behavior, to identify barriers for PA, and to set goals enhancing PA in their obese children. As a result, motor skills improved significantly in subjects compared to control peers, but objectively measured PA remained unchanged between groups. Therefore, family involvement is an important component of treatment when aiming to enhance gross motor development, while improved MC may act as a mediator for increased PA [27]. However, it is crucial to further also research direct strategies for affecting PA, as interventions aimed at increasing PA in children have generally only produced modest results [14]. We clearly need more knowledge about how to effictively involve families, for example, in enhancing PA in children.

Although the present study did not show significant effect on TCB in children, there is a need to find ways to support the development of object control skills in children. Object control skills (i.e. ball-handling skills) have been stated to be more difficult to change than locomotor skills [50] and, most importantly, acquired ball-handling skills have been shown to predict PA and fitness later in life, especially in girls [23,25]. However, as previous school-based intervention studies have shown good sustainability of acquired MC in children [51,52], the nearly significant development of object control skills in the present family-based intervention group was attenuated after a reinforced counseling period in the present study. It can be speculated that family-based PA counseling itself does not guarantee a sustained development of ball skills in a school context, for example, because girls generally have less ballgame-oriented lessons at school [53]. Therefore, a home setting should be seen as a potential reinforcer for the development of ball skills. As the MC was only indirectly targeted, a family based counseling targeting ways to support the development of MC, e.g. ball handling skills, would more likely influence the proficiency of these skills in children. It should be further investigated whether increase of the overall level of PA would mediate the improvement of MC in children as the level of PA remained unaffected in the present study and does not therefore provide evidence for or against the question. Educational, curricular and other environmental contexts should ideally be shifted at the same time to strengthen the sustainability of skill development.To our knowledge, this is the first study to suggest a significant interaction between seasonality and PA counseling effects on the development of MC in children of the intervention group. Interestingly, the family based PA counseling had a simultaneous negative influence on PA behavior. The explanation for this can be found from the multifaceted relationship between PA and MC. Because the development of object control skills requires training of these specific skill domains and they are not simply the result of accumulated PA [31,54], it is possible that accelerometer-based PA monitoring is not able to detect this kind of PA accurately enough. Regarding the development of KTK, accelerometer-derived sedentary- to light-intensity PA, along with MVPA, may be associated with physical activities typically seen as developing components of MC in children [55], and thus it may be difficult to capture some developmentally appropriate PA via typical objective PA measurements. Additionally, aside from the proportion of time spent in MVPA, brief but high impact peaks may play a role in the development of MC [22]. Clearly, a more comprehensive interpretation of accelerometer-derived PA from the point of view of motor development warrants future study. Also, self-reports or parent-reports would have been useful supplementary tools for assessing, for instance physically active time spent outdoors and in natural environments, as children may engage in activities that help their MC development but are not reflected in the objective measurements.

For counseling planning, some important issues emerged from the present study. Individual face-to-face counseling was considered as the most useful study tool among the parents in the intervention group. This finding endorses the value of parent-authority interaction and justifies the use of MC targeted counseling for parents, for instance, as a part of maternity and child welfare clinic visits. Additionally, parents rated the initial lecture and feedback on the measurement results among the most important study tools. Parents would probably gain even more from instant feedback about children's MC and practical advice on how to increase the development of MC in their children. On the other hand, a significant decrease in MVPA in the intervention group compared to the control group was unexpected, although there are some parallel findings [11]. Perhaps the increased time spent with family was compensated for with decreased time spent with peers, which may have led to a decrease in overall physically active play. More specifically, as the importance of PA in diversified outdoor environments was highlighted in the counseling process, it may be that time spent, for instance, in forests instead of parks may partly explain the compensation of accelerometry-derived MVPA by PA of lighter intensity. Time spent in diversified environments might also associate with the significant intervention effect on the KTK performance. On the other hand, it may be that the advance knowledge of being part of a study where PA counseling is given may have induced an unwanted treatment effect already at the baseline PA assessments potentially explaining the significantly higher baseline level of MVPA and lower baseline level of sedentary time in children of the intervention group compared to the control group. However, these explanations remain speculative.

