PHYSICAL EDUCATION AND MUGI MOTOR SKILLS TRAINING: A NINE-YEAR INTERVENTION STUDY WITH SOCIETAL GAINS IN SWEDEN

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ABSTRACT

Objective: The aim was to investigate long-term effects on motor skills and scholastic performance of increased Physical Education (PE) and adapted motor skills training according to the Motor skills as Ground for Learning (MUGI) model – [in Swedish: Motorisk Utveckling som Grund för Inlärning]. Another aim is to describe the implementation and the society gains of the Swedish *Bunkeflo project–a healthy way of living.*

Methods: All students born 1990-92 in one school in the south of Sweden were included in a longitudinal study during nine years. The school day was prolonged and an intervention group (n=129) received

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daily PE (5x45 minutes/week) and if needed one extra lesson/week of adapted (MUGI) motor skills training. The control group (n=91) had the school´s ordinary PE 2x45 minutes/week. All teachers and school staff were educated in the MUGI model of motor skills observing and training. Motor skills were evaluated by the MUGI observation checklists and scholastic performances by achievements and grades in Swedish, English, mathematics, PE, and proportion of students who qualified for upper secondary school.

Results: Statistical analyses after three years and at follow up six years later showed that both girls and boys improved more in motor skills (balance and coordination) and their learning performance in Swedish and mathematics became significantly better compared to a control group who had ordinary PE twice per week. In the intervention group 93 percent of the students had good motor skills after nine years compared to 53 percent in the control group ($p<0.001$), and 96 percent of the students in the intervention group compared to 89 percent in the control group ($p<0.05$) qualified for higher education in upper secondary school. The sum of evaluated grades was higher among boys in the intervention group than in the control group ($p<0.05$). Health-economic analyses show that daily PE and adapted motor skills training in school would increase the potential production value and reduce morbidity costs during the ten-year period after school. An investment in staff and premises per student of 500 Euro for all nine school years would give productivity gains and reduced morbidity costs of 4,130 Euro for every student.

Conclusion: Daily PE and adapted motor skills training during the compulsory school years is a feasible way to improve not only motor skills but also scholastic performance and the proportion of students who qualify for upper secondary school. The health-economic evaluation of the project shows that the investment was clearly profitable for the municipality.

Keywords: academic achievements, cognition, economic health analysis, implementation, motor skills checklists, motor skills development, physical education, scholastic performance, the Bunkeflo project, the Pediatric Osteoporosis Prevention (POP) study

INTRODUCTION

A great number of children do not get enough physical activity (PA) to give them optimal health (Dencker, 2007). Several studies report increased obesity and cardiovascular disease risk factors in children, who are physically inactive, e.g., The European Youth Heart Study (Andersen, Haaro, Sardinha et al., 2006). Recommendations for physical activity often focus on the quantitative aspects of physical activity and health-related components of physical fitness (e.g., aerobic fitness, muscular strength, muscular endurance, flexibility, and body composition). The importance of motor skill acquisition early in life is often overlooked, which may limit qualitative aspects of interventions, such as motor skill development, socialization and enjoyment of exercise.

Physical activity play is important for children's social life, since friendships develop in conjunction with physical activity play during the first school years. Pellegrini (1995) found that exercise play (with gross motor movement) increase and peak during primary school years. Being able to participate in physical activities is, according to Blatchford (1998) an important factor in acquiring friends, maintaining friends, and belonging in peer groups.

Physical Education (PE) teachers describe low skilled children as clumsy, poorly coordinated, low competent or with motor development problems. These children have difficulties acquiring and performing fundamental motor skills such as running, jumping, catching or throwing (Ruiz-Pérez, Palomo-Nieto, Gómez-Ruano et al., 2018).

Children whose fitness is poor and whose motor skills are insufficiently developed often end up in a downhill spiral leading to less and less physical activity. They are physically passive during their leisure time, and do not participate in any sports activities. They are caught in a cycle in which, children who are in need of motor skills training the most get the least practice. Because they do not participate in physical activity they have poor motor skills, and because they have poor motor skills they don't participate in sport and other physical activities so that their motor skills further decline. They seem to be trapped in a spiral of declining motor skills, fitness and motivation to take part in physical activity. The lack of development of fundamental motor skills (FMS) in early years can lead to a disinterest in physical activities, lack of fitness, low self-esteem and health problems as they grow older (Brown, Walkley, & Holland, 2004). Research has shown that between 30% and 87% of children who reported these difficulties continued to have them during adulthood (Williams, Thomas, & Kirby, 2015). Some children with impaired coordination may not become involved at all in social physical play and they are at risk of becoming isolated and solitary in the school playground. School-aged children with the diagnosis Developmental Coordination Disorder (DCD) spend less time in formal and informal team play than other children in similar age (Smyth & Anderson, 2000). FMS may thus be an important part in motivation for being physically active and being able to participate in social physical play.

PHYSICAL EDUCATION AND SCHOLASTIC PERFORMANCE

In several countries there has been a trend of decreasing academic achievements (OECD, 2010). Many students leave compulsory school without being qualified to apply for higher education. The relationship between PA and scholastic performance could thus be of international interest.

To qualify for national upper secondary school programs in Sweden the grade Passed in each of the subjects Swedish, English and mathematics was required in the years 1994 through 2012. Despite efforts the number of Swedish students who finished the 9th and final year of the compulsory school with eligibility for upper secondary school programs has decreased. In spring 2009, the proportion of qualified students were 88 percent in Sweden (National Agency for Education, 2009) and 86 percent in 2015, which is the lowest percentage since 1998. In 2018 only 84 percent of students in Malmö qualified for upper secondary school. This is a paradox since researchers claim that 100 percent of Swedish students have the potential and capacity to reach the goals in all school subjects (Ekman & Dolan, 2010).

Research studies support Physical Education (PE) as an important component of children's health and wellbeing. But many schools have reduced time for PE, in an effort to increase students' academic performance. However, no empirical evidence exists to suggest that the reduction of PE is related to higher academic achievement. In fact, empirical evidence shows that aerobic fitness and good motor skills are positively associated to academic achievement, and body mass index (BMI) has a negative relation (Hillman, Erickson, & Kramer, 2008). Many of the educational benefits claimed for PE and school sport are however dependent on contextual and pedagogic variables. Type of activity and psychological factors (e.g., self-esteem and depression) could mediate the association between PA and academic performance (Bailey, Armour, Kirk et al., 2009). PA can promote scholastic performance in a broad sense. Whether it does so, depends on active participation and engagement in the physical activities. Initiatives and adjusted practice to increase motivation and competence for participation is thus essential. Increased focus on and time for PA with qualified activities can be a possible way to promote motor skills, school performance as well as motivation for participation in PA (Bangsbo, Krustrup, Duda et al., 2016).

In eleven of 14 studies Rasberrya, Leea, Robina et al. (2011) found one or more positive associations between school-based PE and indicators of academic performance; three studies found no significant association. The studies examined increased PE time and/or improved quality of PE, e.g., trained instructors and increasing active time during PE class.

Costa, Abelairas-Gomez, Arufe-Giraldez et al. (2015) emphasize the importance of PE and qualified PE teachers in child development. In an experiment, motor skills activities were used to enhance children's overall development and body awareness. For 24 weeks, three-year-old children (n=47) underwent a structured PE plan conducted by a PE teacher. The sessions included e.g., motor coordination, overall coordination, spatial structure, body knowledge, and laterality. The control group (n=48) also had PA in the school playground, but it was not structured or conducted by a PE teacher. The results showed that ability scores were significantly higher than in the control group, for all measured abilities: Coordination and Balance, Body Scheme, Temporal Organisation, and Spatial Organisation.

Structured PA by the school´s PE teacher versus unstructured PA in 12 to 17-year-olds (n=439) was found to have beneficial effects on executive functions, e.g., attention, concentration, non-verbal fluency, and mental flexibility. Both groups received the same amount of PA (120 minutes six days per week) during a 6-month intervention period and showed improved performance, with significantly better scores on all constructs measured in the group who received structured PA compared to unstructured PA (Subramanian, Sharma, Arunachalam et al., 2015).

In a meta-analysis by Singh, Saliasi, van den Berg et al. (2018) only 11 out of 58 included intervention studies received a high-quality rating for methodological quality. All high-quality studies measured the effects of additional/adapted PA activities compared to regular curriculum activities. For academic performance, 15 of 25 analyses found a significant beneficial effect of PA, and beneficial effects on mathematics were reported in six out of seven outcomes. PA programs were only effective if they were carried out for a longer period of time and with a certain frequency. The programs where positive effects on children's math performance were reported ran for approximately 2–3 school years and additional PA was offered 3–5 times per week. The conclusion is that there is strong evidence for beneficial effects of PA in school on mathematic performance.

In 39 intervention studies Fedewa and Ahn (2011) found significant effects on children´s achievement and cognitive outcomes from perceptual motor training, regular PE classes and aerobic training. But there were no significant effects from resistance/circuit training and no positive association was found between muscle strength and scholastic performance. Significantly higher effect sizes were found when PA was provided three compared to two times per week. Elementary age children were found to benefit the most. Cognitively impaired or physically disabled children appeared to benefit even more than typically developing children.

