UNIVERSITY OF PRIMORSKA
FACULTY OF MATHEMATICS, NATURAL SCIENCES
AND INFORMATION TECHNOLOGIES

Vedrana Sember

IMPACT OF PHYSICAL ACTIVITY AND PHYSICAL FITNESS ON ACADEMIC PERFORMANCE IN SELECTED SLOVENIAN SCHOOLCHILDREN

VPLIV GIBALNE AKTIVNOSTI IN GIBALNIH SPOSOBNOSTI NA UČNI USPEH V IZBRANIH SLOVENSKIH ŠOLAH

Doctoral thesis

Izola, March 2017

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APPLIED KINESIOLOGY

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Doctoral thesis

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Abstract: INTRODUCTION: Physical activity is behavior and is influenced by many factors. These factors are classified into four levels: physiological, psychological, sociocultural, and ecological (Lindquist, Reynolds & Goran, 1999). Many experts note that additional hours of physical education have a positive impact on the academic success (Shephard, 1997) since learning of complex movements stimulates the frontal cortex in the brain, which is also active in learning and problem solving (Jensen, 2005). The results of studies suggest a positive relationship between physical and academic achievement (Singh, Uitjtdewilligen, Twisk, Van Mechelen & Chinapaw, 2012). The global research question of the doctoral dissertation is how physical activity affects the intellectual development or academic performance of the child and how academic performance of elementary schoolchildren changes through a different quantity of physical activity and time. METHODS: Physical activity of children was measured subjectively with CLASS and SHAPES questionnaires and objectively with accelerometer Actigraph and multi sensor device SenseWear. Physical fitness parameters were measured during school day in selected schools and academic performance was obtained through Grade point average and math grade. Measurement of all variables were held as a part of the ARTOS study. In pilot study n=16 girls participated; in Study 2, n=3728 children; in Study 3 n=166 children and in 4th, Longitudinal study, n=123 children participated. RESULTS: In "Elementary school girls' physical activity and academic performance study" positive and strong link between physical activity and math grade ($r=0.77$; $p<0.01$), Slovene language ($r=0.73$; $p<0.01$) and Grade point average ($r=0.83$; $p<0.01$) was found. Math grade was positively correlated to physical fitness measurements standing long jump ($r=0.75$; $p<0.01$), sit and reach ($r=0.70$; $p<0.01$) and running on 600m ($r=-0.72$; $p<0.01$). In "Self-reported physical activity and academic performance study", significant link between physical activity and indicators of physical fitness (Flamingo

test, Hand grip, Situps 60s, Shuttle run, height, weight and Body mass index), very small, but significant link was found. Explosive strength (Standing long Jump), muscle strength (Hand grip), repetitive strength (situps 60s) and physical dimensions of the body (height, weight, BMI) were found. Children with higher index of academic performance are better in some motor abilities (balance, repetitive strength, and physical dimensions of the body) compared to children with lower index of academic performance. Children with lower index of academic performance performed better in muscle strength (hand grip). In "Objectively measured physical activity and academic performance study", a small, but significant link between mother's education (r_{ap}=0.26, $p<0.05$), father's education (r_{ap}=0.22, $p<0.05$) and children's academic performance was found. Mother's educational levels are also significantly correlated to children's overall physical activity (r_{pa}=0.10, $p<0.05$). In "Objectively measured physical activity and academic performance study", moderate (ES=0.39) and statistically significant difference in academic performance was found between normal and high physical activity group. Children from Ljubljana area performed better in mathematics compared to rural schoolchildren. Results in "Longitudinal study" showed statistically significant differences between physical activity duration in grade-6 and grade-9 (Z=-7.343, p=0.00). Physical activity duration of same children is lower in grade-9 compared to physical activity in grade-6. Rural school children are significantly more physically active in grade-6 (U=1518.5; p=0.00) and in grade-9 (U=1042.5; p=0.02) than urban children. CONCLUSION: Physical activity positively affects intellectual development and academic performance of elementary schoolchildren. Since there are significant links between academic performance, physical fitness and physical activity, we can not ignore the fact that many cofactors are responsible for such positive links between these three variables, such as parental education, place of residence and children's maturity levels.