The strengths of this study were 1) a unique family-based counseling approach, 2) frequent and objective measurement of the main study outcomes, and 3) following of the intention-to-treat principle by keeping dropouts in the analyses of study effects, decreasing potential bias caused by selectiveness of drop-outs.

There are some limitations to take into consideration in this study. The KTK measurement protocol is designed for children aged 5–15, but children under 5 years of age at the baseline ($n = 9$) were also included in this study. Because the developmental rate of the KTK was statistically consistent between children under and over 5 years old, the inclusion of children under 5 was considered justified. Secondly, different study protocols were used to measure the TCB in younger and older children, and the distribution of the TCB was not normal at the baseline. Therefore, non-parametric tests were used to examine differences between groups in terms of changes in the TCB. Additionally, the clustered samples were not taken into account in the non-parametric analysis which has to be understood as a limitation of the study. However, the change in the TCB was generally greater in the intervention group compared to the control group between the baseline and the end of the reinforced counseling period. This favors a real study effect, although just below the level of significance, in change of the TCB. Lastly, the families included in this study were highly educated and, therefore, the results cannot be generalized to less educated families.

In conclusion, family-based counseling was found to decrease objectively measured MVPA but to increase motor coordination as measured using KTK in children. The findings indicate that there is a lack of knowledge how children's PA can be enhanced by parents. However, the present study suggests that initiation of family-based PA counseling during the inactive season may induce a more sustainable effect on the development of KTK performance.

Supporting Information

S1 CONSORT Checklist. CONSORT checklist.
(DOCX)

S1 Protocol. Clinical trial protocol.
(DOCX)

Acknowledgments

We would like to thank Piia Haakana, M.Sc., and Kasimir Schildt, M.Sc., for their assistance in data collection, Dr. Neil Cronin for revising the language, and the Center for Scientific Computing (Espoo, Finland) for computer resources.

Author Contributions

Conceived and designed the experiments: TF AKS AL AJP. Performed the experiments: AL AJP TF. Analyzed the data: AL RH. Wrote the paper: AL AJP RH AKS TF.

