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The effects of 6 weeks recess time training on pupils speed and speed strength abilities

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Introduction

Physical education at school is very important for children, but alone it is not enough to cover the needs of physical activity and it’s influence on children’s development. According to Hakkarainen et al. (2009) physical education affects positively many areas in life such as physical and mental functions. At best, physical education is more than just physical education.

Children spend a large part of their youth at school. The maximum number of hours of school time takes recess. If we understand to use this time better, we can support children’s physical development more efficiently. Big part of the pupils in secondary schools and most of the pupils in high school are physically inactive during recess. Therefore we should pay attention to that age group. In children’s development there are different stages when specific abilities should be trained. This should also be taken into account in the design of physical activity in recess time. According to Ford et al. (2011) middle school is the last time when we can effectively affect children’s speed abilities.

There is evidence that two times a week (a 30-45 min) speed training supports the development of speed abilities among 13- to 15-year-old youth (Chaouachi et al., 2008). My research focuses whether it is possible to develop speed abilities of young boys at middle school, with six-week training. Training takes place three times per week during the recess time. Training period is limited to 15 minutes. The results are compared to the control group to eliminate natural development of the speed abilities. In this research we concentrate in short-term muscle power (STMP), which is measured in jumps and 15m runs. According to Praagh & Doré (2002) youngsters are spontaneously more involved in short-burst activities than in endurance exercises. STMP is a fundamental aspect of child’s physical capacity.

There are studies about children’s recess behavior and about developing children’s speed abilities. But there is lack of studies if it is possible to affect exact physical characteristics during recess time with only a few short training sessions per week. In this research we try to find this out. Possible positive effects in children speed abilities would courage to use recess time more efficiently and appropriate.
1. **Review of the literature**

1.1. Development of children

Children and adolescents should not be regarded as miniature versions of adults. The state of maturity of child or adolescent can be defined by *chronological age, skeletal age, and stage of sexual maturation* (Kenney *et al.*, 2012). Physical differences as well as performance capabilities at different ages vary due to genetic potentials and growth rates (Kraemer & Fleck, 2005). The first two years of life are called *infancy* and childhood is defined as the period from the second birthday to the onset of the puberty. *Childhood* refers to the period 2 to 12 years of age. *Adolescence* refers to the period 12 to 18 years of age. This period sees to the beginning of the physical changes relating to one of the major milestones in human development: *puberty* (Praagh & Doré, 2002).

According to Hakkarainen *et al.*, (2008) the physical changes in children’s development can be divided in four different parts. *The first* part is the physical growth which consists of growth in height, growth in weight and growth in human organism. *The second* is the biological development which means the growth of sexual organs and sexual maturity. *The third* change is the physiological development of human organs performance. *The fourth* change happens in body composition.

*The physical growth* of the body is dependent upon three changes at the cellular level; 1) increase in cell number, called hyperplasia, 2) increase in the individual cells, called hypertrophy and 3) increase of interstitial fluid and structures. Former changes occur mainly from birth to 15-20 years of life and changes can vary greatly depending on the individual (Hakkarainen *et al.*, 2009).

According to Kraemer & Fleck (2005) every child makes progress toward adulthood on an individual time line, and therefore we must remember that each one has both the chronological, and the physiological age. Maturation has been defined as the developmental progress toward adulthood. In a clinical evaluation of maturity, a physician assesses several areas, including

- physical size
- bone maturity
- neuromuscular maturity
- reproductive maturity
- emotional maturity
Growth and development of a child involve many factors, not simply a single element such as height. Although genetic potential (called genotype) is the basis for a given trait, its expression, phenotypic expression, can be positively affected by many factors, including exercise (Kraemer & Fleck, 2005). The terms growth and maturation are often used together, but each refers to specific biological activity. Growth refers to the increase in the size of the body as a whole and of its parts. Maturation refers to the tempo and timing of the progress towards a mature biological state (Praagh & Doré, 2002).

1.1.1 Height and weight development

Change in height is assessed in terms of centimeters per year and change in weight in terms of kilograms per year (Kenney et al., 2012). Big part of the weight variation between children in the same age is caused by the variation of children's height. That is why children’s weight should be examined compared to one’s height, not to the age-based estimations (Mero et al., 2007). Postnatal growth in length consists of infancy growth, childhood growth and puberty growth spurt. Infancy covers the first year of life and is typically time for rapid growth. Childhood begins after infancy and will continue until the onset of puberty. This phase is characterized by the slow growth rate. The last stage of growth happens in puberty and then children reach the final length of the body (Hakkarainen et al., 2009; Kenney et al., 2012).

Differences between males and females are obvious in the way they grow and mature. In general, girls mature much sooner than boys. The growth spurt in girls may start as early as in the age of 10 and peak at the age of 12 or 13. In boys, the primary growth spurt occurs between the ages of 12 and 15 (Kraemer & Fleck, 2005). The increase of the total mass during growth follow the graph of the length increase. There are clearly visible deceleration, acceleration, peak and end phases. The peak phase of increased mass, in boys, is scheduled 0,2-0,4 years after the peak phase of increased length. In girls this peak phase is 0,3-0,9 years after the peak phase of the increased length (Hakkarainen et al., 2009).
1.1.2 Development of bones

During childhood and throughout adolescence, bone mineral density increases significantly, generally peaking sometime in the second decade and falling thereafter throughout the lifespan. On average, girls achieve full bone maturity several years before boys (Kenney et al., 2012). According to Kraemer & Fleck (2005) the greatest bone mineral content peaks occur in girls in the ages of 11.5 to 13.5 years and in boys in the age of 13 to 15 years.

1.1.3 Development of skeletal muscle

Muscle tissue attains remarkable differentiation and has a great growth capacity. Fibre composition is generally thought to be genetically determined and unaffected by age and training (Praagh & Doré, 2002). On the other hand, the cell mass increases due to the increase of operational structures. Therefore muscle cell cross-sectional area is increased which is also called hypertrophy. Muscle cross-sectional area achieves a natural adult size in the age of 10 in girls and around the age of 14 in boys (Hakkarainen et al., 2009). From one to six years of age the average muscle fibre areas do not increase significantly or increase only moderately (Viru et al., 1999). From the age of seven years, a moderate increase is observed in the muscle fibre area of all the muscle studied. After the age of 12 years the age-dependent increase becomes more pronounced than earlier (Viru et al., 1999). From birth through adolescence, the body’s muscle mass steadily increases, along with the weight (Kenney et al., 2012).

According to Ford et al. (2011) strength increases in both boys and girls until about the age of 14 years, when it begins to plateau in girls and a spurt is evident in boys. Calculations based upon creatine excretion indicate that in males from age of 7 up to the age of 13,5 years, the percentage of muscle mass increases by an average of 0,6% per year and during the next two years the increase amounts to 29% per year (Viru et al., 1999). Age-dependent improvements in peak muscle power may be related to improved neural control of muscle activity. The expression of maximal muscle strength requires synchronous recruitment of all the motor units of agonist muscles. It has been suggested that less mature boys and girls are not able to maximally activate their muscles because of the level of voluntary neural drive, and thereby the number of recruited motor units, is lower than by older children (Viru et al., 1999).
1.1.4 Development of nervous system

During the first postnatal year the glial cells and myelin increase. Simultaneously the neurons increase in size and undergo arborisation. Hence myelination of many motor nerves are incomplete until sexual maturity, thus the neural control of muscle function should be limited before that time (Viru et al., 1999). Various actions can modify neuronal development throughout the childhood and adolescence. In other words, childhood-term nervous development is also affected by environmental stimuli. As the nervous system matures strongly in childhood, the wide range of motor stimuli should be emphasized in children’s activities through the whole childhood (Hakkarainen et al., 2009).

The development of various brain and nerve pathways is reflected in the acquisition of natural movements, as well as further improvement in motor coordination. The highest level of motor skills occurs from 12 to 14 years of age (Viru et al., 1999). It is during puberty that the pyramidal system attains full functional maturity and the individual becomes capable of developing the fine coordinated movements based on the integration of nervous activity from various levels of the central nervous system and the impact from all peripheral receptors (Praagh & Doré, 2002).

1.1.5 Oxygen transport system

The basic structure of the lungs and bronchial tubes are ready at birth, but structural size, capacity and gas exchange change through the whole growth period. Respiratory or pulmonary factors are very rarely a limiting factor in performance of children (Hakkarainen et al., 2009). In preschool age children’s heart remains small in relation both, to the body mass, and to the diameter of the major arterial vessels. This limit the oxygen supply of contracting muscles (Viru et al., 1999).