Engström (2005) conducted a survey among approximately 2000 randomly selected 15-year-olds in different parts of Sweden and followed most of them in their middle ages. He found that attitudes towards the school subject PE and especially grades in the subject were highly associated with later PA habits. Of those who had the highest grade 60 percent were physically active 33 years later, whereas less than 20 percent of those with the lowest grade were active sports practitioners at 47 years of age. He suggests that skills that you are good at you are likely to continue with. The relationship between grades in PE and later PA may be due to the fact that the actual skill in sports practice is the important underlying factor.

According to previous research the majority (88 percent) of Swedish students participate in the school subject Physical Education and Health (PEH) (Lundvall & Meckbach, 2008). Ericsson and Cederberg (2015) studied compulsory school students who failed to achieve sufficient grades for upper secondary school (n=389), about one in five students in the city of Malmo, and found a comparatively smaller proportion (61 percent) who usually participated in PEH lessons grade 9. The results revealed that less than 50 percent were physically active in PEH lessons, and 14 percent never participated. Forty-five percent were never physically active during their spare time and 29 percent failed to reach the goals in PEH in this specific group of students. Significant correlations were found between the level of PA and grade in PEH, as well as between PA and total grades. Grades in PEH correlated with grades in Swedish, mathematics, and English. Students who responded that they skipped lessons once a week or more, had significantly lower grades in PEH and in total than students who never or less often skipped school lessons.

Reasons for students not to participate in PEH-lessons can be, according to teachers, for example: today's focus on body frame, that students find it embarrassing to show their skills and/or body to others, uncertainty, poor self-esteem, lack of interest, and that students who play truant from other subjects also play truant from PEH (Franzén, 2009; Larsson, 2003). In a study among students with low motivation in PEH (Åström, 2009), the interviewed students revealed perceptions of incompetence, and that they were not able to perform tasks put forward by the teacher, or to perform tasks good enough compared to their classmates.

The findings of the relatively low levels of PA among students who fail to qualify for higher education and the significant correlation between grades in PE and scholastic performance indicate the importance of examining how schools can improve students' self-esteem and motivation to be physically active and participate in PE and other lessons.

Physical Education and Health in Sweden

In Sweden the school subject is called Physical Education and health (PEH). The teaching should be research-based, which means that there should be evidence to support any teaching methods and knowledge used by school teachers (Socialstyrelsen, 2016). According to the Swedish curriculum basic motor skills are significant parts of the goals for students to achieve in the school subject PEH. In the syllabus (Skolverket, 2018) a clear aim can be noticed that all students should develop their motor skills and motivation for PA. The students are supposed to develop their physical, psychological, and social ability and additionally a positive self-image. A basic aim of the subject is to create conditions so that everyone can participate in different activities on their own terms, develop a sense of community, and ability to co-operate, as well as an understanding and respect for others.

Another basic part of the PEH subject is for students to develop an all-round competence in physical activities, since a repertoire of all-round physical activities is supposed to provide a ground for an active and healthy lifestyle. A positive experience of movement and rhythm promotes different motor skills. "The teaching should create the conditions for all students to participate continuously in the physical activities of the school throughout their school hours and contribute to that students develop a good body perception and confidence in their own physical ability" (Skolverket, 2018, p. 1). The purpose of the PEH subject is in summary that students develop movement competences and interest in being physically active (Skolmyndigheten, 2018).

However, a national evaluation of the Swedish school subject PEH revealed that ten percent of the students felt bad and clumsy during PEH lessons and that seven percent of the girls did not reach the subject's goals (Eriksson, Gustavsson, Johansson et al., 2003).

The syllabus (Skolverket, 2000) states that the school in its teaching of PEH should aim to ensure that students

- develop a keen awareness of their own bodies, and a knowledge which makes it possible to see, choose and evaluate different forms of exercise from a health perspective,
- develop a permanent interest in regular physical activity and take responsibility for their own health,
- develop and strengthen their ability and desire to exercise, as well as be encouraged to express their imagination, feelings and sense of community,
- develop the ability to play, exercise and take part in sports on their own and together with others. (pp. 19-20)

Among goals that students should have attained by the end of the fifth grade are to

- be able to manage basic motor activities and perform movements with balance and body control, as well as be able to perform simple dances and movements to music. (p. 21)

By the end of the ninth grade students should have attained the following goals:

- understand the relationship between food, exercise and health, and be able to apply a knowledge of ergonomics in everyday situations,
- be able to participate in games, dance, sports and other activities, and be able to perform movements appropriate to a task,
- be able to design and carry out activities for their own exercise, – have a knowledge of common physical activities and how these can be performed safely. (pp. 21-22).

In a later syllabus for the subject (Skolverket, 2018, p. 2) the central content involves motor skills in different grades:

- Fundamental movement skills, such as running, jumping and climbing. Their composite forms in equipment exercises, games, dances and movements to music, both indoors and outdoors (grades 1-3)

- Composite basic forms combined with gymnastic tools and other tools (grades 4-6)
- Complex movements in games, games and sports, indoors and outdoors, as well as dances and moves to music (grades 7-9).

Students who have high grades in the school subject PEH often have high grades also in other subjects (Thedin Jakobsson, Lundvall, Redelius et al., 2012). How teachers evaluate and grade their students is of great importance for how students value their abilities, how they understand what knowledge is important to learn, and additionally their self-esteem. Several grading criteria in PEH include different forms of motor skills, e.g., balance, precision, speed, motor control, mobility, functional exercise program, adapts body movements, movements appropriate to a task, and appropriate movement patterns. But when students are asked what they think would give them a high mark in PEH, the answers vary from cooperation and social competence, doing their best to having a fighting spirit and a positive attitude. Very seldom motor skills are mentioned, although many students put forward physical condition, strength, technique, or having good sport results (Redelius, 2009). Most of the students look upon the assessment as a form of sport competition (Larsson, 2009).

Grading criteria for PEH (Skolverket, 2000) include the ability to perform movements with control and precision as well as with regard to rhythm. Students' ability to use the body for composite and complex movement patterns in an appropriate manner as well as a variety of the physical activities should also be part of the assessment, according to the syllabus. But when teachers are interviewed about what the students are supposed to learn in the subject, they rarely mention motor skills as a goal for students to achieve. Among teachers´ grading criteria the following can be found: Sports results, social ability, helpfulness, and having a positive attitude (Redelius, 2007).

There has been some criticism regarding the forms and contents of PEH lessons, which sometimes seem to be the same as in sport federations. Ball games and other team sports are frequently on the schedule. In an evaluation of the subject (Skolinspektionen, 2018) a questionnaire was given to students in grades 7-9 and their teachers at 100 randomly selected Swedish schools. In 22 of the schools included in the survey, observations during lessons were made. Interviews of students, teachers and principals and documentary studies were also conducted, in order to evaluate the design and quality of the teaching. The visited schools and student answers show that ball games and competitions are frequently used during PEH lessons, followed by activities aimed at improving the students' fitness and strength. Any teaching of movement skills were not seen during these observations.

There seems to be a large amount of confusion concerning teachers´ perspectives on the subject´s goals, content, knowledge to achieve, and what grading criteria to use in the subject. Teachers also value boys´ achievements higher than girls´. PEH is the only school subject where girls have significantly lower grades than boys.

Motor Skills Learning

Motor skills development can be regarded as a lifelong process, which begins already in the fetal stage and continues in a life-long process. A newborn child´s motor skills are undeveloped, and unnecessarily large and unmotivated movements in children's motor skills can be seen up to the age of eight years. Small children often perform gripping movements with both hands at the same time, whether necessary or not (Åhs, 1981).

Children's motor development appears to follow a pattern with certain determined stages or phases, which are approximately similar to all children. Motor development is about solving motor tasks with greater and greater variation and flexibility. Neuromotor development occurs in the same order in much the same way in all children, so that previously learned skills form the basis for the following. The child's motor skills undergo a development that corresponds to the central nervous system, e.g., to pave the way for impulses from the brain through synapses (contact between nerve cells) out to the muscles. Holle (1978) describes the child's motor development in four phases:

1) Reflex movements (without the brain's involvement)
2) Symmetrical movements (beginning brain involvement)
3) Intentional, motivated, differentiated movements
4) Automatized movements

When the child can stabilize the body in different positions, it can use inherited movement programs and also learn new intentional movements. Gradually as the nervous system develops, the child can learn more advanced and finely coordinated movements. The speed of these changes varies from child to child in the same age group. The speed of development can be affected with moving experiences and training when the previous patterns are developed and automatized (Mortensen, 1997). Children will expand and refine their movement repertoire and action strategies if they are given the opportunity (Gjesing, 1997).

Motor development is assumed to follow three development principles:

1) The cephalo-kaudal (top to bottom) principle
2) The proximo-distal (from central to peripheral) principle
3) The principle of differentiation and integration (from gross motor skills to refined accurate movement patterns)

According to the cephalo-kaudal principle, the motor development goes from above, i.e., from the head down to the feet. That means that first of all the child learns to lift the head, then the chest and when the child reaches control over the hip part, it can learn to sit. The child first gets control over the muscles near the head, and then the muscles of the trunk, and finally the muscles in the legs, feet and toes. The proximo-distal development principle means that centrally located body parts develop before periphery, i.e., the arm and leg muscles develop before the child gets control of the fingers and toes.

The principle of differentiation and integration means that basic movement control is achieved before babies and young children can learn to control their body and limb movements. These FMS will be refined, modified, and varied to become new movement patterns, e.g., fundamental play-game skills like running, jumping, and functional hand skills for daily living tasks (Keogh & Sugden, 1985).