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Povzetek: UVOD: Gibalna aktivnost je katerokoli telesno gibanje, ki ga proizvedejo skeletne mišice, njen rezultat pa je poraba energije. Gibalna aktivnost pozitivno vpliva na splošno zdravje, saj zmanjšuje krvni pritisk, holesterol ter vpliva na boljše počutje otroka. Poleg pozitivnih vplivov na zdravje pa ima gibalna aktivnost tudi pozitiven učinek na učni uspeh otroka, saj učenje kompleksnih struktur stimulira frontalni korteks v možganih, ki je prav tako aktiven pri učenju in reševanju miselnih problemov. Rezultati dosedanjih raziskav kažejo pozitiven odnos med gibalno aktivnostjo, motoričnimi sposobnostmi in učno uspešnostjo otrok. Krovno raziskovalno vprašanje doktorske disertacije je, kako gibalna aktivnost vpliva na intelektualni razvoj oziroma učni uspeh otroka in kako se le-ta spreminja glede na njeno kvantiteto in čas. METODE: Gibalna aktivnost otrok je bila izmerjena subjektivno, z vprašalniki CLASS in SHAPES, ter objektivno, s pospeškometrom Actigraph GT3X in multi senzorsko napravo SenseWear Armband. Merilnike Actigraph in SenseWear Armband so otroci nosili vsaj 5 zaporednih dni. Gibalne sposobnosti in antropometrični parametri so bili izmerjeni v dveh dopoldnevih na matični šoli otrok, akademska uspešnost pa je bila pridobljena z oceno iz matematike in povrečnim učnim uspehom. Meritve vseh spremenljivk so potekale v sklopu študije ARTOS. V pilotni študiji je sodelovalo n = 16 deklet, v drugi študiji n = 3728, v tretji študiji n=166 in v zadnji, longitudinalni študiji n= 123 fantov in deklet. REZULTATI: V študiji "Gibalna aktivnost in učni uspeh osnovnošolk" je bila najdena močna in pozitivna korelacija med gibalno aktivnostjo in oceno iz matematike ($r= 0,77$; $p< 0,01$), oceno iz slovenščine ($r=0,83$; $p<0,01$) in povprečno zaključno oceno, ki predstavlja povprečje vseh šolskih ocen ($r= 0,83$; $p < 0,01$). Ocena iz matematike je statistično značilno povezana z gibalnimi sposobnostmi skok v daljino z mesta ($r= 0,75$; $p< 0,01$), predklon sede ($r= 0,70$; $p< 0,01$) in s tekom na 600m ($r= -0,72$; $p< 0,01$). Med skupinami gibalne aktivnosti, gibalnimi testi ter merami antropometrije (flamingo, stisk pesti, dvig trupa, stopnjevalni tek, masa, višina in indeks telesne mase) obstajajo statistično značilne razlike. Otroci z nizko gibalno aktivnostjo imajo