At the age of 8 to 10 years an extensive development of the cardiorespiratory system appears. At the same time the peak of VO₂ in boys rise from 50 ml·kg⁻¹·min⁻¹ to 58.9 ml·kg⁻¹·min⁻¹ (Viru et al., 1999). According to Viru et al. (1999) several longitudinal studies show that peak development of relative aerobic capacity (ml·kg⁻¹·min⁻¹) occurs between 12 and 16 years in both boys and girls. However cross-sectional research shows that the peak
development period for aerobic capacity occurs at 10-16 and 7-13 years in boys and girls, respectively (Ford et al., 2011; Viru et al., 1999).

1.1.6 Metabolic capacities

In aerobic tasks or sport events such as sprint cycling, jumping or running, the children’s performance is distinctly lower than that of adults. This partly reflects children’s lesser ability to generate mechanical energy from chemical energy sources during short-term intensity activity (Praagh & Doré, 2002).

There is a large amount of supportive literature to suggest that from a young age children naturally possess a well-developed aerobic capacity (Ford et al., 2011) and different methods of physical training have been shown to enhance the development of aerobic capacity in children and adolescence (Ford et al., 2011; Viru et al., 1999). In the skeletal muscles of newborn humans, substrate concentrations and enzyme activities are slightly below those found in later life when expressed per unit dry weight (Viru et al., 1999). During and after the growth spurt, anaerobic (lactic) muscle energy metabolism is enhanced and due to that training with lactic acid is safe and effective (Hakkarainen et al., 2008).

According to Viru et al., (1999) it is possible to assume that together with the increase in aerobic power and improvement of cardiac function, the anaerobic threshold appears at higher exercise intensities. It has been reported that the anaerobic threshold occurs at 58,5% peak VO$_2$ in prepubescent, 65,4% in pubescent children, and 68,7% in adults. According to some research the actual oxygen uptake at the ventilatory threshold increased from 6 to 9 years of age and decreased between 13 and 17 years of age (Viru et al., 1999).

The contribution of anaerobic capacity to endurance is unquestionable. Biopsy studies have indicated that the activity of phosphofructokinase in 11-year-old boys is only one third of that untrained men. Since phosphofructokinase is considered the rate-limiting enzyme of glycolysis, its low activity may limit anaerobic capacity in children (Viru et al., 1999). The smaller muscle mass per body mass, lower glycolytic capability and deficient neuromuscular coordination pointed to the possible reasons for a low anaerobic performance in children (Nikolaïdis, 2012).
1.2. Effects of physical activity on development of children

1.2.1 General views of the effects of physical activity

Fitness tests in Finnish schools and in the army show that the physical condition of young people has declined in recent decades. At the same time Finnish pupils have got fatter. In part the obesity results from decline of the total amount of physical activity (Hakkarainen et al., 2009). In fact, physical activity (PA) in children has declined in recent decade, highlighting the need for effective intervention programs for school-aged children (Magnusson et al., 2011). A vast amount of research has confirmed that physical inactivity is an important factor in the causal mechanism of major chronic diseases such as obesity, cardiovascular diseases, diabetes, and many more (Magnusson et al., 2011).

Ontogenetic development involves several so-called "critical" or "sensitive" periods (Viru et al., 1999). During these periods ontogenetic development reaches a qualitatively new level which provides opportunities for the further improvement of an organ, tissue or function (Viru et al., 1999). To use these sensitive developmental periods in training is called "Long Term Athlete Development" (Ford et al., 2011). In appendix 1 is presented the adaptation to training and optimal trainability.

As the body changes and adapts, certain tissues and glands become more responsive to the exercise stimuli. The body starts to learn how to recover itself from the stress of exercise, which damage structures such as muscle and connective tissues. The stimulation of the repair process due to physical activity allows the body to come back stronger, with bigger muscles, stronger bones, and more dense ligaments and tendons, which in turn help to resist the forces and stress of sport and everyday activities (Kraemer & Fleck, 2005).

Current knowledge emphasizes jumps and running in young children movements and hobbies. Nerves, muscles, tendons, connective tissues and bones will develop and get stronger because they have multifaceted action. These kinds of activity will support possible sport career or on the other hand the whole lifetime physical exercises (Mero et al., 2007).

The load of the physical activity doesn’t negatively effect the growth and children’s development. Extremely high load of training might postpone the start of puberty and delay the faster growth period (Hakkarainen et al., 2008). Daily physical activities promote children’s growth by increasing the excrete of growth hormone and accelerating the protein synthesis (Hakkarainen et al., 2009).
The children experience the stress and the load at school. They need ways to reduce these problems. Regular physical exercise can reduce the stress in young people and prevent possible symptoms of depression and anxiety. Through right kind of physical activity children's self-esteem and self-perception may be enhanced (Hakkarainen et al., 2009; Ridgers et al., 2012).

Regular physical activity during childhood and adolescence is associated with numerous physiological and psychosocial benefits and has the potential to improve the quality of life (Faigenbaum et al., 2009). In general boys are more active than girls and may even respond better to school-based intervention compared to girls. Also those with higher body mass index (BMI) are less active during school-hours. Designs of school-based interventions should take this in to consideration in order to maximize the effects of increased physical activity among all children (Magnusson et al., 2011).

1.2.2 Effects of physical activity on children’s physiology

According to Praagh & Doré (2002) it has been suggested that short-term spontaneous physical activity has an important effect on growth and development during childhood by modulating anabolic agents at the cellular level. Most pediatric exercise scientists consider that anaerobic function is more performance-related and less health-related than aerobic function.

The number of the muscle cells doesn’t chance much after the birth. Natural growth and regular physical load affect positively the muscle cell function and structure. The nerve cells are mainly developed during first months of the fetus. To support the connections between nerve cells, the children should have a wide range of sensory and motor stimuli. On the other hand the lack of stimuli and one-sided practice might have an opposite effect (Hakkarainen et al., 2008). Stretching is also an effective form of exercise because it has been suggested that the potential mechanism for reduced injury risk with increasing flexibility is the change in the viscoelastic properties of muscle tendon units (Chaouachi et al., 2008).

Physical activity is positively associated with bone health and motor skill development (Ridgers et al., 2012). Bone growth in length is followed by individual growth curve and it ends at the end of the growth spurt. On the other hand the bone mass and the density of the bone can be affected by the load of the training and nutrition. Bone mass increases
particularly sensitive when the load comes from longitudinal axis at the end of the growth period just before puberty. In particular, forms of exercise, which include jumps, torsions and shocks are effective to increase the bone mass. The practice shouldn’t be too one-sided or exhausting (Hakkarainen et al., 2008).

Physical exercise doesn’t actually increase the size of the respiratory system but it has a positive effect on muscles involved in respiratory activity. On this basis we have potential to have a positive impact on respiratory function in the growth age. Physical activity also increases the vascular density and that is why aerobic exercise is recommended for children (Hakkarainen et al., 2008). Physical activity is negatively associated with waist circumference and clustering of cardiovascular disease risk factors and positively associated with bone health and motor skill development (Ridgers et al., 2012).

During adolescence several quantitative peculiarities appear in exercise-induced hormonal responses. Most of them are related to sexual maturation. These peculiarities may be significant in the adaptation to muscular activity (Viru et al., 1999). During exercise, insulin is essential because it controls the relative mobilization of carbohydrate and lipid stores as well as their rate of utilization. Insulin also contributes to the control of translatory process in protein synthesis. The possibility of changes in the metabolic action of insulin is supported by data showing a decrease in insulin sensitivity during the growth spurt (Viru et al., 1999).

The body learns to repair itself and send anabolic signals to other tissues and glands to make changes in muscles, bones tendons, and ligaments, which all contribute to greater strength and power and injury prevention. It is clear that the exercise responses of hormone signals in the body are important to a child’s adaptive capability. To produce such physiological signals that tell the body to increase the size and density of muscle and bone takes time, and thus training adaptations can take months to achieve (Kraemer & Fleck, 2005). According to Hakkarainen et al. (2009) exercise and training have a positive impact on adenosine triphosphate (ATP), creatine phosphate (CP) and carbohydrate stocks on children as early as in the age of 12 years. Physical quantity and quality in childhood have a greater impact on adult’s body construction and performance than expected. Before puberty the focus should be on the short-term (from 5 to 15 seconds) hard-power performances and quantitative aerobic exercises.
1.3. Speed and speed strength

1.3.1 Speed

One important biomotor ability required in sport is speed. In other words: the capacity to travel or move quickly. The term speed incorporates three elements: reaction time, frequency of movement per time unit, and speed of travel over a given distances (Bompa & Haff, 2009). Speed can be thought of as the final product of reaction time and quickness. Each athlete can improve reaction time, quickness and speed until they reach the edge which is written in their genes (Sharkey & Gaskill, 2006). There are many elements which influence speed development. Those factors include heredity, reaction time, the athlete’s ability to overcome external resistance, technique, concentration, willpower and muscle elasticity (Bompa & Haff, 2009). Sprinting involves the rapid release of muscular energy to propel an athlete forward with maximum attainable velocity (Keskinen et al., 2010; Ross et al., 2001).