Children's motor development is often described in different stages. These descriptions can never be comprehensive because the transition from one stage to another takes place successively and without any clear limits. The movements that a child naturally does during each of the stages are important not only for the motor development but also for perceptual and brain development (Sandborgh-Holmdahl & Stening, 1993).

Several researchers have observed and chronologized the child's early motor and perceptual development, e.g., Holle, Bønnelycke, Kemp et al. (1984). How children acquire the ability to move can vary between rolling, crawling and creeping movements. A variation is also noted between boys´ and girls´ motor development, especially in various jumping exercises such as hopping, skipping, jumping on one leg, and rope skipping. Girls tend to do any hopping tasks sooner and better than boys do (Keogh & Sugden, 1985). Also, Holle et al. (1984) report, from a statistical analysis and standardization of Danish children's motor development, some differences between boys´ and girls´ motor skills before the age of 6-7 years. Boys for example, have a little more muscle strength at five months of age, while girls seem to be previously developed in terms of jumping exercises and in skills which requires coordination and neurophysiological development. Girls can generally do hopping tasks eight months before boys.

Many studies support the theories of motor development phases and combinations of motor skills. In certain periods the influence of specific functions is particularly sensitive, e.g., walking stimulation when the child is about one year old. Combinations of motor skills develop when FMS are automatized. This means that the child's motor skills should be developed as versatile as possible up to 9-10 years of age, and only after that be subjected to more specialized training (Åhs, 1981).

In an educational perspective, and according to theories of motor development phases, a child who do not master a certain motor skill should be offered the skill that comes earlier in motor development, so that this is learned and automatized. This reduces the risk of failure and reduced self-esteem. In this way you avoid stimulating the child into a function he/she is developmentally not ready for, by always following the development phases order (Holle, 1978).

According to the motor skill learning theory, preadolescence is the optional time to develop and maintain FMS, reaction time, and attention. The timing of brain development and associated neuroplasticity for motor skill learning makes the preadolescence period a critical time to develop**,** reinforce and automatize FMS in boys and girls (Myer, Faigenbaum, Edwards et al., 2015). Children who do not participate regularly in structured motor skill-enriched activities during PE classes or sports programs may never reach their genetic potential for motor skill control which underlies sustainable physical fitness later in life. Youth who are ill-prepared for play and sport have fewer opportunities for positive social interaction and are less likely to experience enjoyment of PA (Myer et al., 2015).

In a systematic review and meta-analysis Morgan, Barnett, Cliff et al. (2013) included 22 articles. All studies reported significant intervention effects for FMS. The meta-analyses revealed large effect sizes for overall gross motor proficiency and locomotor skill competency. There was a medium effect size for object control skill competency. The author´s conclusion is that school- and community-based programs that include developmentally appropriate FMS learning experiences, delivered by PE specialists or highly trained classroom teachers, significantly improve FMS in youth.

Competence or competent functioning requires appropriate learning experiences; it does not emerge spontaneously. In social cognitive theory, formulated by Bandura (1997), striving for competence is motivated by benefits of competent actions. Cognitive guidance is especially important in the early phases of skill development, when a cognitive representation of the skill is formed. It is of importance that any feedback given is structured to build a sense of personal efficacy as well as a specific skill. Corrective feedback that highlights successes and directs attention to relevant aspects of sub skills aids the development of proficiency. Informative feedback improves the performance as well as facilitates observational learning for similar activities. Skills are perfected by repeated corrective adjustments in a conception-matching process. With continued practice, skills become fully integrated and are executed with ease. Once a skill becomes routinized, i.e., automatized, it no longer requires higher cognitive control. The execution can then be regulated by lower sensory-motor systems in managing recurrent task demands. “After people develop adequate ways of managing situations that recur regularly, they act on their perceived efficacy without requiring continuing directive or reflective thought” (Bandura, 1997, p. 34). This disengagement of thought from action performing has considerable functional value. Having to think about details in every skilled activity would consume most of the brain’s attentional and cognitive resources.

The automatization on of complex skills involves several processes, in which Bandura (1997) outlines three major steps, which are also central in the practice of the so called MUGI [Motorisk Utveckling som Grund för Inlärning] model for motor skills training:

1) Segments of a skill is merged into larger skills until it becomes a fully integrated routine that no longer requires cognitive organization or linkage.
2) Production of contextual linkages. Practiced actions which are repeated in similar situations are linked to similar contexts so that performers respond instantly without having to think about what to do.
3) The brain shifts from attention of execution to result of the action.

Motor Skills and Self-Esteem

Physical self-concept is known to be an important part of self-definition in childhood (Harter, 2003). Raudsepp, Neissaar, and Kull (2013) found a reciprocal relationship between physical self-worth and PA in early adolescent girls (n=272). In a study by Ericsson and Karlsson (2011) significant correlations were found between motor skills and self-esteem overall and between motor skills and two components of self-esteem: *friendship/sports efficacy* and *attention/learning efficacy*. Favorable perceptions of one's physical capacity contribute to an increase of participation in PA. Furthermore, efficacy beliefs can predict enduring changes in lifestyle activity patterns. Belief in one's physical efficacy has been found to be a better predictor of long-term engagement in everyday physical and social activity than physiological capacity, age, or perceived exertion (Bandura, 1997).

Ericsson and Cederberg (2015) found in a study of students who did not qualify for upper secondary school (n=389) that students who had good self-esteem were significantly more physically active than those who had low self-esteem. Evidence indicates that motor competence (MC) is positively associated with perceived competence and multiple aspects of health (i.e., PA, cardiorespiratory fitness, muscular strength, muscular endurance, and healthy weight status). Children (11 years old) with low MC performed poorer on fitness tasks, were less physically active and had lower perception of athletic competence and social acceptance than children with high MC (Vedul-Kjelsås, Stensdotter, Sigmundsson et al., 2015).

Children whose fitness is poor and whose motor skills are insufficiently developed often develop a negative self-image and end up in a downhill spiral leading to less and less PA. Some children do not participate in sport or exercise because they have not established early coordination skills while at school. Researchers who found low motor skill levels among children in Australia claim that more children and young people would play sport and take part in other physical activities if they had better motor skills (Brown et al., 2004). However, research has shown that engagement in organized team sport does not necessarily increase physical self-worth and exercise habits in a lifelong perspective (Hofstetter, Sallis, & Hovell, 1990). One of the criticisms of teaching approaches that are directive and focus on the execution of skill is that they actually can discourage the less skilled from participation by highlighting what they can't do in front of their peers and the teacher (Light & Fawns, 2003).

Boys often have higher levels of perceived competence and greater self-esteem than girls in relation to sport activities (e.g., Moreno, Gimeno, Lacárcel et al., 2007). These differences may reflect underlying growth and developmental influences since children and adolescents undergo physical changes that affect the physical development of both boys and girls, as well as the process of personal and social identity construction. Teachers need to be aware of and pay attention to these matters to be able to increase, and not decline, students perceived self-efficacy. Ruiz-Pérez, Palomo-Nieto, Gómez-Ruano et al. (2018) interviewed female adults about their experience of clumsiness and low motor competence in PE classes during their school stage. The narratives revealed the role that the PE teachers played in their experiences of awkwardness, the absence of help or advice to learn the skills and the hostile behaviors that teachers could show to them. In addition many teachers confused a motor coordination difficulty with a problem of attitude and motivation. School PE thus seems to be one logical and practical point for intervening in the damaging cycle described above.

Motor Skills and Scholastic Performance

Cognition is grounded in perceptual-motor experiences within social and cultural contexts and perceptual-motor behaviors can facilitate future development and advance readiness to learn in school (Lobo, Harbourne, Dusing et al., 2013). According to Rosenbaum, Carlson, and Gilmore (2001) intellectual skills and perceptual-motor skills are psychologically more alike than different and they are learnt in fundamentally similar ways.

Children´s cognitive functioning can be facilitated by well-developed gross motor skills and higher levels of motor control are associated with higher levels of cognitive function, working memory and processing speed (Westendorp, Hartman, Houwen et al., 2011). Perceptual-motor behaviors has been found to facilitate readiness to learn and improve scholastic performance in school. In a study by Son and Meisels (2006) 12,583 children in US kindergartens were included. The results showed that gross motor skills and visual motor skills were unique, significant predictors of first-grade reading and mathematics achievement. The study indicate that there are longitudinal relations between early motor skills and skills in later cognitive achievement. These findings support the hypothesis that motor skills are related to later cognitive achievement and that early motor skills screening could successfully identify children at risk for academic underachievement later in school.

Gross motor skills of 7- to 12-year-old children with learning disabilities (n=104) were compared with motor skills of typically developing children (n=104) by Westendorp et al. (2011). The children with learning disabilities scored poorer on both locomotor and object-control than their typically developing peers. Significant relationships were found between reading and locomotor skills and between mathematics and object-control skills: the larger children's learning lag was, the poorer were their motor skill scores.

Children´s gross motor skills and cognitive function (n=118) were examined by Draper, Achmat, Forbes et al. (2012). The children took part in exercise play with opportunities to develop and master motor skills. The results showed statistically significant improvements in the cognitive scores of children who participated regularly in the program. Children exposed to eight months of intervention had significantly better overall scores for locomotor and object control skills compared to a control group. The findings suggest that even limited exposure to a low intensity program for motor development can positively impact gross motor skills and cognitive function in preschoolers. The authors conclude that play and opportunity to develop and master FMS form the foundation for the development of skills that can be used in sport later in childhood and adolescence. Participation in motor skills play can also serve to enhance the social skills of participants and increase levels of self-efficacy regarding motor skills.