značilno boljše rezultate pri stisku pesti (ES= 0,10). Otroci z višjo gibalno aktivnostjo imajo boljše rezultate pri dvigu trupa (ES= 0,21), so višji (ES= 0,12), imajo višjo maso (ES= 0,12) in indeks telesne mase kot manj gibalno aktivni otroci. Otroci, ki so bolj gibalno aktivni, imajo boljše rezultate gibalnega fitnesa. Bolj učno uspešni otroci so primerljivo boljši v ravnotežju, repetitivni moči in indeksu telesne mase, saj imajo boljše rezultate pri merskih nalogah dvig trupa, flamingo testu, imajo nižjo maso, so višji in imajo nižji indeks telesne mase. V študiji "Objektivno izmerjena gibalna aktivnost in učna uspešnost" obstaja majhna, ampak značilna povezanost med izobrazbo matere ($r= 0,26$, $p< 0,05$), izobrazbo očeta ($r=0,22$, $p<0,05$) in gibalno aktivnostjo otrok. Materina stopnja izobrazbe je tudi pozitivno značilna z gibalno aktivnostjo otrok ($r= 0,10$, $p< 0,05$). V študiji "Objektivno izmerjena gibalna aktivnost in učna uspešnost" je bilo ugotovljeno, da obstaja značilna ($p< 0,05$) in velika razlika (ES= 0,39) v učnem uspehu med normalno in zelo gibalno aktivnimi otroci. Otroci iz Ljubljane so značilno boljši pri matematiki v primerjavi z otroki iz drugih slovenskih mest. Z rezultati "Longitudinalne študije" je bilo ugotovljeno, da so isti otroci v 6. razredu bolj gibalno aktivni kot v 9. razredu ($Z= -7,343$, $p = 0,00$) ter da so otroci s podeželja bolj gibalno aktivni v 6. razredu ($U = 1518,5$; $p = 0,00$) in v 9. razredu ($U=1042,5$; $p=0,02$) kot otroci iz mesta. ZAKLJUČEK: Gibalna aktivnost pozitivno vpliva na intelektualni razvoj in učno uspešnost osnovnošolcev. Ker obstajajo značilne povezave med učno uspešnostjo, gibalnimi sposobnostmi in gibalno aktivnostjo, pa ne smemo spregledati vpliva številnih spremljajočih dejavnikov, ki vplivajo na pozitivne medsebojne povezave, kot so izobrazba staršev, kraj bivanja in zrelost otrok.

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pod mentorstvom Doc. Dr. Shawnde Morrison

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1 INTRODUCTION

In modern thinking, there is quite a sharp distinction between mental and physical activities. In addition to separating between mental and physical activities, thinking of the superiority of the language, logic, mathematics, and academics compared to physical activity is also present. Physical activity is any activity that raises heart rate and can be implemented in the form of sports, playing with friends, family, walking to school, dancing or other daily physical activities (Roberts, Tynjälä & Komkov, 2004). From the physiological point of view each event produced by contraction of skeletal muscles, which requires consumption of energy (Bouchard, 1990) is physical activity.

Physical activity has a positive impact on child's development, but only if it is frequent, of sufficient quality, intensity and duration. Several studies examined the relationship between physical activities, motor and physical development of a child. Since physical activity is an integrative part of every child’s development (Grissom, 2005), which combines physical and mental processes, it can be considered an important but not the only factor influencing children's academic performance.

Academic performance is one of the most critical areas in the development of a child, especially in late childhood (Papalia, Olds & Feldman 2003). Despite continued dramatic increases in children's health risks, physical education programs are being cut more than ever to make room for more academic time (Shannonhouse, 2013). This negative trend continues despite the evident positive influence of physical activity on academic performance.

The widest research question of the doctoral dissertation is whether physical activity affects the intellectual development or academic performance of the child and how academic performance of elementary schoolchildren changes through a different quantity of physical activity and time. The following sections review the benefits of physical education and related physical activity on physical fitness and academic performance. A detailed examination of physical activity is discussed next.

1.1 Physical activity

Physical activity is a behavior influenced by many factors. These factors work on four levels: physiological, psychological, sociocultural, and ecological (Lindquist, Reynolds & Goran, 1999). Physiological level of physical activity in children is determined by age, gender, and ethnicity (Reynolds et al. 1990 & Hudson, 2008). It has been found that girls are less active than boys, older children less active than younger and black girls less active than white girls (Ogden et al. 2006; Robinson & Killen, 1995; Zakarian et al. 1994; CDC, 1997). Psychological determinants of physical activity are self-efficacy (Dishman et al. 2004), a perception of physical competence (Sallis, Prochaska & Taylor, 2000), positive attitude (Trost et al. 1997), enjoyment of physical activity (Dishman et al. 2005) and perceiving benefits from engaging in physical activity (Zakarian et al. 1994). Sociocultural factor includes support for participation in activity from peers and siblings, parental level of physical activity (Sallis, Pattersen, Buono, Atkins & Nader, 1988; Adkins, Sherwood, Story & Davis, 2004), parental support (Sallis et al. 2000) and parental income. Ecological determinants include facilities, availability of equipment and transportation to activities (Sallis et al. 1992).