References

1. Spittaels H, Van Cauwenberghe E, Verbestel V, De Meester F, Van Dyck D, Verloigne M, et al. Objectively measured sedentary time and physical activity time across the lifespan: a cross-sectional study in four age groups. Int J Behav Nutr Phys Act. 2012; 9. doi: 10.1186/1479-5868-9-149
2. Nikander R, Sievänen H, Heinonen A, Daly RM, Uusi-Rasi K, Kannus P. Targeted exercise against osteoporosis: A systematic review and meta-analysis for optimising bone strength throughout life. BMC Med. 2010; 8: 47. doi: 10.1186/1741-7015-8-47 PMID: 20663158
3. Wrotniak BH, Epstein LH, Dorn JM, Jones KE, Kondilis VA. The relationship between motor proficiency and physical activity in children. Pediatrics. 2006; 118: e1758–65. doi: 10.1542/peds.2006-0742 PMID: 17142498
4. Reed K, Wood C, Barton J, Pretty JN, Cohen D, Sandercock GRH. A repeated measures experiment of green exercise to improve self-esteem in UK school children. PLoS One. 2013; 8: e69176. doi: 10.1371/journal.pone.0069176 PMID: 23894426
5. Tomporowski PD, Lambourne K, Okumura MS. Physical activity interventions and children's mental function: an introduction and overview. Prev Med. 2011; 52: 53–59.
6. Sibley BA, Etnier JL. The relationship between physical activity and cognition in children: a meta-analysis. Pediatr Exerc Sci. 2003; 15: 243–256. doi: 10.1515/ijsl.2000.143.183
7. Singh A, Uijtdewilligen L, Twisk JWR, van Mechelen W, Chinapaw MJM. Physical activity and performance at school. Arch Pediatr Adolesc Med. 2012; 166: 49–55. doi: 10.1001/archpediatrics.2011.716 PMID: 22213750
8. Ekelund U, Luan J, Sherar LB, Esliger DW, Griew P, Cooper A. Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. J Am Med Assoc. 2012; 307: 704–12. doi: 10.1001/jama.2012.156
9. Timmons BW, Leblanc AG, Carson V, Gorber SC, Dillman C, Janssen I, et al. Systematic review of physical activity and health in the early years (aged 0–4 years). Appl Physiol Nutr Metab. 2012; 37: 773–792. doi: 10.1139/H2012-070 PMID: 22765840
10. Biddle SJH, Braithwaite R, Pearson N. The effectiveness of interventions to increase physical activity among young girls : A meta-analysis. Prev Med. 2014; 62: 119–131. doi: 10.1016/j.ypmed.2014.02.009 PMID: 24530611
11. Gordon ES, Tucker P, Burke SM, Carron A V. Effectiveness of physical activity interventions for preschoolers: a meta-analysis. Res Q Exerc Sport. 2013; 84: 287–294. doi: 10.1080/02701367.2013.813894 PMID: 24261007
12. Dellert JC, Johnson P. Literature Review: Weight control interventions with children and parents to improve physical activity and body mass index: a meta- analysis. Am J Heal Promot. 2014; 28: 259–268. doi: 10.4278/ajhp
13. Van Sluijs EM, Kriemler S, McMinn A. The effect of community and family interventions on young people's physical activity levels: a review of reviews and updated systematic review. Br J Sports Med. 2011; 45: 914–922. doi: 10.1136/bjsports-2011-090187 PMID: 21836175
14. Metcalf B, Henley W, Wilkin T. Effectiveness of intervention on physical activity of children: systematic review and meta-analysis of controlled trials with objectively measured outcomes (EarlyBird 54). BMJ. 2012; 345: e5888. doi: 10.1136/bmj.e5888 PMID: 23044984
15. Mehtälä MAK, Sääkslahti AK, Inkinen ME, Poskiparta MEH. A socio-ecological approach to physical activity interventions in childcare: a systematic review. Int J Behav Nutr Phys Act. 2014; 11: 22. doi: 10.1186/1479-5868-11-22 PMID: 24559188
16. O'Connor TM, Jago R, Baranowski T. Engaging parents to increase youth physical activity a systematic review. Am J Prev Med. 2009; 37: 141–149. doi: 10.1016/j.amepre.2009.04.020 PMID: 19589450
17. Morgan PJ, Lubans DR, Plotnikoff RC, Callister R, Burrows T, Fletcher R, et al. The "Healthy Dads, Healthy Kids" community effectiveness trial: study protocol of a community-based healthy lifestyle program for fathers and their children. BMC Public Health. 2011; 11: 876. doi: 10.1186/1471-2458-11-876 PMID: 22099889
18. Rhodes RE, Quinlan A. The family as a context for physical activity promotion. In: Beauchamp MR, Eys MA, editors. Group dynamics in exercise and sport psychology: contemporary themes. 2nd editio. New York: Routledge; 2014. pp. 203–222.
19. Beets MW, Cardinal BJ, Alderman BL. Parental social support and the physical activity-related behaviors of youth: a review. Heal Educ Behav. 2010; 37: 621–644. doi: 10.1177/1090198110363884
20. Edwardson CL, Gorely T. Parental influences on different types and intensities of physical activity in youth: A systematic review. Psychol Sport Exerc. 2010; 11: 522–535. doi: 10.1016/j.psychsport.2010.05.001

21. Hinkley T, Crawford D, Salmon J, Okely AD, Hesketh K. Preschool children and physical activity: a review of correlates. Am J Prev Med. 2008; 34: 435–441. doi: 10.1016/j.amepre.2008.02.001 PMID: 18407012

22. Laukkanen A, Pesola A, Havu M, Sääkslahti A, Finni T. Relationship between habitual physical activity and gross motor skills is multifaceted in 5- to 8-year-old children. Scand J Med Sci Sports. 2014; 24: e102–110. doi: 10.1111/sms.12116 PMID: 24118456

23. Barnett LM, van Beurden E, Morgan PJ, Brooks LO, Beard JR. Childhood motor skill proficiency as a predictor of adolescent physical activity. J Adolesc Heal. 2009; 44: 252–259. doi: 10.1016/j.jadohealth.2008.07.004