Reaction time is the ability to respond quickly to a stimulus. Reaction time represents the time between exposure to a stimulus and the first muscular reaction (Mero et al., 2007; Keskinen et al., 2010). Reaction time is also inherited. Reaction can be separated in simple or complex reaction time. Simple reaction time is the predetermined conscious response to a known signal performed unexpectedly. When a person receives several stimuli and has to choose between them, it is called complex reaction time (Bompa & Haff, 2009). Keskinen et al. (2010) separates the reaction time in pre-motor and motor time. Pre-motor time represents the time it takes from stimulus to muscle activity in working muscles. Motor time represents the time from the muscle activity to power generation in the muscles.

The capacity of an athlete to display the force is one determinant factor in performing fast movements. This requires athlete’s ability to overcome external resistance. Technique is the ability to perform a skill with ease and high degree of coordination. Speed of a movement is determined by the mobility and harmonious character of the nervous processes, the frequency of the nervous impulses and their precise manner, and strong concentration (Bompa & Haff, 2009). Muscle elasticity and cooperation with agonist and antagonist muscles are important achieving a high frequency of movement and correct technique (Bompa & Haff, 2009). Well-stretched muscles that flow easily through the range of different motion require less energy and may facilitate better skill performance (Sharkey & Gaskill, 2006). Take-off action of the stride in sprinters is the best example of an eccentric-concentric muscular cycle.
During the eccentric phase a certain amount of elastic energy is accumulated in the muscular-tendon complex, which can then be utilized during the second phase (Čoh & Babić, 2010).

There is considerable variation in the nature and magnitude of performance gains observed in response to sprint training. This variation is caused by different sprint-training protocols used (notably differences in volume, duration, recovery and frequency), the training status of individuals and the performance assessment employed. To develop sprint or speed ability, athletes and coaches often employ training methods that involve brief maximal intensity sprint repetitions of varying duration interspersed with either long or short recovery periods (Ross & Leveritt, 2001). This type of training has been shown to elicit improvements in sprint performance (peak and mean power) after as little as 3 weeks of training. Training frequency is one factor that may alter performance adaptations and one report suggested that daily sprint training does not improve either peak or mean cycle sprint power. In contrast, training every third day significantly increased both (Ross & Leveritt, 2001).

1.3.2 Speed strength

Speed strength is the ability of the neuromuscular system to produce the greatest possible force (F) at the shortest possible time (t) or the maximum possible speed (v). The interaction of strength and speed (speed strength) can be expressed as power (P). The unit of the power is watt (W):

$$P = F \times v$$

where speed (v) indicates the change in distance per unit of time (Keskinen et al., 2010). Power production is limited by the rate at which energy is supplied (ATP production) for the muscle contraction (ATP utilization), in other word the rate at which the myofilaments can convert chemical energy into mechanical work (Praagh & Doré, 2002). Thus two athletes can possess similar levels of power, but different ratios of strength and speed (Nikolaïdis, 2012). The three aspects of speed strength are starting strength, explosive strength and isoinertial strength. Starting strength is the force developed in 30 ms from the start of a concentric contraction. Explosive strength is the ability to continue the initiated force as fast as possible. The time period is approximately 150 ms. It is the maximum rate of force development (RFD)
in a maximum isometric contraction. In isoinertial strength the power is generated in muscles during stretch shortening cycle (SSC) (Keskinen et al., 2010).

The effort of large muscles activates the Golgi tendon organ, which prevents the activity of the muscle. As a result of specific training, the activation of the Golgi tendon organ is being inhibited and thus athletes can withstand large forces at landing without decreasing the produced force of the muscles (Čoh & Babić, 2010). First known simply as "jump training”, plyometric training conditions the body through dynamic movements which involve a rapid eccentric muscle action that is immediately followed by a rapid concentric muscle action (Faigenbaum et al., 2009). In the process of training jumps among athletes, the so-called plyometric jumps and plyometric training produce high quality results in the development of take-off strength (Čoh & Babić, 2010).

1.3.3 Speed abilities in children

Speed is a very strongly inherited property. However, it can be developed if you start exercising in a young age and adequate training focuses on specific sensitivity periods (Hakkarainen et al., 2008). Compared with strength and endurance, which can be trained and have spectacular improvements, speed is determined by heredity and it requires more natural talent (Bompa & Haff, 2009). Building the optimal physiological strategy of profile for an athlete in some sport begins with genetics that support the primary needs of sport (Kraemer & Fleck, 2005).

Both boys and girls show similar sprint speed during the first decade of life (Ford et al., 2011), with a period of accelerated adaptation suggested to occur between the ages of 5 and 9 years in both sexes (Viru et al., 1999). A second period of accelerated adaptation has been reported to occur around the age of 12 in girls and between 12 and 15 years in boys (Ford et al., 2011). According to Viru et al. (1999) the initial period of accelerated adaptation observed before the end of the first decade of life has been suggested to be linked to the development of the central nervous system and improved coordination (see appendix 1).

Speed is a complex and subtle biomotor ability, which in real sport situations occurs in various forms. Optimal neuromuscular coordination is the main limiting factor of maximum speed. Therefore, the forming of correct dynamic stereotypes is a long term process, which has to have a precisely defined technique and has to begin at very early age (Čoh & Babić,
2010). In speed training it is important to improve as many fast motor units as possible, which are more suitable for fast movements (Gevat et al., 2012). If the main purpose of training is to have a good physical condition, the numbers on training sessions do not have to be as large as those who try to reach the top level in sport. Children whose goal is to have a sport-career, need professional trainers. They must also train in their leisure time. The quality of the training sessions must be high to have the best possible advantage (Hakkarainen et al., 2008).

1.4. Developing children’s speed and speed strength abilities

Performance in sprint exercise is determined by the ability to accelerate, the magnitude of maximal velocity and the ability to maintain velocity against the onset of fatigue. These factors are strongly influenced by metabolic and anthropometric components (Ross et al., 2001). Speed may be defined as displacement in per unit of time and usually is measured covering a fixed distance as time (Gevat et al., 2012). The development of speed throughout childhood will be influenced by quantitative changes in muscle cross-sectional area and length, metabolic changes, morphological alterations to the muscle and tendon as well as coordination factors (Ford et al., 2011). Improved temporal sequencing of muscle activation and/or improved fast twitch fibre recruitment may contribute to superior sprint performance (Ross et al., 2001). There is also no doubt that considerable human variation exists in the ability to perform maximally over a short time period (Praagh & Doré, 2002).

The current long term athlete development (LTAD) model speculates that two "windows of opportunity” exist to maximize training gains in childhood. These "windows” are related to chronological age and occur at approximately in the age of 7-9 years in both boys and girls. The second "window” occur between 11 and 13 years in girls and between 13 and 15 years in boys (Ford et al., 2011). According to Viru et al. (1999) the speed training during the second period was related to hormone-dependent selective hypertrophy of fast-twitch fibers in both boys and girls. Identifying a single mechanism responsible for improved speed during childhood is unlikely. Instead, a number of biological, neural, and biomechanical factors will influence the development of speed (Ford et al., 2011). According to Nikolaidis’s (2012) research, it was implied that age exerted a significant influence on all force velocity (F-v) parameters (e.g relative maximal power $rP_{\text{max}}$ and maximal power $P_{\text{max}}$) which were
explained chiefly by the developmental changes in body dimensions and body composition during adolescence.

1.4.1 Children’s rest and recovery time during training

The speed is known to be a strongly inherited ability and its development is at easiest in a very early stage of a child. Because the fundament of the coordination is built very early, it is clear that speed training during childhood is crucial. The neglects of speed training at childhood are difficult to compensate later in life (Mero et al., 2007). Speed is one of the most difficult physical characteristics to develop, but it’s possible with systematic and correct training. A possible key variable determining the adaptations caused by repeated short-sprint training is the duration of the recovery interval, or the ratio of sprint to recovery time. If there is comparison between exercise-to-rest ratio in training with short (≤10s) sprints, a very short exercise-to-rest ratio (1:1) is more effective in improving speed maintenance than with a longer ratio (1:6) during runs of 200-300 m (Saraslanidis et al., 2011).

The ability to produce the best possible average sprint performance over a series of sprints ≤10 seconds, separated by short ≤60 seconds recovery periods has been termed repeated sprint ability (RSA) (Bishop et al., 2011). Previous research is suitable especially for adults and according to Hakkarainen et al. (2009) children can perform anyway short sprints with short recovery, because alactic anaerobic metabolism is very effective at child. Children seem to recover faster from sprint running than adults. This should be taken into account when planning anaerobic training for the children. Trainers should emphasize less than 10 seconds intensive periods of work with short 20-30 seconds of recovery (Hakkarainen et al., 2008). Training frequency is one factor that may alter performance adaptions with one report suggesting that daily sprint training does not improve either peak or mean cycle sprint power; in contrast, training every third day significantly increased both (Ross & Leveritt, 2001).