Quantity, intensity, frequency and types of physical activity differ by gender and age (Telford, Salmon, Timperio & Crawford, 2005). After the second year of life, children begin experimenting with their bodies and various other movements. By the age of 4 children are usually proficient in patterns of natural movements, such as running, jumping, throwing and catching and standing or moving on one leg (Škof, 2007). After the age of 7, movement and physical activity becomes more accurate, easy, efficient and useful in different situations. Younger children move more than older, and boys move more than girls (Riddoch et al. 2007), and children are physically less active than a decade before (Strel et al. 2003).

Physical activity is any bodily movement, produced by skeletal muscles and resulting in energy expenditure. It can be measured in kilocalories and can be classified into occupational, sports, conditioning, household and other activities. It is a complex behavior, including sports and non-sports activities (Caspersen, Powell & Christenson, 1985; Gabriel, Morrow & Woolsey, 2010), so also measuring it is complicated. Sports and movement are often planned, structured and repetitive, whereas non-sport activities are occupational and not planned. The difficult nature of physical activity makes it challenging to precisely measure (Plasqui & Westerterp, 2006) all of its aspects and outcome parameters, such as energy expenditure. Different measuring techniques can be grouped into five categories: behavioral observation, self-report, physiological markers, motion sensors and indirect calorimetry (Plasqui & Westerterp, 2007).

1.2 Effects of physical activity on health and brain in children and adolescents

Physical activity has positive effects on physical, psychological/social, and cognitive health on school-aged children and youth (Janssen & LeBlanc, 2010). Evidence showed that physical activity improved body composition and the prevention of overweight and obesity, improved skeletal (Gunter, Almstedt & Janz, 2012), metabolic (Janssen & LeBlanc, 2010) and cardiovascular health (Fernhall & Agiovlasitis, 2008). Despite biological benefits on biological health, physical activity also affects psychosocial health, such as reduction of symptoms of depression, stress, anxiety and improvements in self-confidence and self-esteem (Biddle & Asate, 2011).

1.2.1 Effects of physical activity on health in children and adolescents

It is widely known that physical activity has benefits on psycho-social health, functional ability and overall quality of life (Powell & Pratt, 1996). The prevalence of childhood obesity and health-concerned factors is increasing and is anticipated to increase (Zaninotto, Wardle, Stamatakis, Mindell & Head, 2010). Promotion of physical activity in children and adolescents has become a key focus to promote health (Lobstein, Baur & Uauy, 2004). It has been shown that physical activity reduces blood pressure and certain types of cancer (Batty & Thune, 2000). Physical activity reduces the risk of coronary heart disease (Batty & Lee, 2004) and raises cardio respiratory function (Strauss, Rodzilsky, Burack & Collin, 2001), improves muscular fitness and reduces the risk of falls (World Health Organisation, 1997). Physical activity engages directly on weight reduction and allows better control of fat in blood (Leon & Sanchez, 2001), reduces the amount of body fat (Kromhout, Bloember, Seidell, Nissinen & Menotti, 2011), raises the level of protective cholesterol (HDL), reduces the level of harmful cholesterol (LDL) (Sasaki, Shindo, Tanaka, Ando & Arakawa, 1987) and increases bone density (Centres for Disease Control and Prevention, 1997). Low physical activity has been identified as major risk factor for cardiovascular disease (Sandvik, Erikssen, Thaulow et al. 1993; Yusuf, Hawken, Ounpuu et al. 2004), which is the leading cause of death for men and women (World Health Organisation, 2011). Elevated body mass index (BMI) represents a greater risk for cardiovascular disease (CVS) as adults (Haque, Gadre, Taylor et al. 2008). Physical activity in childhood significantly affects healthy lifestyle and health status in adulthood (Gillander & Hammarstrom, 2002), since positive linear connections have been established between increased physical activity and positive health outcomes (Pate, 1993).