24. Lopes VP, Rodrigues LP, Maia JAR, Malina RM. Motor coordination as predictor of physical activity in childhood. Scand J Med Sci Sports. 2011; 21: 663–9. doi: 10.1111/j.1600-0838.2009.01027.x PMID: 21917017

25. Barnett LM, van Beurden E, Morgan PJ, Brooks LO, Beard JR. Does childhood motor skill proficiency predict adolescent fitness? Med Sci Sports Exerc. 2008; 40: 2137–44. doi: 10.1249/MSS.0b013e31818160d3 PMID: 18981934

26. Barnett LM, Morgan P, van Beurden E, Beard J. Perceived sports competence mediates the relationship between childhood motor skill proficiency and adolescent physical activity and fitness: a longitudinal assessment. Int J Behav Nutr Phys Act. 2008; 5: 1–12.

27. Cohen KE, Morgan PJ, Plotnikoff RC, Barnett LM, Lubans DR. Improvements in fundamental movement skill competency mediate the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children. J Sports Sci. 2015; 33: 1908–18. doi: 10.1080/02640414.2015.1017734 PMID: 25716899

28. Stodden DF, Goodway JD, Langendorfer SJ, Roberton MA, Rudisill ME, Garcia C, et al. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. Quest. 2008; 60: 290–306. doi: 10.1080/00336297.2008.10483582

29. Bandura A. Social foundations of thought and action: a social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall; 1986.

30. Cools W, De Martelaer K, Samaey C, Andries C. Fundamental movement skill performance of preschool children in relation to family context. J Sports Sci. 2011; 29: 649–60. doi: 10.1080/02640414.2010.551540 PMID: 21424981

31. Barnett L, Hinkley T, Okely AD, Salmon J. Child, family and environmental correlates of children's motor skill proficiency. J Sci Med Sport. 2013; 16: 332–36 doi: 10.1016/j.jsams.2012.08.011 PMID: 23020935

32. Iivonen S, Sääkslahti AK. Preschool children's fundamental motor skills: a review of significant determinants. Early Child Dev Care. 2014; 184: 1107–26. doi: 10.1080/03004430.2013.837897

33. Reilly JJ, Kelly L, Montgomery C, Williamson A, Fisher A, McColl JH, et al. Physical activity to prevent obesity in young children: cluster randomised controlled trial. BMJ. 2006; 333: 1041. doi: 10.1136/bmj.38979.623773.55 PMID: 17028105

34. Cliff DP, Okely AD, Morgan PJ, Steele JR, Jones RA, Colyvas K, et al. Movement skills and physical activity in obese children: randomized controlled trial. Med Sci Sports Exerc. 2011; 43: 90–100. doi: 10.1249/MSS.0b013e3181e741e8 PMID: 20473216

35. Carson V, Spence JC. Seasonal variation in physical activity among children and adolescents: a review. Pediatr Exerc Sci. 2010; 22: 81–92. Available: http://www.ncbi.nlm.nih.gov/pubmed/20332542. PMID: 20332542

36. Augste C, Künzell S. Seasonal variations in physical fitness among elementary school children. J Sports Sci. 2014; 32: 415–23. doi: 10.1080/02640414.2013.830189 PMID: 24016228

37. Finni T, Sääkslahti A, Laukkanen A, Pesola A, Sipilä S. A family based tailored counselling to increase non-exercise physical activity in adults with a sedentary job and physical activity in their young children: design and methods of a year-long randomized controlled trial. BMC Public Health. 2011; 11: 944. doi: 10.1186/1471-2458-11-944 PMID: 22185647

38. Moher D, Hopewell S, Schulz KF, Montori V, Gøtzsche PC, Devereaux PJ, et al. CONSORT 2010 Explanation and elaboration: updated guidelines for reporting parallel group randomised trials. J Clin Epidemiol. 2010; 63: e1–37. doi: 10.1136/bmj.c869 PMID: 20346624

39. Ajzen I. From intentions to actions: a theory of planned behavior. In: Kuhl J, Beckmann J, editors. Action control: From cognition to behavior. Berlin, Germany: Springer; 1985. pp. 11–39.