Motor skills training and regular PA has been found to enhance corticomotor development and academic performance in school age children and in a consensus conference 24 researchers conclude that mastery of FMS is beneficial to cognition and scholastic performance in children and youth (Bangsbo et al., 2016). It is, however unclear whether simple aerobic exercise (such as walking or running) without a cognitive component or motor skills training without an aerobic component, assists developing cognitive functions in growing children. The effects of a nine-month controlled intervention on working memory in preadolescent children (n=43) were studied by Kamijo, Pontifex, O'Leary et al. (2011). The intervention had focus on improving cardiorespiratory fitness and the children participated in at least 70 minutes of motor skills practice and moderate to vigorous PA per day. Children also engaged in games with a skill theme (e.g., dribbling) and small-area games were part of the motor skill practice. The results indicated that increases in cardiorespiratory fitness were associated with improvements in the cognitive control of working memory in preadolescent children. However, the beneficial effects of the PA intervention were greater for tasks, which required greater working memory demands. The activities were aerobically demanding, but simultaneously provided opportunities to refine motor skills. Gao, Hannan, Xiang et al. (2013) found beneficial effects on math scores from a video-based dancing intervention 3x30 minutes per week. Although the intervention included high intensity PA it also included motor skills and cognitive challenges, as children had to carry out the increasingly difficult instructions they saw on the screen. Thus, it is not clear if it was the PA, the cognitive load, motor skills or the combination of these factors that caused the effect.

In a study by Koutsandréou, Wegner, Niemann et al. (2016) the effect of different types of exercise programs were examined on primary school children's working memory. The 9-10 year old children (n=71) were randomly assigned to a cardiovascular exercise (CE) group, a motor exercise (ME) group, or a control group, who had assisted homework sessions. The intervention involved ten weeks of 45 minutes afterschool exercise, three times per week. Working memory performance benefited from both the cardiovascular and the motor exercise programs, but not from the control sessions. The increase in working memory performance was significantly larger for children in the ME compared to the CE group.

Sjöwall, Hertz, and Klingberg (2017) found no effect of a high intensity CE intervention, neither on working memory nor on arithmetic performance in preadolescents, age 6-13 years. The intervention school (n=228) increased PA (aimed at increasing cardiovascular fitness) from two to five times per week while the control school (n=242) remained at two days. PA classes in the intervention school were high intensity based and consisted of aerobics classes, obstacle course, boxing, rope skipping, running, and various forms of high-intensity play. There was no beneficial development of working memory or arithmetic performance for the intervention school as compared to the control school. However, a significant increase in self-rated stress was detected for the intervention school, more in girls than boys. These results indicate that high intensity PA does not lead to a beneficial development of working memory or arithmetic in preadolescent children. Motor skills training and special motor demanding interventions thus seem to be a better strategy to improve working memory and mathematics in preadolescent children than CE or high intensity PA.

MUGI = Motorisk Utveckling Som Grund För Inlärning

The MUGI model – Motor skills as Ground for Learning (in Swedish: Motorisk Utveckling som Grund för Inlärning), an education program, started in Lund in the early 1980s (Ericsson, 1987). The model was developed in collaboration with the school health service and started as a local PE project. All six-year-old children from three preparatory schools took part in the MUGI motor training program 60 minutes per week in the school's PE hall and under the superintendence of the school's teacher in PEH. When starting school the children who needed extra motor training were offered to come and practice with the PEH teacher in a smaller group one hour per week as long as they needed it. An evaluation of the MUGI model showed that the extra motor training had positive effects on children's motor control and perception. The MUGI trained children had, when they started school one year after taking part of the MUGI motor training program, significantly better balance, coordination, and ability to remember details than children who had not participated in the MUGI program (Ericsson & Lindström, 1987).

The MUGI Observation Checklists

The MUGI model includes motor skills observations of all children at school start, information to teachers and parents, and when needed, offers of extra motor skills training. We felt a need of early identification of children with any problems or difficulties in motor skills in order to give early support and stimulate their motor skills development. We wanted to identify children in need of adapted motor support while the children still had a positive movement experience. The MUGI observation checklist emerged from this need after a number of other motor skills tests had been found too complex and tiring for the children, too complicated for teachers to use, and/or too time consuming. In the construction process some challenges had to be considered: The sense of test situation should be avoided as far as possible; no measuring instruments were used and no maximum performance was measured. The exercises would be varied, not too many of them and they should not be tiring for the children; therefore, playful gross motor movements were focused. A little boy suddenly bursts out after a jump in the easy obstacle course: "- Oh, it's like at the amusement park! Only this is for free!" This felt as if the goal that children would feel enjoyment of PA had been achieved.

The MUGI checklists consists of nine gross motor tasks measuring two variables of motor skills: *balance/bilateral coordination*, e.g., hopping and balancing on one leg and *eye-hand coordination* with tasks like throwing, bouncing and catching a ball. The observation checklists have been validated and tested for reliability, which has been described in earlier publications (Ericsson, 2003, 2008, 2014) and have been found to fulfil the criteria of validity and reliability as assessment tools for motor skills and group comparisons. The principles of the MUGI motor observation checklists can be summarized as:

- The motor observations give an early indication of children in need of extra support in motor skills development
- Children´s joy and pleasure are important goals
- There are no clear test situations

- No measurement of strength, speed, or maximal exertion is conducted
- There are no fixed instructions
- 10-12 children are observed together
- The MUGI motor tasks are relatively easy to observe and evaluate

The MUGI Motor Skills Training

After the motor skills observations have been carried out children in need of extra motor training are offered adapted gross motor skills practice under the supervision of a PE teacher in a smaller group one hour per week for as long as they need it. The training is a part of the school's remedial teaching program for children with difficulties in motor skills and perception. With better motor skills the students hopefully will improve in self-esteem, attention ability and social qualities. The MUGI model for motor skills training is built on the assumption that embodied cognition is attained through sensory–motor interactions and experienced automatization of FMS. The MUGI theory was developed with inspiration from the social cognitive theory (Bandura, 1997) and the concept self-efficacy. According to the social cognitive theory cognitive guidance is especially important in early phases of skill development. The MUGI model suggests that perceived self-efficacy as well as physical self-esteem is associated with success in school work and that they both might be positively affected by success in motor skills and physical activities. Based on earlier research (Ericsson, 2003, 2008; Ericsson & Karlsson, 2011) and practice of the MUGI model, the following theoretical assumptions regarding the relationships between PA and scholastic performance can be summarized as follows: Improvements and automatization of FMS lead to increased physical self-esteem, which give better prerequisites for attention and comfort in school, which lead to increased motivation to learn and to attend classes. An illustration of this positive spiral is shown in Figure 1.

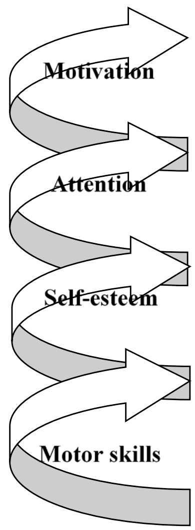

Figure 1. Theoretical assumptions in the MUGI model: Improvements and automatization of FMS lead to increased self-efficacy and physical self-esteem, which give better prerequisites for attention and comfort in school, which lead to increased motivation to learn and to attend classes.

Many children with motor skills problems have experienced a lot of failure when asked to do coordination or balance tasks during PE lessons. The failures are probably perceived even worse by being visible and obvious to all classmates. Therefore the MUGI model for motor skills training is based on the principle of success (instead of failure), i.e., the children are never asked to do things they cannot perform or feel uncomfortable doing, but instead offered tasks with the aim of automatization of skills coming earlier in motor skills development. One of the most important goals in the MUGI model is that children feel motivated and enjoy taking part in PA. It is important that the focus is on what each child wants to learn, that the goals are achievable, and that the child takes pleasure in practicing. Since children are often very good at finding skills they need to practice, the introduction to the training often includes questions like: "What do you think would be a good skill for you to know? "What would you like to learn?"

Learning motor skills and body knowledge provides enjoyment in PA and increases self-esteem, which is a good foundation for all learning (Bandura, 1997). Motor skills training should never be felt as a compulsion, and children should not be encouraged to train what they feel uncertain about. Only when the child feels comfortable should it practice. It is thus a challenge for the teacher/instructor to use his/her knowledge in motor skills development and imagination to motivate the child so that it will be fun to practice, move and play together.

Adults who work with children's physical exercise need to have a good knowledge of children's motor development. It is not, so to say, good enough to just run around having fun with the child. A child who has difficulty with an exercise should be encouraged to perform exercises in the previous development phase in many different contexts, several times every day, until the movements are automatized and the child can perform the movements while thinking about something else (e.g., does not stop moving when answering a question).