It has been reported that relations between physical activity of children and benefits on health are hard to find in children (Riddoch, 1998). Following a systematic review of the health benefits of physical activity and fitness in school-aged children (Janssen & LeBlanc, 2010), authors limited their research on seven health associated indicators. These indicators are high blood cholesterol, hypertension, the metabolic syndrome, obesity, low bone density, depression, and injuries.

1.2.2 Effects of physical activity in cardiovascular disease in children and adolescents

Development of cardiovascular disease becomes evident in middle-age, but the beginning of development of cardiovascular disease starts in childhood and adolescence (McGill, McMahan, Herderick et al. 2002), especially elevated blood cholesterol and blood pressure**.** It has been demonstrated that physical activity has a beneficial effect on lipids, lipoproteins (Kraus, Houmard, Duscha et al. 2002) and blood pressure (Whelton, Chin, Xin & He, 2002) in adults. Armstrong and Simons-Morton (1994) reported minimal, but beneficial effect of physical activity on lipids and lipoproteins in children and adolescents. Aerobic training had only weak relationship with blood pressure, but that kind of exercise reduced systolic and diastolic blood pressure in adolescents. After a thorough review of literature, Riddoch (1998) reported that six studies found no beneficial associations (Al-Hazzaa, Sulaiman, Al-Matar, Al-Mobaireek, 1994; de Visser, Van Hooft, Van Doornen et al, 1994; Dwyer & Gibbons, 1994; Harrell, McMurray, Bangdiwala et al. 1996; Rowland, Mattel, Vanderburgh, Manos & Charkoudium, 1996) between physical activity and lipids and lipoproteins, whereas another six showed a limited association (Suter & Hawes, 1993; Bistritzer, Rosenzweig, Barr et al. 1995; Craig, Bandini, Lichtenstein, Schaefer & Dietz, 1996; Gutin, Cucuzzo, Islam, Smith & Stachura, 1996; Twisk, Kemper, Mellenbergh, 1996; Boreham, Twisk, Savage, Cran & Strain, 1996). 12-year old boys (n=1005) from two Moscow districts, divided into a reference group and an intervention group participated for three years in a 3-year intervention study. The intervention group received counseling for children and their parents on diet, physical activity and smoking hazards. Follow ups were carried out after one and three years, following baseline measures. Examinations at 1-year showed greater reduction of cholesterol level, triglycerides, systolic blood pressure in the intervention group (Alexandrov, Maslenikova, Kulikov, Propirnu & Perova, 1992). DuBose, McKune, Brophy, Geyer and Hickner (2015) reported lower systolic blood pressure values related to higher physical activity levels in children (n=72), aged 9,5 $\pm$ 1,2 years. Despite the strong links between physical activity and cardiovascular fitness and coronary heart disease risk in children and adolescents, it appears to be mostly mediated by fatness (Boreham and Riddoch, 2001).