Saraslanidis et al. (2011) showed that a very low training volume, compared to other studies, can be very effective in increasing sprint performance (by about 5%). In the study was trained short sprints (≤10s) with a very short exercise-to-rest ratio (1:1).
1.4.2 Speed components and their training in children

Speed components according to Hakkarainen et al. (2009)

1. Reaction time, the ability to react
2. Sense of rhythm
3. Frequency (of the movement)
4. Speed strength
5. Skills
6. Flexibility
7. Relaxation during movement
8. Elasticity

Reaction time can be practiced and it shortens during 6-10 years of age. It can also be developed slightly during 11-15 years of age, but in the end of puberty the development of the nervous system ends and the shortening of the reaction time ends (premotor reaction) (Mero et al., 2007). Sensory organs (ears, eyes, sense of touch) which respond to an external stimulus, are difficult to develop. Anyway, reaction to the information which came from the senses, can be intensified through training (Hakkarainen et al., 2008).

Sense of rhythm means in this context the ability to produce a variety of movements and to move between different tempo. The sense of rhythm is dependent on the structure of the nervous system and its operational capability. Therefore the training should be scheduled to childhood, when the development of the nervous system is at strongest. Good exercises are for example different kind of rhythm tracks, stair exercises and movements with the music (Hakkarainen et al., 2009). According to Faigenbaum et al. (2009) training session can end with speed and agility drills which are specifically designed to enhance children’s ability to accelerate, decelerate, change direction, and then accelerate again.

Frequency of the movement can be trained in childhood and it should be emphasized in particular before puberty. Good exercises include for example downhill runs and training with downwind. These exercises emphasize the frequency of the movement (Hakkarainen et al., 2009). Efficiency of maximum speed is defined in terms of frequency and the length of one’s stride (Čoh & Babić, 2010).

Speed strength is based on the ability of neuromuscular system to produce force as quickly as possible. The training effect is very specific so strength training should be similar
to the sport that the child is normally practicing (Hakkarainen et al., 2009). Strength training program combined with maximal strength training and speed strength exercise have beneficial effect both in the acceleration phase as in the max speed phase in 100 m run (Dasteridis et al., 2011).

**Skills.** Speed depends on power which is dominated by skill. Previous visualize the importance of skills as speed factor. Learning different kind of movements in childhood support the speed development in later stages of life (Hakkarainen et al., 2009). Testing can be carried out at home and at school with very simple tests which measure for example balance ability and adaptability (Mero et al., 2007).

*Flexibility* is an intrinsic property of body tissues that determines the range of motion achievable without injury at a joint (Chaouachi et al., 2008). Adequate range of motion in the joints and muscles are essential for rapid force production. Passive static stretching up to 20 s can be performed at the beginning and middle of the speed training, as a part of warm-up training. Chaouachi et al. (2008) research showed that stretch- and sprint-trained group had significantly faster sprint times than the sprint-only group when subjected to prior stretching.

*The relaxation during movement* is successful when the active working phase in muscle is short and the relaxation time is as long as possible. This is particularly difficult in speed disciplines and that’s why it is important to try to find a relaxed condition before a sprint performance. The main way to practice relaxation is to focus on relaxation when practicing and competing (Mero et al., 2007).

*Elasticity.* Previous studies have indicated that stretching induces greater compliance of the viscoelastic properties of muscle tendon units (MTU). This increased compliance can increase the stored elastic energy, which can promote better movement economy (Chaouachi et al., 2008). According to Markovic (2007) plyometric training can increase the vertical jump results up to 8.7% and it enhance the ability to use the elastic and neural benefits of the stretch shortening cycle (SSC).

### 1.4.3 Strength and plyometric training in children

One factor of the speed is the speed strength. Before the puberty, speed strength training consists mainly of learning muscle coordination, jumping and throwing exercises. The necessary abilities of speed strength development are created in early childhood, in which
case it is possible to recruit new muscle cells and alter their metabolism in the faster direction (Hakkarainen et al., 2009). Combination of strength and speed training can offer a significant improvement in sprinters’ performance (Dasteridis et al., 2011). According to Dasteridis et al. (2011) both neuro-muscular and hypertrophy strength training programs can improve young athletes’ sprinting performance. In their research the weights in strength training were between 80-90% from maximum. Training also contained speed running and jumps. Previous training model is beneficial for young athletes running the 30 m.

According to Hakkarainen et al. (2009) speed strength can be divided into speed power and explosive power. Speed power can be trained with 0-50% weights. Resistance and weight must be so light that the performance can be carried out quickly. One training session consist of 2-5 series, 4-8 repetitions with full recovery. The purpose of the training is to develop the ability of the nervous system to activate muscle cells. Explosive power differs from the speed power in the number of the repetitions which are 1-6 repetitions. The purpose of the training is to develop nervous system’s ability to activate muscle cells as quickly as possible.

More recent observations suggest that children and adolescents may also benefit from plyometric training provided that age appropriate training guidelines are followed. Although more evidence is required, it appears that plyometric training may help to enhance functional abilities in school age youth. Plyometric training can include hops, skips, jumps, sprints and throws (Faigenbaum et al., 2009). According to Faigenbaum et al. (2009) repeated bouts of moderate and high intensity plyometric exercise can enhance anaerobic and aerobic fitness in children. Other studies confirm that high-intensity intermittent activities (e.g., short sprints) can improve aerobic performance in youth.

Markovic (2007) bring out that there may be a positive transfer of the effects of plyometric training on vertical jump ability to other athletic performance. Plyometric training could be recommended for healthy individuals aiming to improve not only their vertical jumping ability, but also other athletic performance like cycling, sprinting and distance-running performance.

Some of the influences are related to “nurture,” meaning they can be readily changed (e.g. through practice of a motor skill or positive reinforcements for developing coping skills), while other developmental aspects are related to nature; and therefore environmental factors, including weight training, have only a minimal impact on them (Kraemer & Fleck, 2005).

Also the human locomotor system undergoes age-related changes that influence motor
function, so that the physical performance of prepubescent children improves with age (Mendez-Villanueva et al., 2011).

The primary goal in speed training is the creation of an optimal movement model, which is based on the coordination of muscle group work. Optimal neuro-muscular coordination is the main limiting factor of maximum speed. Therefore, the forming of correct dynamic stereotypes is a long term process, which has to have precisely defined technique and has to begin at a very early age (Čoh & Babić, 2010).

1.5. Pupils’ physical activity in school environment

Recent decades have seen monumental changes in the developed societies of the world, and many of these changes have reduced the demand for physical activity. These societal changes in the availability of sedentary forms of entertainment and the demand for physical activity have profoundly influenced the behavior of children and youth. Concurrent with these changes, the prevalence of overweight has increased rapidly in young people across the developed world (Pate et al., 2011). According to Tremblay et al. (2011) physical inactivity and sedentary behavior are pervasive and persistent public health challenges to overcome. Former highlights the need for effective intervention programs that focus on increasing both the amount and intensity of physical activity among school-aged children (Magnusson et al., 2011).

Schools are generally considered ideal setting for the promotion of physical activity and healthy lifestyle for several reasons: access to a large number of children, controlled environment of the school, and the general lack of cost to families (Magnusson et al., 2011). Children and adolescents spent a substantial proportion of their waking hours at school (Ridgers et al., 2012). It is recommended that children engage in ≥ 60 min of physical activity daily (WHO). Because most children spend 6 h or more per day in school, it is reasonable that at least 30 min of this time is devoted to physical activity. Physical activity during school hours may occur during physical education, recess, and classroom instruction (Mahar, 2011).

There is a marked trend toward an increase in sedentary lifestyle among school-age children from the most active segments of the population in developed societies (Trudeau & Shephard, 2005). Tremblay et al. (2011) presented that increased sedentary time was associated with negative health outcomes in both boys and girls. Children spend a large
proportion of their day in sedentary behavior, and there is strong evidence that children spend more time in sedentary with increasing age. Television viewing is a common screen-based sedentary behavior (Pate et al., 2011). According to Tremblay et al. (2011) children and youth should watch less than 2 hours TV per day during their discretionary time. Recent trend has been to reduce the frequency and duration of school recess, or remove it altogether, often because of academic pressures. It is important that recess is included in school-based physical activity programming and policy, and that the recess environment is conducive for youth to make physically active choices (Ridgers et al., 2012).

According to Mahar (2011) physical activity levels are impacted by the opportunities available to youth. Several concerns can limit opportunities for children to be active, including a shortage of play spaces, unsafe neighborhoods, increased screen time, and increased demands of schooling. Increasing access to different facilities during recess and lunchtime at school may benefit physical activity of the youth although single spaces may not be effective on their own. Providing access to a range of spaces and facilities may stimulate physical activity by increasing a sense of choice and providing supportive environments that facilitate active behaviors (Ridgers et al., 2012).