It is important that the teacher/instructor makes sure that the previous step in the motor development chain is really automatized, before more difficult tasks are given. This requires that the instructor has good knowledge of how the natural motor development chain looks like, i.e., which motor skills are generally learnt and automatized at different ages and in which order most children learn them. One should avoid stimulating the child into a function that it is not developmentally ready for. A child, who does not master a certain degree of motor skills, should accordingly be offered the skills that evolve at an earlier age, in order to make this skill automatized. When a child has failed, e.g., to keep the balance on a leg, the child´s motivation to practice that skill decreases after a while. Trying to jump on one leg may feel more stimulating and if this is also difficult: try to jump forward on one leg or both legs. When jumping forward is automatized, it may be time to try jumping on one leg again, etc. This procedure reduces the risk of repeated failing in front of comrades. To avoid failure is particularly important in children’s motor training, where a failure appears so clearly and becomes so obvious. A well-visible failure probably involves greater risk of developing a negative self-image and less self-esteem than other less visible failures, where the body does not participate, and where a failed attempt is not so prominent. The principles of motor training according to the MUGI model can be summarized as follows:

- Movement joy is an overall goal
- That the child succeeds, instead of failing, is important
- No training of exercises that the child cannot perform, i.e., if the child feels uncertain or uncomfortable
- Automatization of skills at the development level that comes before the skill the child cannot perform
- Since children are often good at knowing what they need to practice, initial questions to them may be: "What would you like to be able to do? and/or "What would you like to learn?"
- No weight training with weights before puberty!

Children's learning in motor skills and technic are greatest between seven and nine years of age. Before puberty, endurance and strength training do not have any significant effect. Consequently, the focus should be on the automatization of FMS and movement patterns prior to puberty. Motor skills can be practiced and beneficially learned in the ages of 6-10 years. For automatization of FMS, the following suggestions could be starting points for practicing in different ages:

- 0-3 years - Gross motor skills: Roll, crawl, creep, jump, spin, swing, balance, hang.
- 4-6 years - Continued training of FMS, for automatization in different contexts and situations.
- 7-9 years - Composite movements, i.e., combination of motor skills that allows simultaneous movements of different parts of the body. Balance ability, finding and maintaining equilibrium in different situations, belongs to combination of motor skills.
- 10-12 years - Specific sports skills. Note that early specialization is not necessary to succeed as an elite sportsman! Automatization of FMS, varied training and a wide range of movement repertoires are more important!

This way of working with motor skills training may affect how children perceive physical activities in the playground, which may in turn affect their attitudes to physical exercise and to what extent they continue to be physically active after they have finished school.

OBJECTIVE

The aim of the nine-year pedagogical intervention study was to investigate long-term effects on motor skills and scholastic performance of increased PEH and extra motor skills training according to the MUGI model. In addition the implementation and society gains of the Swedish Bunkeflo project, also called the Pediatric Osteoporosis Prevention (POP) study, are accounted for.

Research Questions and Hypotheses

The following questions served as starting points in the MUGI study:

- Will children's motor skills (balance and co-ordination) improve with extended physical activity and motor training in school?
- Will extended physical activity and motor training in school affect children´s attention?
- Will extended physical activity and motor training in school affect children´s academic achievements?
- How will extended physical activity and motor training in school affect children with deficits in motor control and attention?
- Will boys and girls be affected differently by the intervention?

The MUGI-study was hypothetic-deductive and had three hypotheses:

- Children's motor control will improve with extended physical activity and extra motor training in school.
- Children's attention will improve with extended physical activity and extra motor training in school.
- Children's scholastic performance will improve with extended physical activity and extra motor training in school.

Intervention with Daily PE and the MUGI Model for Motor Skills Training

The Swedish *Bunkeflo Project – a healthy way of living* involves different research studies, the MUGI study being one of them and the Pediatric Osteoporosis Prevention (POP) study another. According to Fritz (2017) the greatest effect of PA on musculoskeletal health occurs during childhood. Increased PA for all children could thus be a strategy to improve bone mass, bone structure and muscle strength. The MUGI and the POP studies are population-based prospective controlled exercise intervention studies. All students in three school years at two schools in the south of Sweden were studied for nine years. PEH was made a daily compulsory subject for all students who started school since 1999 at one of the schools involved in the project. This school, Ängslättskolan in Bunkeflostrand, was the first school in Sweden to put PA on the schedule one lesson every school day. An important goal with the intervention was for children to feel motivated and experience joy when taking part in PA.

The school day was prolonged with 45 minutes and the intervention group had PEH on the schedule five lessons (5x45 minutes) per week and also if needed one extra lesson (60 minutes) of MUGI motor training per week. The control group had the school's regular PEH two lessons (2x45 minutes) per week. In total 251 students were included in one intervention group (n=152 in seven classes) and one control group (n=99 in five classes).

All parents were informed and gave their written consent; only the parents of two children choose not to participate in the study. The research was conducted according to the principles of the Declaration of Helsinki.

When starting school all students participated in motor skill observations according to the MUGI model conducted by the school nurse and the children's teachers. In order to study development of motor skills, observations with the MUGI checklists were conducted by the school nurse and the children's teachers in the same way every year the first three school years and finally in grade 9. Students in the intervention group who needed extra motor training were offered this according to the MUGI model. This meant that some students had PA on the schedule six times per week in the Bunkeflo project.

Implementation of the Bunkeflo and MUGI Model

Before introducing the intervention with daily PA and extra motor skills training some questions about implementation had to be considered. Implementation is about different approaches for introducing new methods into an activity (Socialstyrelsen, 2018). If you use the knowledge available on implementation, there is a much greater chance that an intervention or change is going to work as planned. Sometimes it may take several years before a new method has been integrated and become part of the regular work. Implementation research in healthcare, crime prevention and social work shows that with knowledge about implementation, an average of 80 percent of the planned work changes are carried out within three years. Without such knowledge, only 14 percent of the work changes have been completed after an average of 17 years. The Swedish National Board of Health (Socialstyrelsen, 2018) describes the implementation process in four phases: Needs Inventory, Introduction, Use, and Maintenance.

Needs Inventory

All changes in work and interventions should start with an inventory of the need for new methods. PE teachers in Sweden have noticed that more and more children who start school have untrained and/or inexperienced motor skills. Both the National Agency for Education and pediatricians emphasize the need to be able to discover at an early stage when pupils need special support in the teaching. The importance of early identification of children with motor skills problems is also emphasized by PE teachers, doctors and researchers, so that children in need of support get it, preferably before any motor skills deficits has caused problems for the children. The MUGI observation checklist emerged from this need after a number of other motor skills tests had been tested.

The planning for the Bunkeflo project started at the orthopedic clinic at the University Hospital in Malmö 1996 after a similar intervention study of increased PE for older students (grades 7-9) had been completed. The results showed improvements in the boys' skeleton but not in the girls´. Therefore, a previous intervention in the Bunkeflo project, was planned for, starting already in grades 1 and 2. The intervention itself started in 1999 as a collaborative project between school, sports association and research at Lund University. We wanted to study if daily PA with moderate intensity, at such a level that all children could participate in the activities, could also affect children with lower sports interests to change their health behavior and specifically enhance skeleton and improve motor skills.

Introduction

The next step is to secure the necessary resources such as premises, materials, time and activities as well as recruitment and training of staff. In order for a change to succeed, it needs to be anchored to the staff that will implement the change. Education should include information as well as exercises and continuous feedback. Implementation of the MUGI model and the Bunkeflo intervention meant a lot of preparations and considerations. Most PA interventions require a high level of commitment from school staff to be implemented.

The planning process and the coordination of the various research studies in the Bunkeflo project lasted about one year before the intervention started and was followed up with regular meetings led by the project group, where researchers, the school's principal and health promoter participated.

The idea was that intervention with daily PA, motor observation and motor support would be permanent and not "die out" when the researchers/enthusiasts left the school.

At the start of the project, the subject of PEH was extended from two to three lessons, which gave the school's PE teacher an extended opportunity to work according to the school's governing documents and achieve set goals with the teaching. Various sports associations led PA two lessons a week, in total the students received 225 minutes of PA in the school per week. In addition, students in need of extra motor support received an additional 60 minutes of motor skills training per week according to the MUGI model and under the guidance of the school's PEH teacher.

The largest local sports club, Bunkeflo IF, was involved and helped to organize and provide the extended PA. Another sports club Friskis & Svettis was also involved in a child-friendly workout at school. The only criteria of the training was that it would be generally held and at such a level that all the children could participate, and that the activity contained a large amount of joy in movements and a minimum of competitions.

The school's teachers and the sports instructors involved in the project received during education days, education in children's sensorimotor development and motor training according to the MUGI model, which is based on theories of gross motor development phases and the integration of sensory impulses. This training included observing and stimulating children's motor development at different levels. The education, which also invited other schools in the district, continued during the project with workshops, study circles and education days containing didactics of the subject PEH and motor skills development in theory and practice. We discussed what the subject should contain and how we could best utilize the extended PA to reach the curriculum and syllabus' goals for PEH.

Ängslättskolan (grade 1-5) employed a healthcare promotor with health education. This health promoter worked together with school staff, students, parents and associations and helped implementing the project. Also at Sundsbroskolan (grade 6-9) a health promoter was employed, an educated PE teacher who led PEH lessons and carried out health-promoting work at the school. The health promoter planned the activities, organized study visits to the school, held contact with the researchers, and spread information about the Bunkeflo project.

A reference group of ten PE educators from different universities and colleges in Sweden was formed to assist school teachers and sport club leaders with guidance on issues related to motor skills and PE.

Parents and other interested were invited to education days, study visits and seminars with the theme "School - a health promotion arena," which gave a positive response from the parents. Important to keep in mind, is that language, words and concepts are not always common to all involved in a project. During an information meeting, a mother raised her hand and asked: - Motor skills, what are they really? Sometimes we take for granted that everyone understand everything in the same way. In this case motor skills had to be explained: Motoric, derived from the Latin motor, (that which is moving) means movement patterns and mobility. In the Bunkeflo project basic mobility was in focus, i.e., the FMS which children may need to participate in the friends' movement play.