1.2.3 Effects of physical activity on metabolic syndrome in children and adolescents

Metabolic syndrome is characterized by hyperinsulinemia, low glucose tolerance, hyperlipidemia, hypertension, and obesity (Brage, Wedderkopp, Ekelund et al. 2004). Metabolic syndrome has been present in adults (34,4%), adolescents (8,6%), and children (5%) (DuBose, Addy, Ainsworth et al. 2005; Ford, Li and Zhao, 2010; Johnson, Kroon, Greenway et al. 2009). Obese children and adolescents have higher prevalence of metabolic syndrome compared to non-obese peers (Cook, Weitzman, Auinger et al. 2005) and obesity may be a primary risk factor for development of metabolic syndrome in youth (Goodman, Dolan, Morrison et al. 2005). Physical activity has been negatively associated with development of metabolic syndrome in adults and adolescents and total physical participation seems not to be associated with metabolic syndrome in children (Brage, Wedderkopp, Ekelund et al. 2004; Ekelund, Anderssen, Froberg et al. 2007). DuBose, McKune, Brophy, Geyer & Hickner (2015) examined the relationship between physical activity and the metabolic syndrome Score in 72 children, aged 9,5 ± 1,2 years. Metabolic syndrome score was created from blood pressure, waist circumference, high-density-lipoprotein, triglyceride, and glucose values; physical activity was assessed with an accelerometer. Time spent in different levels of physical activity were not related to metabolic syndrome after controlling for confounders. Jiménez-Pavón, Konstabel, Bergman et al. (2013) report that odds for having metabolic syndrome were higher for boys (6-9-year-olds) in the lowest physical activity quartile, compared to children in highest physical activity quantile. Several studies suggest negative associations between metabolic syndrome, physical activity intensity and metabolic syndrome Score (Martínez-Gómez, Eisenmann, Moya et al. 2009; Ekelund, Anderssem, Froberg et al. 2007). Martínez-Gómez, Eisenmann, Moya et al. (2009) reported an interaction between metabolic syndrome score, cardiorespiratory fitness metabolic syndrome score. Children with high physical activity levels and physical fitness had lower metabolic syndrome score than those with low physical activity levels and physical fitness levels. Vigorous physical activity may be substantial for determination the metabolic syndrome score (DuBose, McKune, Brophy et al. 2015).

1.2.4 Effects of physical activity on obesity in children and adolescents

Obesity is a multifactorial disease which is dependent on many factors and multiple interactions between genes and environment (Maffeis, 2000). Obesity in youth is associated with conditions such as dyslipidemia (Stensel, Lin, Ho & Aw, 2001) and an increased risk of type II diabetes mellitus (Sinha, Fisch, Teague et al. 2002). Obesity is defined as excess body fat, which is mostly defined by body mass index (BMI) (Flodmark, Lissau, Moreno, Pietrobelli & Wilham, 2004). BMI is a value derived from weight and height of an individual (expressed in units kg/m$^{2.)}$. The overweight equivalent in children and adolescents corresponds to the cut-off points of BMI at or above 25.0 and obesity equivalent corresponds to the cut-off points of BMI at or above 30.0. Children's and adolescents' obesity around the world is a significant health problem and showed an increased prevalence of pediatric and adolescent obesity in Europe (Caroli, 2003), USA (Ogden, Flegal, Carol et al. 2002) and in other less developed countries (Ebbeling, Pawlak & Ludwik, 2002). Since 1980 the percentage of obese children in the United States aged from 6 to 11 has doubled and the proportion of obese adolescents aged from 12 to 19 has tripled (Centers for

Disease Control, 2013). The highest prevalence of overweight children in Europe was found in children and adolescents from Finland, Ireland and Greece (expressed as 85th centile BMI) (Flodmark, Lissau, Moreno et al. 2004). In the USA prevalence was higher than in Europe (expressed as 95th centile BMI) (Lissau, Overpack, Ruan et al. 2004). More accurate comparisons between American and European children and adolescents cannot be made, since the same method and the same reference values for definition of obesity were not available (Livingstone, Prentice and Coward, 1992; Troiano and Flegal, 1998 in Flodmark, Lissau, Moreno et al. 2004). The two countries with the highest prevalence of overweight and obese youth participated in Health Behaviour in School-Aged Children Study, were Malta (33,3 %) and United States (31,9 %). Countries with the lowest prevalence of overweight youth were Lithuania (5,5 %) and Latvia (6,4 %) (Janssen, Katzmarzyk, Boyce et al. 2005). Children of obese parents have a higher risk of becoming obese compared to children of non-obese parents (Garn & Clark, 1976). Obesity in childhood and adolescence in 30% to 60% of cases continues to obesity in adulthood (Serdula, Ivery, Coates et al. 1993). The risk of obesity is reduced when children and adolescents engage in recommended levels of physical activity daily (Pate, McLever, Colabianchi et al. 2015).