Increasing physical activity in children is a primary objective for public health. Active travel to school is a potential method of increasing physical activity in children (Southward et al., 2012). For an increasing majority of children, the physical education (PE) period is now the only opportunity to engage in moderate-to-intense physical activity (PA) and since almost all children in industrialized countries attend school, physical education program has the potential to reach most children. The time offered for physical education classes varies greatly, both between schools and with age (Trudeau & Shephard, 2005). There facilities and equipment are often available, and personnel who could lead physical activities are in place. Therefore the school environment provides an excellent opportunity for children to be physically active (Mahar, 2011).
1.5.1 Positive effects of physical activity in school environment

Health professionals are increasingly urging that physical education is essential to health and happiness as an adult. The physical education teacher is expected to offer a varied and enjoyable physical activity experience, despite sometimes being allowed no more than 1 hour per week during school year. Participants are expected to develop motor skills, increase their physical fitness and self-esteem, and reduce the level of cardiovascular disease risk factors and obesity (Trudeau & Shephard, 2005). Accumulating evidence suggests that childhood physical activity could reduce the prevalence of cardiovascular risk factors in children and retard the development of atherosclerosis later in life. Children also gain other immediate benefits from adequate levels of physical activity (Trudeau & Shephard, 2005).

Physical activity performed in the classroom can increase on-task behavior. Former can motivate teachers to incorporate physical activity into their daily lessons. Evidence is moderate to good that physical activity incorporated into the school day can improve attention to task and teachers can be trained in a relatively short amount of time to effectively lead such activities (Mahar, 2011). According to Trudeau & Shephard (2005) schools also have the potential to influence the habitual physical activity of children by encouraging increased participation in extracurricular sports activities, by favoring active commuting to school and by providing exercise equipment and supervision for youth in their neighborhoods. An increase in the time that schools allocate to physical education has indeed been suggested as a means on compensating for the ever-more sedentary behavior among children outside of school (Trudeau & Shephard, 2005).

School playgrounds provide important settings and opportunities for children to engage in MVPA (moderate-to-vigorous physical activity), as children spend more than one-sixth of the school day in lunch and short breaks. The school lunchtime provides the most extended period for children to be active during the school day (Willenberg et al., 2010). The school offers an environment with the potential to exert a positive influence on total weekly physical activity through the encouragement of intramural activities, active commuting to and from school and provision of equipment and supervision for out-of-hours activities by youth from the neighborhood of the schoolyard (Trudeau & Shephard, 2005).
1.5.2 Possible ways to increase pupils physical activity in school environment

Supervision has a big role in physical activity and it can effect how children participate in physical activity during recess. Among boys the effect is bigger than in girls. The effect may be attributed to boys showing off and demonstrating their skills to their teachers. The findings that the presence of teachers in the playground merely in a yard duty role is positively associated with the activity levels of children, gives teacher supervision an added importance (Willenberg et al., 2010). Active travel is a possible method to increase physical activity in children. The journey to and from school is a significant contributor to moderate-to-vigorous physical activity in children aged 11-12 years. Research showed that physical activity levels during journeys to and from school contributed 22.2 minutes (33,7%) of total daily moderate-to-vigorous physical activity (Southward et al., 2012).

While it is acknowledged that patterns of moderate physical activity (MPA) and vigorous physical activity (VPA) are influenced by children’s characteristics (sex) and preferences interacting with activities and settings, Willenberg et al. (2010) suggest that relatively simple changes such as the provision of loose equipment and painting of court lines, goals and play markings may provide opportunities for increased physical activity. According to Mahar (2011), he developed with his colleague, classroom-based physical activities, called Energizers. Energizers are short classroom-based physical activities for grades that provide opportunities to increase daily physical activity in school. It take approximately 10 minutes to perform.

It is recommended that schools increase overall facility provision, provide unfixed equipment, and identify methods to increase social support, particularly by peers, to benefit children’s and adolescents’ physical activity during recess. Examining whether the provision of unfixed equipment is a suitable strategy for increasing adolescents’ recess physical activity is warranted (Ridgers et al., 2012). Fixed play equipment and markings, particularly color, are seen by children as areas inviting active play, but had a greater impact on moderate activity levels. Children liked a mix of playground areas with different surfaces including open spaces (Willenberg et al., 2010).
According to Willenberg et al. (2010) there are some factors which need to be properly arranged to support children’s physical activity during recess:

- Ready access to loose equipment (e.g. balls) for children’s play activities
- High levels of teacher supervision
- Strategies to address gender differences in engagement and interest in active play
- Different play surfaces with court/play markings and goals

A recent study reported a highly effect program among elementary school children which relied on a multi-component physical activity program, including re-structuring three physical education lessons each week and adding two extra lessons a week, daily short activity breaks, and physical activity homework (Magnusson et al., 2011).

Bishop et al. (2011) presents that one way to support children sprint training are small-sided games. One game lasts 2,5 to 4 minutes and there can be 2-4 games in a session. These kind of exercises have been indicating a significant differences between pre- and post-tests.

Some intervention studies have shown significant increase in moderate-to-vigorous physical activity (MVPA) after and during the intervention but in Magnussons et al. (2011) study no increase in physical activity was observed at the end of the study period, suggesting that any increase in physical activity during school hours may be highly linked to the motivation and training of general teachers (Magnusson et al., 2011).
2 Purpose of the research and tasks

The general aim of this study was to clarify the effects of 6 weeks recess time training on pupils speed and speed strength abilities. It was hypothesized that recess time training would improve speed and speed strength abilities.

According to the main aim the specific tasks were:

1. To determine the effect of six weeks recess time training on pupils acceleration ability.

2. To determine the effect of six weeks recess time training on pupils maximum running speed.

3. To determine the effect of six weeks recess time training on pupils jumping ability.
3 Methods

3.1 Participants

Participants were healthy male volunteers in the age of 13-14 years. They were pupils of 7th grade at Finnish middle school. The participants were divided into two groups: the test group and the control group (Table 1).

Permission to carry out the recess time training and test during physical education class was obtained from the headmaster and the physical education teacher of the school. The parents of the pupils had given a written permission for testing and training through to completion.

Table 1. Anthropometric characteristics of the subjects (mean ±SD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test group (n=10)</th>
<th>Control group (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>13,69 (±0,3)</td>
<td>13,64 (±0,3)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164,88 (±9,3)</td>
<td>163,25 (±9,8)</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>49,16 (±6,7)</td>
<td>54,0 (±12,3)</td>
</tr>
<tr>
<td>Body mass index</td>
<td>18,02 (±1,3)</td>
<td>20,11 (±3,6)</td>
</tr>
</tbody>
</table>

The training background outside the school was asked out with a questionnaire. In the questionnaire was asked the amount of week training and the quality of the training. Options were organized training and independent training. Organized training demanded coach who instructed children. Independent training was occurred alone or for example with the parents (Table 2).

Table 2. Training experience of the subjects (mean ±SD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test group (n=10)</th>
<th>Control group (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organized training (min/ week)</td>
<td>279,0 (±237,6)</td>
<td>153,5 (±256,6)</td>
</tr>
<tr>
<td>Independent training (min/ week)</td>
<td>87,0 (±137,0)</td>
<td>102,6 (±151,7)</td>
</tr>
<tr>
<td>Total (min/week)</td>
<td>366,0 (±222,3)</td>
<td>256,1 (±256,1)</td>
</tr>
</tbody>
</table>
The amount of the organized training by the control group was 55% of the amount of the test group training. Instead the amount of the independent training was bigger in the control group than in the test group. The amount of the independent training by the training group was 84.8% compared to the control group. Total amount of all training in the control group was 70.0% compared to the training group.

During six week training there were 18 training sessions and pupils were present in 86.1% of all events. The best presence was 100% and the mean of the presence was 15.5 of 18 sessions.

3.2 Study design

The training intervention lasted 6 weeks and it included three different training sessions in a week. Total number of training sessions were 18. The training days were Monday, Wednesday and Friday. Some of the dates changed due to holidays. One training session took time 15 minutes. The sprint performance testing was carried out two times: the first one was twelve days before the training session, the final testing was two days after the last training. The training sessions were planned to arrange during the break and pupils didn’t need to wear any special sportswear. Other pupils’ physical training continued as normal, as well as physical education classes.