An unforgettable experience comes from our first information meeting with parents of the students who would get PA every school day and thus the school day extended by 45 minutes. Some uncertainty existed about the parents' reaction: How would they like their children to have longer school days and to bring sports clothes every day? How would the parents react whose children would be offered extra motor training? Was there a risk that those children would feel stigmatized? However, in my experience as a PE teacher the vast majority of children who start school have high mobility needs and are full of movement pleasure. School friends who are not in need of extra motor training can sometimes exclaim: "- Oops, do you get extra PE! I want to come too!" If resources and time admit it, some friend have sometimes come along to help out as an "instructor." This has increased the opportunity for good social relations between the peers.

The headmaster read out of the syllabus for PEH and concluded with the words: "That's what it says in the curriculum. And we will do it like this in this school!" It seemed as if the parents were grateful, nodded and bowed. Never before in my 25 years as a PE teacher, a principal had so clearly emphasized the importance of the subject PEH. Even though the school day was extended by 45 minutes, the implementation was done with the existing teaching staff, none of whom had PE teacher training.

Five different research groups conducted studies with measurements and observations on the students, including the health clinic, the child and adolescent psychiatric clinic, the clinical physiological clinic, teacher training and dental care, linked to either Malmö University or Lund University. The various research projects were funded through grants from, e.g., the General Heritage Fund, the Center for Sport Research, the Swedish Research Council, the Lund University Funds, the Swedish Medical Association, the Region of Skåne, the National Institute of Public Health, the Teacher Education at Malmö University, the Swedish Gymnastic Teachers' Association, the KK Foundation, and the GCI-GIH association.

Usage

Each method contains elements that make up the essence of the method. These parts are called core components. An important part of the implementation of a new method is to use the core components as intended. Only if the core components are used properly can it be argued that the method has been implemented correctly. When, after almost a year, teachers, school leaders, and researchers evaluated their experiences of what the daily PA and motor skills training brought about in terms of motor skills, ability to concentrate and other school achievements, the school decided that all new classes at Ängslättskolan should have daily scheduled PA. Consequently, the PA lessons gradually increased, and from autumn 2006 all children in grades 1-5 at Ängslättskolan and all students in grades 6-9 at the nearby Sundsbroskolan had at least 45 minutes of PA every school day.

Maintenance

When more than half of the professionals use a new method in the manner set aside, according to the National Board of Health and Welfare (Socialstyrelsen, 2018), the method is implemented. Operations that have managed to maintain evidence based working methods often have strong leaders who manage to show the benefits of running a research based business. Good leaders create a working climate that supports constant development and improvement of the efforts being carried out. In the Bunkeflop project, the orthopedist Per Gärdsell and the principals of the school were driving and supportive. The health promoters and school teachers, as well as assistants, contributed to the changing in teaching, and implementation of the intervention as planned.

In order to take advantage of and spread the knowledge shown by the project, the concept of the "Bunkeflo Model" was created, whose ideology is simple: Everyday PA is facilitated by identifying arenas for health promotion, where collaboration between different stakeholders creates new opportunities for exercise. The purpose of the activity is not to create world champions, but individuals who choose daily PA and a healthy lifestyle, a lifestyle that hopefully follows individuals up into adulthood. The intervention of the Bunkeflo project was transferred to the Bunkeflo Model, to emphasize that it is a working model and not a transient project. The working model consists of:

- 45 minutes of PA scheduled daily for all students
- The school subject PEH is expanded from 2 to 5 lessons per week
- The school's teachers are trained to observe and support children's motor skills development
- Motor observations are made on the basis of the MUGI observation checklist each year at school start
- Students with motor deficiencies receive adapted motor training according to the MUGI model.

The Bunkeflo model also means that other schools in Bunkeflostrand have conserved the working model by default. Already in the first project years, there were 1100 schools participating in the Bunkeflo model network. These schools have also extended the education time in PEH. The working model is thus not just a transient project but has been defined as a way of working where all students have daily scheduled PEH and where motor skills observations are routinely conducted at school start. In addition, when necessary, adapted motor training is given in smaller groups.

Data Collecting

The data collecting started in the spring term of 1999 and the intervention with extended PA started in the autumn of 1999. Adapted MUGI motor training in the intervention group started directly after the motor skill observations had been carried out.

- The teachers of special needs education at the school documented every student's reading development in grades 1 and 2. Results from these Reading Development Tests for students in the control group were obtainable already from autumn term in 1997 when the students in the control group started school.
- Results from the National Tests in Swedish and mathematics were collected during spring term in grade 2.
- In grade 3 the students were given a word test and a reading test.
- Motor skill observations with the MUGI checklists (Ericsson, 1998) were conducted at project start, and in grades 2, 3, and 9.
- Conners' questionnaire (Conners, 1999) concerning the students' attention were given to teachers in grades 1, 2 and 3 and to parents at the project start and in grade 3.
- At follow up after nine years scholastic performance was evaluated by grades in Swedish, English, mathematics, PEH and the proportion of students who reached the goals of compulsory school and qualified for upper secondary school.
- To further evaluate scholastic performance Fritz (2017) made comparisons between all students who finished compulsory school from 2003 through 2012 in all of Sweden (N=1,161,807) and students in the intervention school (N=633). Grade scores and eligibility for upper secondary school programs were evaluated in both groups. Scholastic performance could thus be compared within and between the groups before the intervention was initiated (students who finished school in year 2003 through 2006) and with

the intervention group (who finished school in year 2007 through 2012).

Analyses

Collected data were analyzed in the Statistical Package for the Social Sciences (SPSS). Since most of the measure instruments used in the study gave data on ordinal scales and collected data were mostly not normally distributed, non-parametric tests (Kruskal-Wallis and Mann-Whitney U test) were used to study differences in motor skills and scholastic peformance between the groups. The Wilcoxon Signed Ranks Test was used to compare pre to post changes.

The sample in the study was not randomized, which means that it is not strictly representative of a larger population. However, since the study included all students in grades 1 through 9 at two compulsory schools the results may still be generalized to other similar populations. According to this, analyses of significance (One-Way ANOVA) were used to study differences between the intervention and the control group. An alpha level of 0.05 was used for all statistical tests.

Base Line Data, External and Internal Validity

It could be difficult to conclude how much of any changes that were caused by the training and how much that could be explained by the child's general development and other factors during the same period. Such a factor could be that more PA and movement joy in school could lead to a spirit of community and a general increase in comfort with school work, which could have positive effects also for the students' scholastic performances. Furthermore it cannot be excluded that the teachers would expect a positive intellectual development and therefore would be more attentive and encouraging to the students in the intervention groups than usual. This positive attention could make the students more motivated so that they also learn more. In this case the teachers' expectations are still caused by the intervention, which then may have had an indirect effect on the student's academic achievements.

Social economic status, i.e., background and environmental factors such as positive attitudes among students and their parents towards being part of the Bunkeflo project, might stimulate the students to be more physically active even during their spare time, which may affect their development in motor skills. This was checked by a large questionnaire to parents. The students in the intervention group and in the control group were as alike as possible concerning the following demographic aspects. They all lived in the same area and 15 of the children in the intervention group had the same parents as 15 children in the control group. Eleven percent of both groups spoke another language at home than Swedish. There were no significant differences between intervention and control groups in fathers' or mothers' education or income. Circa 40 percent of both fathers and mothers in both the intervention and the control group had higher education (from university). The parents´ attitudes to PA and reported time spent in PA were not significantly different between the groups. There were also no significant differences between the children's amount of PA in their spare time, when comparing intervention and control group.

Contextual school factors were similar for the intervention and the control group. All students were educated by the same teachers and the school's three teachers in special needs education gave the same amount of special needs education in Swedish and mathematics in both groups. Education in motor skills observation and motor training was given to the teachers in the same way and at the same time in the intervention and in the control group. The students in the control group took part in all the school's health promoting activities except for the increased PEH and the extra MUGI motor training. The only difference between the intervention and the control group concerning their school situation was the extended PA and the extra motor training. All together the students in the intervention group and in the control group were considered to be alike, concerning school situation and demographic background.

RESULTS

The results from motor skill observations in the Bunkeflo project confirm the first hypothesis that children's motor skills will improve with extended PA and extra motor training in school. Already after one year there were rather large differences between the intervention and the control group (Cramér's index 0.24). In grade 3 the differences were very large (Cramér's index 0.37) and largest in the variable balance/bilateral coordination.

Both boys and girls improved significantly in motor skills and the differences between them decreased with extended PA and extra motor training in school. In the control group, however, differences between boys´ and girls´ motor skills increased from grade 2 to grade 3. But in the intervention group there were no significant differences, neither in balance/bilateral coordination nor in eye-hand coordination between boys and girls in grade 3. At this point, 90 percent of the boys and 94 percent of the girls had good motor skills. The corresponding values in the control group were 46 percent and 83 percent respectively (Ericsson, 2003).

The results showed that motor skills improved from grade 1 to grade 9 in both groups, but more in the intervention than in the control group so that motor skills were superior in the intervention compared to the control group in grades 2, 3, and 9. In grade 9 there were no motor skills deficits in 93 percent of the students in the intervention group compared to 53 percent in the control group ($p<0.001$). At this point 92 percent of the boys and 95 percent of the girls in the intervention group had good motor skills. In the control group 44 percent of the boys and 63 percent of the girls had good motor skills (Ericsson & Karlsson, 2014).