40. Soini A, Tammelin T, Sääkslahti A, Watt A, Villberg J, Kettunen T, et al. Seasonal and daily variation in physical activity among three-year-old Finnish preschool children. Early Child Dev Care. 2014; 184: 589–601. doi: 10.1080/03004430.2013.804070

41. Fjortoft I. Landscape as Playscape: The effects of natural environments on children's play and motor development. Child Youth Environ. 2004; 14: 1–24.
42. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity. Med Sci Sport Exerc. 2000; 32: 963–75.
43. Penpraze V, Reilly JJ, MacLean CM, Montgomery C, Kelly LA, Paton JY, et al. Monitoring of physical activity in young children: how much is enough? Pediatr Exerc Sci. 2006; 18: 483–91.
44. Van Cauwenberghe E, Labarque V, Trost SG, de Bourdeaudhuij I, Cardon G. Calibration and comparison of accelerometer cut points in preschool children. Int J Pediatr Obes. 2011; 6: e582–9. doi: 10.3109/17477166.2010.526223 PMID: 21121867
45. Kiphard E, Schilling F. Body coordination test for children. 2nd ed. Weinheim: Beltz Test GmbH; 2007.
46. Numminen P. APM inventory: manual and test booklet for assessing pre-school childrens's perceptual and basic motor skills. Jyväskylä, Finland: LIKES; 1995.
47. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000; 320: 1240. http://dx.doi.org/10.1136/bmj.320.7244.1240 PMID: 10797032
48. Vuorela N, Saha M-T, Salo M. Prevalence of overweight and obesity in 5- and 12-year-old Finnish children in 1986 and 2006. Acta Paediatr. 2009; 98: 507–12. doi: 10.1111/j.1651-2227.2008.01110.x PMID: 18983437
49. Hamilton M, Goodway J, Haubenstricker J. Parent-assisted instruction in a motor skill program for at-risk preschool children. Adapt Phys Act Q. 1999; 16: 415–26.
50. Morgan PJ, Barnett LM, Cliff DP, Okely AD, Scott HA, Cohen KE, et al. Fundamental movement skill interventions in youth: a systematic review and meta-analysis. Pediatrics. 2013; 132: e1361–83. doi: 10.1542/peds.2013-1167 PMID: 24167179
51. Lai SK, Costigan SA, Stodden DF, Salmon J, Barnett LM. Do school-based interventions focusing on physical activity, fitness, or fundamental movement skill competency produce a sustained impact in these outcomes in children and adolescents? A systematic review of follow-up studies. Sports Med. 2014; 44: 67–79. doi: 10.1007/s40279-013-0099-9 PMID: 24122775
52. Zask A, Barnett LM, Rose L, Brooks LO, Molyneux M, Hughes D, et al. Three year follow-up of an early childhood intervention: is movement skill sustained? Int J Behav Nutr Phys Act. 2012; 9: 127. doi: 10.1186/1479-5868-9-127 PMID: 23088707
53. Redelius K, Larsson H. Physical education in Scandinavia: an overview and some educational challenges. Sport Soc. 2010; 13: 691–703. doi: 10.1080/17430431003616464
54. Logan SW, Robinson LE, Wilson AE, Lucas WA. Getting the fundamentals of movement: a meta-analysis of the effectiveness of motor skill interventions in children. Child Care Health Dev. Department of Kinesiology, Auburn University Department of Fisheries and Allied Aquacultures, Auburn University, Auburn, AL, USA.: Blackwell Publishing Ltd; 2011; 38: 305–15. doi: 10.1111/j.1365-2214.2011.01307.x PMID: 21880055
55. Laukkanen A, Finni T, Pesola A, Sääkslahti A. Brisk physical activity ensures the development of fundamental motor skills in children–but light is also needed! Liik T. 2013; 50: 47–52.

IV

PARENTAL SUPPORT AND OBJECTIVELY MEASURED PHYSICAL ACTIVITY IN CHILDREN: A YEAR-LONG CLUSTER-RANDOMIZED CONTROLLED TRIAL.

by

Laukkanen, A., Pesola, A.J., Finni, T. & Sääkslahti, A. 20XX

Submitted article.