A comprehensive verbal description of the nature and purpose of the study was given to the pupils and their parents. Pupils provided their parents a form, where parents authorized their child to participate in this research. Without parental approval pupils wouldn’t have been allowed to participate on training. Progressive overload was applied by increasing the number of the jumps in a session. The load was added max 5% per week. During the last week of exercising the stress level was not increased and the focus was on decent performances.
3.3 Summary of the training program

Table 3. Training load during the research

<table>
<thead>
<tr>
<th>Week</th>
<th>Monday</th>
<th>Wednesday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13*10 m</td>
<td>12*10 m</td>
<td>60 jumps</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>13*10 m</td>
<td>63 jumps</td>
</tr>
<tr>
<td>3</td>
<td>14*10 m</td>
<td>13*10 m</td>
<td>66 jumps</td>
</tr>
<tr>
<td>4</td>
<td>15*10 m</td>
<td>14*10 m</td>
<td>69 jumps</td>
</tr>
<tr>
<td>5</td>
<td>15*10 m</td>
<td>14*10 m</td>
<td>72 jumps</td>
</tr>
<tr>
<td>6</td>
<td>15*10 m</td>
<td>14*10 m</td>
<td>75 jumps</td>
</tr>
<tr>
<td>7</td>
<td>15*10 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>870 m</td>
<td>800 m</td>
<td>405 jumps</td>
</tr>
</tbody>
</table>

In sprint training the estimated recovery time was about 40 seconds after 10 m run. Acceleration was at least 10 m and after that rolling until the next wall. The number of the sprints couldn’t be much above 15, otherwise the recovery time would have been too short. In jumps the recovery time was also about 40 s after every performance.

3.4 Test equipment

Measuring system was Spin Test equipment, invented by Ivan Krause.

Figure 1. Measuring system
All the photocells were assessed by aligning the photocells with the distance corresponding the distances being measured. All photocells were 100 cm above the ground. The test persons were weighted on an electronic scale (Seca, Germany) to the nearest 0.1 kg without shoes. Height was measured with metal measuring tape to the nearest 0.1 cm with each test person shoes off, feet together.

3.5 Test protocol of speed and jump tests

According to Keskinen et al. (2010) the squat jump is performed in the following manner: knees straight angle, both hands on hips, keeping to the lower position 2-3 s and then jumping up. Landing on balls, knees almost straight. The elastic component is eliminated because of 2-3 s break. The test is performed two to three times and the best will remain.

Counter movement jump starts in the standing position. Both hands on the hips, knees and back straight. After this participant descends quickly until the knee joints are straight angle. Immediately after the descent the participant jumps up as high as possible. The test is performed two to three times and the best result will remain.

Prior to the sprint trials, the pupils performed a warm-up which included 10 minutes of jogging and dynamic exercises for the body. Participants were then asked to do two near maximal 10-15 m sprints as a specific part of the warm-up. After a 5-minute break the test began. All the tests were carried out in an indoor hall. Groups were also divided in two to avoid unnecessary waiting for the running performance. The not performing group was doing light warm-up by playing.
In the 15 m sprint trial each pupil was standing behind the starting line in start positions, waiting for tester’s signal. When the examiner gave the signal, the pupil started the sprint, attempting to cover the 15m distance in the shortest possible time. The other 15 m sprint was with flying start. Each pupil were instructed to perform the sprint as fast as they could. Each pupil had two sprints in both runs. The faster time of the run was recorded. Between the sprints there was at least three minutes of recovery. All measurements were performed at the same place and same time of the day, and with the same settings and configurations.

### 3.6 Training program

Table 4. Training methods during the research

<table>
<thead>
<tr>
<th>Week</th>
<th>Monday</th>
<th>Wednesday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Starts in different positions 12*10-15 m</td>
<td>60 jumps (double leg bound, bounding, one leg jump, squat jump) + 2*10 m sprints</td>
</tr>
<tr>
<td>2</td>
<td>&quot;Catch the friend&quot; tag sprints 13*10-15 m</td>
<td>Starts in different positions 13*10-15 m + 10 m sprint</td>
<td>63 jumps (double leg bound, bounding, one leg jump, squat jump) + 2*10 m sprints</td>
</tr>
<tr>
<td>3</td>
<td>&quot;Catch the friend&quot; tag sprints 14*10-15 m</td>
<td>Starts in different positions 13<em>10-15 m + 2</em>10 m sprints</td>
<td>66 jumps (double leg bound, bounding, one leg jump, squat jump) + 2*10 m sprints</td>
</tr>
<tr>
<td>4</td>
<td>&quot;Catch the friend&quot; tag sprints 15*10-15 m</td>
<td>Starts in different positions 14<em>10-15 m + 2</em>10 m sprints</td>
<td>69 jumps (double leg bound, bounding, one leg jump, squat jump) + 2*10 m sprints</td>
</tr>
<tr>
<td>5</td>
<td>&quot;Catch the friend&quot; tag sprints 15*10-15 m</td>
<td>Starts in different positions 14<em>10-15 m + 2</em>10 m sprints</td>
<td>72 jumps (double leg bound, bounding, one leg jump, squat jump) + 2*10 m sprints</td>
</tr>
<tr>
<td>Week</td>
<td>Monday</td>
<td>Wednesday</td>
<td>Friday</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------------------</td>
<td>-----------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>6</td>
<td>Starts in different positions 15*10-15 m</td>
<td>Starts in different positions 14*10-15 m</td>
<td>75 jumps (double leg bound, bounding, one leg jump, squat jump) + 2*10 m sprints</td>
</tr>
<tr>
<td></td>
<td>+ 2*10 m sprints</td>
<td>+ 2*10 m sprints</td>
<td>+ 2*10 m sprints</td>
</tr>
<tr>
<td>7</td>
<td>”Catch the friend” tag sprints 15*10-15 m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Warm-up took time 5 minutes before every training session.

*Monday* training was playful sprint training. Starts in different positions after the examiners signal. Purpose was to develop pupils’ reaction time and activate fast muscle fibers. Playful environment and competitive spirit was created by tag exercise where children run to each other. *Wednesday* training was sprints in different starting positions, start with examiners signal. Purpose was to develop pupils’ reaction time, activate fast muscle fibers and develop sprint abilities. *Friday* training was jumps and jumping. During the six weeks of training the exercises remained the same. Only the training load was increased during the research. Pupils performed the required exercises in part in competition against each other, and partly by themselves, still under instruction.

Monday and Wednesday trainings were so called repeated-sprint training where recovery time was short (30-40s). Sprint time was around 3 seconds. According to Bishop *et al.* (2011) this kind of training would support the sprint performances.

The number of sprints and jumps was gradually increased during the first 3 weeks to minimize the risk of injury.

3.7 Statistical analysis

The data was analyzed using Mixed models ANOVA. Covariant was the pre-test. Statistical significance was set at p<0.05 and all results were reported as mean ± standard deviation. The population was measured by the Shapiro-Wilk test and it showed that the population is normally distributed. Logarithmic transformation was done in 15 m pre-/ post-test and flying 15 m pre-/post-test. They were normally distributed.
In this present study the focus was on determining the possible differences between the test group and the control group after 6 weeks of recess time training.
4 RESULTS

Tables below show the results of the study. Data are presented as the mean ± SD. The symbols indicate the results of statistical analyses.

δ, post-test minus pre-test score.

(*) Significantly greater improvement from pre-test (p< 0.05).

(**) Significantly greater improvement from pre-test (p<0.01)

(A) significantly greater improvement vs. control group (p<0.05)

4.1 15 m run from standing start with signal

Table 5. The results of 15m run from standing start with signal (mean ±SD)

<table>
<thead>
<tr>
<th>15m run from standing start with signal (sec)</th>
<th>pre-test</th>
<th>post-test</th>
<th>δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group (n=24)</td>
<td>3,61 (±0,265)</td>
<td>3,659 (±0,316)</td>
<td>0,052 (±0,115)</td>
</tr>
<tr>
<td>Test group (n=10)</td>
<td>3,406 (±0,185)</td>
<td>3,340 (±0,147)</td>
<td>-0,066 (±0,117) (A)</td>
</tr>
</tbody>
</table>

The improvement in sprint performance at 15 m run from standing start with signal was on average 1,9 % for the test group. The best improvement in the test group was 6,2%. Similarly the control group presented a negative improvement in sprint performance at 15 m run from standing start with signal from the first to the last measurement on average -1,44 %. There was no significant improvement inside the groups. Between the groups the group-interaction was significant (p<0.05).

4.2 15 m run from flying start

Table 6. The results of 15 m run from flying start (mean ±SD)

<table>
<thead>
<tr>
<th>15 m run from flying start (sec)</th>
<th>pre-test</th>
<th>post-test</th>
<th>δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group (n=24)</td>
<td>2,631 (±0,328)</td>
<td>2,502 (±0,250)**</td>
<td>-0,129 (±0,188)</td>
</tr>
<tr>
<td>Test group (n=10)</td>
<td>2,478 (±0,153)</td>
<td>2,337 (±0,126)**</td>
<td>-0,141 (±0,078)</td>
</tr>
</tbody>
</table>
The improvement in sprint performance at 15 m run from flying start was on average 5.7\% for the test group (p<.001). The best improvement in the test group was 12.7\%. Similarly the control group presented an improvement in sprint performance at 15 m run from flying start from the first to the last measurement on average 4.9\% (p<.001). There was no differences between the groups (p>0.05).