In the control group, which had the school's ordinary PEH, there were no measurable differences between pre- and post-test for students with small and large deficits in motor skills at project start. This indicates that motor skill deficits do not disappear by themselves, and that the school's two lessons of PEH per week are not sufficient to bring about improvements in motor skills for these students. These results are in line with other studies (Cantell, 1998; Cratty, 1997; Kadesjo & Gillberg, 1999), which confirm that without any special and adapted motor training many children with deficits in motor skills will still have these problems for many years (Ruiz-Pérez, Palomo-Nieto, Gómez-Ruano et al., 2018).

The results thus indicate that extended PA and extra motor training in school are of great importance to students with small and large deficits in motor skills, but also to students with small and large difficulties in attention when it comes to their development in motor skills. In the intervention group students with difficulties in attention improved in motor skills, while motor skills for students with similar difficulties in the control group did not improve noteworthy (Ericsson, 2003, 2008).

The MUGI observation checklists was found to be useful as a screening as well as a pedagogical instrument. It gave valuable information for planning PEH lessons, motor training in smaller groups and individual programs of motor training. The MUGI model of motor training was found to be useful in improving children's motor skills, i.e., balance/bilateral coordination and hand-eye coordination.

Attention

The results in this study show that among students with good motor skills there are also many who have good attention. The same relationship was found for students with deficits in motor skills and attention. The results show that 68 percent of the students who had small or large difficulties in attention also had small or large deficits in motor skills. Motor skills were significantly associated with ADHD symptoms (Ericsson, 2003).

The second hypothesis of the study that children's attention will improve by extended PA and extra motor training in school could not be confirmed by results in this study. The students in the intervention group had however significant better attention after one and two years of intervention, according to teachers, than the students in the control group. In grade 2 there were significant differences between the intervention and control group, in both the variables attention/hyperactivity and impulse control as well as in attention totally. But the differences were small and did not remain in grade

3, which makes it hard to draw any conclusions about whether the student's attention has been affected by the intervention or not.

However, for girls there was a positive change in attention according to parents' opinions. In grade 3 there were no differences between girls in the intervention and control group, although girls in the intervention group had a less good base line value for attention when the project started than the girls in the control group.

Scholastic Performance

Significantly higher grades in PEH were found in the intervention than in the control group and there were not any student without a grade in the subject, whereas almost four percent of the students in the control group did not receive a grade in PEH. Additionally, for students in the intervention group who had motor skills deficits at project start, the positive effects in motor skills remained from grade 2 and 3 through grade 9. These students received significantly higher grades in PEH compared to students in the control group with corresponding deficits in motor skills at project start (Ericsson, 2011).

The results showed that the amount of PA and the level of students' motor skills had an impact on school achievements in Swedish (reading and writing) and mathematics (room conception/spatial ability and number conception/thinking proficiency).

The third hypothesis of the study that children's academic achievements in Swedish and mathematics will improve with extended PA and extra motor training in school could thus be confirmed by several parts of the results. The students in the intervention group had better results than the students in the control group in the national tests of Swedish in grade 2, especially in writing and reading. In reading and writing ability there were clear connections (Cramér's index 0.27) between results and group belonging, which means that the students in the intervention group performed better than the students in the control group. In Swedish totally the difference between results for students in the intervention group and control groups were also rather large (Cramér's index 0.29) (Ericsson, 2003, 2008).

Students who had had increased PEH and extra motor training in school also had better results in the national tests of mathematics than students who had had only the school's ordinary PEH. In the variables room conception and number conception/thinking proficiency the differences were significant. The largest difference between intervention and control group was in room conception (Cramér's index 0.22). In mathematics totally the difference was also significant (Cramér's index 0.21). Boys in the intervention group had significant better results in all four mathematical tests than boys in the control group (Ericsson, 2003, 2008).

The results showed significant differences between the groups also for students with deficits in motor skills. Motor skills training seems to be more important the larger the deficits in motor skills the students have, also when it comes to academic achievements in Swedish and mathematics. Differences in results in grade 2 between the intervention and control group were larger the larger the deficits in motor skills the students had at project start. Students in the intervention group who had small or large deficits in motor skills at project start, and who received extra MUGI motor training, performed significantly better grade 3 in all parts of the national tests of Mathematics and in three of four tests of the national tests of Swedish than students in the control group with similar deficits, but who had had only the school's ordinary PEH twice a week (Ericsson, 2003, 2008).

There was a larger proportion of students in the intervention than in the control group (96 percent versus 89 percent) who at the end of compulsory school (grade 9) reached qualification to upper secondary school. The sum of grades was also higher for students with no motor skills deficit than students with motor skills deficits as was the proportion of students who reached qualification to upper secondary school (97 percent versus 82 percent). In addition, there were in grade 9, significant correlations between motor skills and the sum of grades of evaluated subjects. Significant correlations were also found between motor skills and the proportion of students that reached qualification to upper secondary school (Ericsson & Karlsson, 2014).

The results indicate that extended PEH and extra motor training in school could be of even greater importance for boys´ scholastic performance than for girls´. Apart from room conception and number conception/thinking proficiency there were differences between boys´ results in the intervention and control group, also in the variable logical thinking and creativity, which means in all parts of the national tests of mathematics investigated in grade 3. When finishing school the evaluated grades in Swedish, English, mathematics and PEH were higher for boys in the intervention group than for boys in the control group.

To Predict Academic Achievements from Motor Observations

Results from earlier research (Cantell, 1998; Cratty, 1997; Ericsson, 1997; Frisk, 1996; Kadesjö & Gillberg, 1999) have shown that many children who have deficits in motor skills as they start school also have problems with learning how to read and write later in school. The results from this study also show that the degree of deficits in motor skills could be of importance to scholastic performance during the first three school years. There are differences in academic achievements between students with good motor skills and students with deficits in motor skills in both the intervention and control group, but the differences are larger in the control group. Hence one may assume that motor skill observations at the school start could be a useful pedagogic instrument to predict academic achievements in Swedish and also in mathematics during the first three school years. Furthermore the results indicate that differences in academic achievements between students with good motor skills and students with deficits in motor skills may decrease with extended PA and extra motor training in school.

Societal Gains from Increased PEH and MUGI Motor Skills Training

The first osteoporosis study in the POP study (Lindén, 2006) showed that moderate PA is associated with increased bone mass and a larger skeleton of both girls and boys. These effects were seen already after one year of increased PEH. At a follow-up study Fritz (2017) showed that the incidence rate ratio of fractures in the intervention group compared to the control group decreased with each year of the intervention. Girls in the intervention group gained more spine and had higher cortical thickness after seven years intervention than girls in the control group. Both girls and boys in the intervention group gained more muscle strength than boys and girls in the control group.

The Commission for a Socially Sustainable Malmö is an independent commission appointed by the City of Malmö, which aim is to suggest actions to reduce inequities in health between different parts of Malmö. The following information can be found in the Commission´s final report 2013.

The so-called Bunkeflo Model in Malmö has attracted international attention. The project included increased PA during the school day. This model is a good example of how schools, parents, students, sports associations and the research community together can lay the foundations for a change in approach that leads to both better health and better scholastic performances. The project is in line with WHO's concept of "Health-promoting schools." It means that everyday life at school should provide a supporting and health-promoting environment for physical, social, and mental health and learning.

The Bunkeflo project started in the autumn of 1999 as a co-operation project between schools, sports associations, and researchers. The project was launched at the school Ängslättskolan in Bunkeflostrand, and the local sports association helped the school to provide all school children with one lesson of PA a day – every school day. All children starting school have PEH as a daily, compulsory subject, even today many years after the original research studies are finished.

The scientific evaluation after nine years showed that both girls and boys improved their PA and their motor skills. Daily PEH and adapted motor skills training produced positive effects on both immediate health and the students' scholastic performance. Their learning performance became significantly better, with nearly ten percent more students being eligible for upper secondary school in the group with increased teaching in PEH, compared with a control group.

The Commission has conducted a health-economic evaluation of the project which shows that the investment was clearly profitable for the municipality. Health-economic analysis methods can be used as basis for prioritizations when resources are limited. The same analysis methods as in other sectors can be used for social interventions in schools, child care, etc. Health-economic analysis together with socioeconomic analysis could thus be used in the prioritization of future investments that aim to reduce inequality in health.

It is well known that that students who have finished upper secondary school are more likely to get an employment than those who have not. In Sweden unemployment among individuals without a degree from upper secondary school is 37 percent, more than four times higher than for students who have finished upper secondary school (Olofsson & Wikström, 2018). The result of this health-economic analysis show that daily PEH and motor training in all of Malmö's compulsory schools would increase the potential production value by SEK 59 million (Euro approx. 6.4 million) during the 10-year period after leaving primary and secondary school.

The higher levels of education, i.e., upper secondary school, which this research shows that the intervention would lead to would in addition make the students more likely to adopt a healthy lifestyle with reduced risk for sedentary behavior, osteoporosis, obesity, diabetes, and cardiovascular diseases. This would in addition reduce morbidity costs by almost: SEK 56 million (> Euro 6 million). These values exceed the approximately SEK 16 million (Euro 1.2 million) that costs of staff and premises to carry out the intervention amount to. The economic gains occur in comparison with scheduled PEH remaining the same as today, i.e., two lessons (2x45 minutes) per week. The investment per student corresponds to SEK 4,600

(Euro 500) for all nine years of compulsory school. The expected productivity gains and reduced morbidity costs would be SEK 38,000 (Euro 4,130) per student over the 10 years after the end of compulsory school (Gerdtham, Ghatnekar, & Svensson, 2013).