The rise of childhood obesity became the global trend and is increasingly prominent; 21,4% of children, aged from 5 to 17 years were considered overweight or obese (OECD, 2012), which represents a double proportion of the comparison in relation to the previous decades. In 1978 and 1979 in Canada 15% of youth, aged 5 to 17 years were overweight or obese; in 2009-2011 31,5% of Canadian youth were overweight or obese (Roberts, Shields, de Groh, Aziz & Gilbert, 2012). To stop the negative trend of obesity among adolescents and children, all children should follow physical activity guidelines within the school premises, since the schools have the maximum control on children's behavior.

1.2.5 Effects of physical activity on bone density in children and adolescents

The overall amount of bone during the development and growing years of children represents a major determinant of the risk of fractures in later life. Childhood and adolescence have been identified as the most critical periods of mineralization (Slemenda, Reister, Hui et al. 1994). The residual bone mass is under environmental influences, which appear to be body mass, diet - calcium intake (Heaney, Abrams, Dawson-Hughes et al. 2000) and the amount and type of physical activity in child and adolescent period (Bailey, Faulkner & McKay, 1996). Slemenda et al. (1994) reported 4-7% increase in bone mineral density for prepubertal children in the highest physical activity quartile. Researchers from the University of Saskatchewan were investigating the influence of physical activity on bone mineral accrual during adolescent years. Children and adolescents in the highest activity quartile had greater peak bone mineral accrual rate and a greater bone mineral accumulation (Bailey, McKay, Mirwald, Crocker & Faulkner, 1999). In 10 months, high impact, strength-building exercise program (n=71) in 9-10 years old girls were investigating positive effects of physical activity on bone and lean mass. At the end of the intervention, there were no differences in height and total body mass, pubertal development or external physical activity. More lean mass, less body fat content, greater shoulder, knee and grip strength and greater total body (control 1,2%; exercise 3,5%), lumbar spine (control 1,2%; exercise 4,8%), proximal femur (control 1,3%; exercise 4,5%) and femoral neck (control 1,7%; exercise 12,0%) and bone mineral density (Morris, Naughton, Gibbs, Carlson, & Wark1997) was found. In research, if moderate exercise during growth in prepubertal boys increase areal bone mineral density, twenty boys (mean age 10,4 years) were participating in 8-months of 30-minute sessions, three times per week of weight-bearing physical education. The increase in areal bone mineral density in the exercise group was twice as in the control group and volumetric bone mineral density increased by 1,14 $\pm$ 0,33 % per month ($p<0,05$) (Bradney, Pearce, Naughton et al. 1998).

Physical activity, especially weight-bearing physical activity during childhood is a significant predictor of bone mineral density, while non-weight-bearing activity, such as swimming or cycling is not (Grimston, Willows & Hanley, 1993). Longitudinal and interventional studies have shown that increased physical activity in prepubertal children stimulates bone mineral accrual (Bailey, McKay, Mirwald, Crocker & Faulkner, 1999; McKay, Petit, Schutz et al., 2000; Fuchs, Bauer & Snow, 2001). Overall, physical activity is the stimulus for bone structure and has potential to increase peak bone mass notwithstanding genetics, hormonal and nutritional influences (Boreham & Riddoch, 2001).