### 4.3 Squat jump

Table 7. The results of the squat jump (mean ±SD)

<table>
<thead>
<tr>
<th>Squat jump (cm)</th>
<th>pre-test</th>
<th>post-test</th>
<th>δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>22,042 (±5,491)</td>
<td>20,946 (±5,471)</td>
<td>-1,096 (±3,158)</td>
</tr>
<tr>
<td>(n=24)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test group</td>
<td>25,43 (±3,733)</td>
<td>27,740 (±5,269)*</td>
<td>2,310 (±2,483) (A)</td>
</tr>
<tr>
<td>(n=10)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The improvement in squat jump was on average 9.08\% for the test group (p<0.05). The best improvement in the test group was 21\%. Similarly the control group presented a negative improvement in squat jump from the first to the last measurement on average -4.9\%. Between the groups there was a significant difference (p<0.01).

### 4.4 Counter movement jump

Table 8. The results of the counter movement jump (mean ±SD)

<table>
<thead>
<tr>
<th>Counter movement jump (cm)</th>
<th>pre-test</th>
<th>post-test</th>
<th>δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>23,196 (±6,033)</td>
<td>22,404 (±5,148)</td>
<td>-0,792 (±3,385)</td>
</tr>
<tr>
<td>(n=24)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test group</td>
<td>26,23 (±4,789)</td>
<td>28,780 (±5,218)**</td>
<td>2,550 (±3,078) (A)</td>
</tr>
<tr>
<td>(n=10)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The improvement in counter movement jump was on average 9.7\% (from 26.23 ±4,789 to 28,780 ± 5,218) for the test group (p<0.01). The best improvement in the test group was 29.6\%. Similarly the control group presented a negative improvement in counter movement jump from the first to the last measurement (from 23,196 ± 6,033 to 22,404 ±5,148) on average -3.4\%. Differences between the groups were significant (p<0.01).
### Table 9. Summary of the results

<table>
<thead>
<tr>
<th>Changes between groups (pre- and post-tests)</th>
<th>Control group (n=24)</th>
<th>Test group (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 m, start with signal</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>15 m, from flying start</td>
<td>↑↑</td>
<td>↑↑</td>
</tr>
<tr>
<td>Squat jump</td>
<td></td>
<td>↑**</td>
</tr>
<tr>
<td>Counter movement jump</td>
<td></td>
<td>↑↑↑ **</td>
</tr>
</tbody>
</table>

* (p<0.05) difference between groups  
** (p<0.01) difference between groups  
↑ improved results inside the group (p<0.05)  
↑↑ improved results inside the group (p<0.01)
5 Discussion

The aim of the study was to explore if it’s possible to have a positive effect on pupils speed and speed strength abilities with 6 weeks recess time training. The results of the study showed that pupils recess time training three times a week gives them enough stimulus to develop their speed and speed strength abilities.

The acceleration of speed improvement is pronounced in boys in age of 12 to 14 years and accelerated improvement of explosive strength appears in boys in age of 12 to 16 years (Viru et al., 1999). Test persons of my study were exactly in this age, but in the control group there was no improvement in these characteristics. Perhaps the 8 week period (interval of pre- to post-test) was too short to recognize the increase of these characteristics.

The training background may have affected the results in the test group. The amount of the training minutes per week was greater and therefore the changes in speed abilities may need more training to get developed. According to Nikolaïdis (2012) strength estimated by the vertical jump, increased by 20,6% in soccer players from 11 to 18 years, while it increased by 48,8% in adolescences from 11 to 18 years. Previous shows the significance of the training background to the development of the results. It is more difficult to develop speed abilities by young people if they have lot of training background compared to people who do not train anything. It would have been better if all the participants would have been without training background in this research. Then we could have seen the absolute training effect. Now the leisure time training might have affected the results. Anyway, the results of recess time training were positive.

Dasteridis et al. (2011) used 8 jumps series in their study when they trained and researched young athletes’ sprint performances. In my research one leg had between 3-8 jumps in one series. Jumps were taken in this research because many researchers like Faigenbaum et al. (2009) have indicated that plyometric training can enhance measures of lower body power.

Designing the training program I followed the ideas of Hakkarainen et al. (2009) that children are capable to perform more than ten maximum sprints with 15-30 seconds of recovery. Children have much more effective capacity to recover from short periods of intensive work (10-30s) than adults. Therefore in my research I used short recoveries between exercises.
Small-sided games can also support the sprint abilities and can be used in warm-up. There can be several periods in one game (2 to 6) and one period can last 2.5-13 minutes. Between the periods there is 1-3 min recovery (Bishop et al., 2011). In my research there was only one period which lasted 5 minutes and it was the warm-up.

Muscle power refers to the ability of the neuromuscular system to produce the greatest possible impulse in a given period (Praagh & Doré, 2002). In this research, short-term muscle power (STMP) or peak power is defined as the highest mechanical power that can be produced during tests. Precise information on peak power output is provided by the results of

1) 15 m running tests
2) maximal squat jump and counter movement jump.

Mendez-Villanueva et al. (2011) had two run attempts in their research and between them was three minutes of rest. The same protocol was used in my research. Power output decreases rapidly as a function of time. If maximal STMP is to be measured, the duration of the test must be as short as possible (Praagh & Doré, 2002). Thus, in this study the speed was measured with 15 m run instead of 30 m.

15 m run from standing start with signal

The study results showed that pupils from the test group improved their sprinting performance at 1,9 %, while in the control group the improvement was negative -1,44 %. Between the groups there was a significant difference (p<0.05), but inside the group there was no significant improvement. It is assumed that greater percentage of the speed improvement among the pupils of the test group is result from the speed training program. This based on the fact that the test group achieved positive results and at the same time in control group results decreased.

In the training sessions all the sprints started with signal (clapping) and therefore reaction to the start signal got trained in every training session. According to Hakkarainen et al. (2009) the adult level of reaction time is reached shortly before the beginning of the puberty but can be developed with systematic training.

Acceleration is influenced by the development of concentric forces and knee extensor activity (Mendez-Villanueva et al., 2011). Knee extensors and concentric forces were activated especially in jumps. Also short sprints and plyometric training could have been
affected positively to the 15m sprints results. Former is well supported by Markovic (2007) who brought forward how plyometric training can affect sprinting positively.

Kotzamanidis (2006) studied effects of plyometric training (10 weeks) on running performance and in post-test all the measured times were worse in the control group. This brings out that the maturation doesn’t always improve the results, but even cause decrease in results.

**15 m run from flying start**

Similarly to the 15 m run from standing start with signal, the results of the 15 m from flying start showed the improvement in sprinting performance. Test group improved their results on average 5.7% (p<0.01) while in the control group the improvement was smaller (on average 4.9 %), but still significant (p<0.01). Between the groups there was no difference. Presumably in this test the maturation was the cause of improved results because there was no difference between the groups. Gevat *et al.* (2012) examined the effects of 8 week speed training program on the acceleration ability and maximum speed with 11 years old athletes. The improvement in the control group, which didn’t train was 5%. Those results are similar with the results of this research.

The training stimulus wasn’t strong enough to observe the statistical difference between the groups. One reason for this might be the lack of longer sprints which support more maximum running speed than fast sprints and plyometric training. Smaller improvement in the control group (compared to the test group) in 15 m from flying start could be explained by the fact that plyometric training and fast sprints with different starting positions (included in six week training) have more effect on pupils’ acceleration ability, but it has also an indirect effect on the maximum speed phase.

The human locomotor system undergoes age-related changes that influence motor function, so that the physical performance at prepubescent children improves with age. So it is likely that different growth- and maturation-related factors influence acceleration and maximal running speed in different ways throughout growth and maturation (Mendez-Villanueva *et al.*, 2011). Previous supports the fact why both groups had significant improvement, but there was no difference between the groups.
A maturational role in the second “window of opportunity” is supported by Viru et al. (1999), who speculated that speed training during this period was related to hormone-dependent selective hypertrophy of fast-twitch fibers in both boys and girls.

**Squat jump**

In squat jump the test group improved their performance on average 9.08% (p<0.05). At the same time the development of the control group was negative. Between the groups the difference was significant (p<0.01). A study among 12-year-old boys showed that the short-term plyometric training significantly improved their jumping performance (Praagh & Doré, 2002). Former study supports very well the results of this study because in recess time training there was plyometric training once a week. Markovic (2007) presented in his research that squat jump results can be improved with plyometric training 4.7% (1.8 to 7.6%). Compared to Markovic’s (2007) results the improvement of the training group was even better.

A number of biological, neural and biomechanical factors influence the development of speed. Rapid period of physical growth may disturb motor coordination in some individuals (Ford et al., 2011). This might be one of the reasons why the results of the test were negative in the control group. Test persons were in that age when their body is changing, because of the growth spurt and that affects their speed abilities. Because the test group had at the same time guided speed training their nervous system received impulses which support their development. This possibly gave them the advantage to develop in the tested abilities. Kotzamanidis (2006) studied the effects of plyometric training on vertical jump and there the control group presented also decreased results in the post-test.