The Malmö commission recommends that educational institutions should actively work with health-related issues through strengthening the school subject PEH to all students in the City of Malmö's schools. Opportunities for children and young people to exercise, play and engage in sports increase physical and mental health. Studies done in Malmö also show that increased investment in PEH leads to improved scholastic performances. The so-called Bunkeflo Model, could in this context serve as a model for increased investments in PEH.

CONCLUSION

The study clearly shows that increased PEH and MUGI motor skills training resulted in better motor skills (balance and coordination) as well as improved scholastic performances, higher grades, and higher proportion of students who reached qualification for upper secondary school. Daily PE and adapted motor skills training during the compulsory school years is thus a feasible way to improve not only motor skills but also scholastic performances, grades, and the proportion of students who qualify for upper secondary school. The health-economic analyses of the project show that the intervention was clearly profitable for the municipality, both in production value and in morbidity costs. The so called Bunkeflo and MUGI models could thus serve as models for increased investments in PEH and adapted motor skills training in school. The current attention that is paid to this area of PE and motor skills research is encouraging, and reflects the urgency of the need to increase PA at school.

At follow-up nine years after the original project, Fritz (2017) concludes that a long-term PE intervention program initiated in pre-pubertal children reduces the fracture risk with each year of intervention, and improves skeletal traits in girls, muscle strength in both genders and academic performance in boys.

EDUCATIONAL IMPLICATIONS

The school is the only arena where we can reach the vast majority of children and youth and public school curricula have the greatest promise for accessibility to all. For many children and youths, schools curricula are the only way they can receive PA on a daily basis. Daily PE in combination with adapted motor skills training during the compulsory school years has shown to be a feasible way to improve not only motor skills but also scholastic performance (Ericsson, 2003, 2008) and the proportion of students who qualify for upper secondary school (Ericsson & Karlsson, 2014). In addition the investment can be health-economic profitable for the municipality (Gerdtham, Ghatnekar, & Svensson, 2013). Educational benefits claimed for PE are however dependent on contextual and pedagogic variables. PA seems to be more beneficial when structured by educated PE teachers compared to unstructured PA. When the individual is engaged in executing complex motor movements and cognitively engaging tasks like goal-directed thinking, the brain executive functioning is thereby influenced. This research conducted in Malmö shows that increased time in PEH and the MUGI model of motor skills training in school lead to improved scholastic performances.

Early discovery gives opportunity for early interventions, which could be of importance when it comes to avoiding discouraging students whose fitness is poor. Motor performance can contribute to predict children's cognitive preparedness for school. Specific interventions are needed for children with learning disabilities, programs that facilitate both motor and academic abilities (Ericsson, 2003; Westendorp et al., 2011). Motor skill screening provides a valuable tool for identifying children in need of adapted support in motor skill development (Bangsbo et al., 2016; Ericsson, 2008). Motor skills assessment is also associated with later school achievement and can be used as one of the indicators of future scholastic perfomances of young children. Including motor skills in early school assessment may increase the probability of identifying children at risk for school failure (Bangsbo et al., 2016, Ericsson, 2008; Myer et al., 2015). The MUGI observation checklists, the tests which were used in this study, could also be used as a screening instrument and provide valuable information for planning PE lessons, as well as motor training in smaller groups and individual programs of motor training. The MUGI observation checklists gives an indication of which children may need extra motor skills stimulation. The purpose of motor skill observations, by the time children start school, is to make possible early identification of deficits in motor control, so that pedagogical remedial programs can start before motor skill deficits become a problem to the children.

Children and adolescents undergo physical changes that affect the physical development of both boys and girls, as well as the process of personal and social identity construction. Boys often have higher levels of perceived competence and greater self-esteem than girls in relation to sport activities. The inclusion of boys and girls in coeducational physical education classes make physical development salient to everybody and might contribute to an uncomfortable situation for many children and students at different phases of adolescence. Teachers need to be aware of and pay attention to these matters to be able to increase, and not decline, students perceived self-efficacy.

Teachers might need education in observing and stimulating children's motor development and how to influence students to have a healthy life-long appreciation of PA. Teachers and school staff also need to know more about interventions and motor training that can stimulate and improve motor functioning, for all children and for those with disabilities. Motor training can preferably be conducted by PE teachers in the school's regular PE programs. However, children with motor skills deficits often need special needs education in a smaller group, where MUGI motor training with focus on balance and coordination has proven to be successful.

The importance of specifically cater young children's movement pleasure and really supporting all children in their motor development cannot be enough emphasized. This can be done by providing qualified and adapted motor training in the school. An increased number of PE lessons are required as well as well-educated PE teachers for all children of all levels. This is fully in line with the European Parliament resolution from 2007, calling upon all member states to accept the principle that the timetable should guarantee at least three PE lessons per week and to ensure that the teaching of PE at all levels, including primary school, is conducted by specialized PE instructors (European Parliament, 2007). The positive results that we can see on motor skills in the Bunkeflo project should give reasons enough for politicians and headmasters to make decisions about increased PE and motor training in school. The following pedagogic implications are worth special attention:

- The school has potential for developing all children´s motor skills, but PE two lessons per week are not enough.
- Special needs education, i.e., adapted motor skills training should be offered to all children in need of it, before deficits in motor skills become a problem to them. Motor skill observations carried out at school start give opportunities of early identification of children in need of adapted motor training.
- All teachers who teach PE should be educated in observing and stimulating children's motor development.
- All adults working in school should get some positive experiences of PA for themselves, in order to be able to motivate children to a healthy life long lasting appreciation of PA.

The MUGI model for motor skills training may affect how children perceive PA, which may in turn affect their attitude to physical exercise and to what extent students continue to be physically active after leaving school. The research results in the Bunkeflo project (Ericsson, 2011) showed a clear link between motor skills and the final grade in PEH, which is of great importance for a physically active lifestyle in adulthood, as pointed out by Engström (2011).

Recommendations from Consensus Conferences

A documented link between PA and learning, regardless of age was established in 2011 at a consensus conference arranged by the Ministry of Culture and the Ministry of Education in Denmark. The recommendations motivated the Danish government to conduct a school reform with the purpose of increasing the level of PA among Danish children and adolescents, stating that every child in all Danish public schools should, by law have on the schedule, a minimum of 45 minutes of compulsory PA each school day.

Five years later, in spring 2016, 24 researchers from eight countries and from a variety of academic disciplines gathered to reach evidence-based consensus about PA in children and youth, i.e., children between 6 and 18 years. The aim, formulated by the University of Copenhagen, was to improve children's and youth's health, well-being and social inclusion (Bangsbo et al., 2016).

The consensus statements present currant knowledge on the effects of PA on children's and youth's fitness, health, cognitive functioning, engagement, motivation, psychological wellbeing and social inclusion, as well as educational and PA implementation strategies. The consensus was obtained through an iterative process that began with presentation of the current knowledge in each domain followed by plenary and group discussions. Ultimately, the consensus conference participants reached agreement on a 21-item consensus statement with recommendations. Some of the statements and recommendations for PA (those relevant to motor skills and learning) are listed here:

- Physical activity and cardiorespiratory fitness are beneficial to brain structure, brain function and cognition in children and youth.
- Physical activity before, during and after school promotes scholastic performance in children and youth.
- A single session of moderate physical activity has an acute benefit to brain function, cognition and scholastic performance in children and youth.

- Mastery of fundamental movement skills is beneficial to cognition and scholastic performance in children and youth.
- Time taken away from academic lessons in favour of physical activity has been shown to not come at the cost of scholastic performance in children and youth.
- Close friendships and peer group acceptance in physical activity are positively related to perceived competence, intrinsic motivation and participation behavior in children and youth.
- Participation of children and youth in physical activity and sport is influenced by socioeconomic status, gender, ethnicity, sexual orientation, skill level and disabilities
- Physical activity can promote scholastic performance in a broad sense. Whether it does so, depends on active participation and engagement in the physical activities. Initiatives and adjusted practice to increase motivation and competence for participation is thus essential.
- Physical activity immediately prior to a learning session should not be too intense since high stress or fatigue may blunt the beneficial effect.
- Mastery of fundamental movement skills is beneficial to cognition and scholastic performance in children and youth, and both physical activity throughout school and in leisure physical activities can benefit motor functions.
- Motor skill screening provides a valuable tool for identifying children in need of adapted support in motor skill development. Specific ‘adapted’ interventions should be developed and offered to children with motor skill deficits in order to benefit motor development and motivation for participation in physical activities.
- The school is the arena where it is possible to reach the vast majority of children and youth, also those who are not otherwise regularly physically active. Increased focus on and time for physical activity with qualified activities can be a possible way to promote motor skills, school performance as well as motivation for participation in physical activity.

The Copenhagen consensus conference calls upon society to provide a wide variety of physical movement experiences for all children early in their lives in order to develop FMS and familiarity with PA. Children and youth should be offered fun, personally meaningful and developmentally-appropriate physical activities with opportunities for positive social interactions (Bangsbo et al., 2016).

To combat declining PA levels there is a need for more knowledge about motor development in children and youth. The link between motor competence, physical and psychological health needs to be examined further. More controlled studies are required in order to be able to make general conclusions about the effects on cognition from motor training programs and other physical activities. When planning intervention programs to increase motivation to be physically active, early school interventions to improve FMS may be successful starting points.

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