In a female sample, a reduction in the height of vertical jump highlighted the contrasting effects of maturation on the explosive strength of the lower limb than in male whose result in vertical jump improved (Ford et al., 2011).

Smaller increase in squat jump results than counter movement jump results is parallel to Markovic (2007) research where plyometric training improved more the counter movement jump than squat jump. The reason is that plyometric training enhanced the ability to use the elastic and neural benefits of the stretch shortening cycle (SSC).
Counter movement jump

In counter movement jump the test group improved their performance by 9.7% (p<0.01). At the same time the development of the control group was negative -3.4%. Between the groups the difference was significant (p<0.01). The result of the test group is similar to that in Markovic (2007) research where he brings out that plyometric training can effect vertical jump by improving the results by 8.7% (7.0 to 10.4%).

According to Viru et al. (1999) age-dependent improvements in peak muscle power may be related to improved neural control of muscle activity. Precise information on peak power output is provided by the results of maximal squat jump and with counter movement jump. Therefore, it is supposed that the basis of the positive changes, in particular jumps, is the result of improved neural activity. Fast twitch fibers were activated by plyometric training and fast accelerations. According to Gevat et al. (2012) development of the nervous system is thought to be deeply related to the development of sport performance components.

A counter movement improves the jump performance by about 10%, because of the more relevant participation of the muscle elasticity (Praagh & Doré, 2002). In my study there were pupils whose jump performance didn’t get better in counter movement jump. It can be suggested that the reason for that was changes in body dimensions.

Both squat jump and counter movement jump require further research to find out the reasons of decreased results in the control group. According to Hakkarainen et al. (2009) there are challenges to develop speed abilities in this age, because the growth in length happens in short time-period. This affects the lever arms. This can delay the development of the frequency or even decline it.

General observations

During the study it appeared how excited children were doing high intensity exercises. The exercises varied and there was competition between children. According to Willenberg et al. (2010) it is very important to have supervision during recess activity because then boys want to show their skills to supervisor.

15 minutes is a really tight schedule to do speed training. 5 minutes longer break would facilitate the training immediately. During this study, the pupils were allowed to start
training 5 minutes before the start of the recess time. They were also authorized to be a little late in next lesson. This kind of arrangement doesn’t work normally. Hence there is need for longer breaks or straightforward training.

There are many different ways to develop speed abilities. Hakkarainen et al. (2009) has divided the speed into components and it shows how many possibilities there are to support children’s speed development. In this research were practiced following of those components: sense of rhythm, speed strength, skills, the relaxation during movement and elasticity.

Ford et al. (2011) proposes that data in his research would seem to contradict the "windows of opportunity" concept proposed in the long term athlete development (LTAD) model, whereby training within certain physical literacy skills at certain stages may result in greater long-term development of those skills. Based on the previous idea, there is need to further study how long recess time training advantage retains in children speed characteristics.

In this study the test group consisted of 10 persons. That would be good if the further researches get more pupils and the training is divided into several groups. This research focused only boys speed development and girls should be taken along to the next research.

School children should have plyometric training and speed workouts every time in their sport lessons. Exercises should be a game-like and they can be used as warm-up to the main task of the lesson. It takes only 10-15 minutes but it affects many physical characteristics. Resent researches (Faigenbaum et al., 2009; Hakkarainen et al., 2009;) have shown that adequate plyometric trainings are safe to children and my research brings forward that plyometric training and fast sprints support the development of pupils’ speed abilities.

Tremblay et al., (2011) suggests in his research that resolving the problem of inactivity requires a sustained change in individual daily activity and sedentary patterns. One possibility is to increase the recess activity in school by arranging games and for example game-like speed training.

According to Gevat et al. (2012) improved acceleration and speed are achieved by increasing the physical metabolic and neurological components associated with sprinting. It can be suggested that neural development was one of the greatest factors which made it possible to develop measured abilities. Fast muscle fibers were activated and their utilization became better.
6 Conclusions

Based on the results of the current dissertation the following conclusions were made:

1. Pupils recess time training three times a week gives them enough stimulus to develop their speed and speed strength abilities.

2. Six weeks of recess time training improved pupils jumping ability in the test group. No change was observed in the control group.

3. Maximal running speed improved in both groups. There was no significant difference between the control and the test group.

4. Six weeks of recess time training did not improved pupils’ acceleration abilities in both groups.
References


KUUENÄDALASE VAHETUNNIAEGSE TREENINGU MÕJU ÕPILASTE KIIRUSJÕU ALASTELE VÕIMELE

Janne Pellikka

Resümee

Uurimustöö eesmärk oli välja selgitada, kas 6 nädala jooksul tehtud treening vahetunni ajal mõjutab õpilaste kiirusjõu alaseid võimeid. Treening toimus kolm korda nädalas ja treeningu kestus oli korruga 15 min. Õpilased jagati testrühma, kes treenisid (n=10; vanus 13,7±0,3a; pikkus 164,9±9,3cm; kaalu 49,2±6,7kg) ja kontrollrühma, kes ei osalenud treeningutel (n=24; vanus 13,6±0,3a; pikkus 163,3±9,8cm; kaalu 54,0±12,3kg).

Kiirusjõualased võimed määrati järgnevate testidega: 15m jooks püstistartist, 15m jooks lendlähest, paigalt üleshüpe allaistega ja poolkükist uleshüpe. Testimine toimus kaks korda, enne ja pärast treeninperioodi.

Töö tulemuste põhjal voib teha järgmisi järelusi

1. Vahetunniaegne treening kolm korda nädalas a 15 minutit on piisav stiimul, et arendada õpilaste kiirusjõulalased võimeid.
2. Kuuenädalane vahetunniaegne treening parandas testgrupi õpilastel hüppevõimet.
4. Kuuenädalane vahetunniaegne treening ei parandanud õpilaste kiirendusvõimet kummaski grupis.
Appendix 1: Adaptation to training and optimal trainability (Ford et al., 2011).
Appendix 2.

The statistic results of 15m run from standing start with signal

Pairwise Comparisons

<table>
<thead>
<tr>
<th>Group</th>
<th>(I) factor1</th>
<th>(J) factor1</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval for Difference</th>
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<td>Lower Bound: -0.018, Upper Bound: 0.001</td>
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</tbody>
</table>

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Inside the group there were no differences.

Multivariate Tests

<table>
<thead>
<tr>
<th>Effect</th>
<th>Value</th>
<th>F</th>
<th>Hypothesis df</th>
<th>Error df</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
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<td>0.882</td>
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</table>

a. Exact statistic
b. Computed using alpha = .05
c. Design: Intercept + log_15m_pre to covariate + Group
   Within Subjects Design: factor1

Between the groups the group-interaction was significant (p<0.05).
Appendix 3.

The statistic results of 15m run from flying start

Pairwise Comparisons

<table>
<thead>
<tr>
<th>Group</th>
<th>(I) factor1</th>
<th>(J) factor1</th>
<th>Mean Difference (I-J)</th>
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</table>

Based on estimated marginal means
* The mean difference is significant at the .05 level.
* a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The improvement inside the groups was significant (p<0.001)

Multivariate Tests
c

<table>
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<tr>
<th>Effect</th>
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</table>

a. Exact statistic
b. Computed using alpha = .05
c. Design: Intercept + log flying 15 pre set to covariate + Group
Within Subjects Design: factor1 (factor1=time)

Between the groups there were no significant difference p>0.05
Appendix 4.

The statistic results of squat jump

Pairwise Comparisons

<table>
<thead>
<tr>
<th>Group</th>
<th>(I) factor1</th>
<th>(J) factor1</th>
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Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

* The mean difference is significant at the .05 level.

In the test group the improvement was significant (p<0.05).

Multivariate Tests:

<table>
<thead>
<tr>
<th>Effect</th>
<th>Value</th>
<th>F</th>
<th>df</th>
<th>Error df</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
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<table>
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</table>

a. Exact statistic

b. Computed using alpha = .05

c. Design: Intercept + squat_jump_pre_to_covariate + Group

Within Subjects Design: factor1

Between the groups there were significant differences (p<0.01)
Appendix 5.

Statistical results of counter movement jump

Pairwise Comparisons

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<tr>
<th>Group</th>
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<th>(J) factor1</th>
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<th>Sig. a</th>
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Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

* The mean difference is significant at the .05 level.

In the test group the improvement was significant (p<0.01).

Multivariate Tests c

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a. Exact statistic
b. Computed using alpha = .05
c. Design: Intercept + countermov_jump_pre_to covariate + Group
Within Subjects Design: factor1

Comparison between the groups the difference was significant (p<0.01).