1.2.6 Effects of physical activity on depression in children and adolescents

Evidence from studies demonstrates that physical activity in adults is inversely associated with depression (North, McCullagh & Tran, 1990). Kanner (1990) compared the effects of two levels of exercise in childhood and adolescence depression. Subjects were children and adolescents (n=68) between age 8 and 18 from Psychiatric Treatment Center in California. Children were randomly divided into two groups; high-level exercise treatment and low exercise treatment. Both groups demonstrated a better reduction in depression compared to pre-test but no statistically significant differences between groups in depression outcome score. McPhie and Rawana (2015) examined the influence of physical activity on a trajectory of depression from adolescence through adulthood. They reported lower levels of depression during mid-adolescence in adolescents with engaging in higher levels of physical activity. Biddle & Asate (2011) synthesized reviews investigating physical activity and depression, anxiety, self-esteem and cognitive functioning in children and adolescents.

Four review articles reported evidence concerning depression (Larun, Nordeim, Ekelund, Hagen & Heian, 2006; Calfas & Taylor, 1994; Craft & Landers, 1998; North & McCullagh, 1990), which summarized that physical activity over no intervention seemed to be potentially beneficial for reduced depression in children and adolescents. All reviewed articles had certain limitations, such as inclusion in interventions with mild depression over a short time frame and bad specification of frequency, duration, and type of activity; therefore all interpretations of articles should be taken with vigilance. Authors summarized that physical activity has positive psychosocial outcomes in young people and higher levels of sedentary behavior are associated with worse mental health.

1.2.7 Effects of physical activity on injuries in children and adolescents

Despite all the positive features and benefits of physical activity on health in children, every engagement in physical activity can lead toward injuries. Among young elite athletes, 40 injuries per 100 children in 1-year incidence rate occurred (Baxter-Jones, Maffulli & Helms, 1993). All activities carry an increased risk of acute injuries, physical activity in any competitive form of sports can result in the additional risk for fracture (Van Mechelen, 1997). Injuries sustained during physical activity engagement have been established as a leading cause of injuries in children and adolescents (Brudvik & Hove, 2003; Finch, Valuri & Ozzane-Smith, 1998). Jespersen, Rexen, Franz et al. (2015) described the epidemiology of diagnosed musculoskeletal extremity injuries and incidence rates about different settings, body regions and injury types in children, aged 6-12 years. Overall, the total of n=1259 injuries were diagnosed, with an overall rate of 1.59 injuries per 1000 physical activity units.

To ensure positive effects of physical activity on children's health, all activities need to be under the watchful eye of teachers and parents, because injuries can lead to absenteeism in school, sport and the occurrence of incipient depression. Injuries may result in locomotors inactivity, weakening of the locomotors system, obesity, high blood cholesterol and bad habits of children and adolescents in the most critical period of development.

1.2.8 Effects of physical activity on the brain

Physical inactivity influences not only the health of children but also cognitive and brain health (Chaddock, Pontifex, Hillman & Kramer, 2011). Low levels of activity and aerobic fitness are associated with declines in academic achievement (Chaddock et al. 2011), brain structure, cognitive abilities and brain function (Sibley & Etnier, 2003; Castelli, Hillman, Buck & Erwin, 2007; Chaddock, Erickson, Prakash et al. 2010).

Research findings in aging population studies showed that exercise and physical activity are protective against cognitive decline, especially working memory and executive planning (Kramer, Hahn, Cohen et al. 1999; Van Boxtel, Pass, Houx et al. 1997). Physical activity may increase oxygen saturation (Kramer al. 1999) and angiogenesis (Kleim, Cooper & VandenBerg, 2002) in brain area responsible for task performance. Several studies have demonstrated a positive relationship between aerobic fitness and cognition (Colcombe & Kramer, 2003; Chaddock, Erickson, Prakash et al. 2010). The prefrontal cortex and the hippocampus are the focus of many human studies of activity and neurocognition; molecular architecture and behavior of basal ganglia may be influenced by physical activity (Chaddock et al. 2010). The prefrontal cortex is the cerebral cortex in the front part of the lobe, containing Brodmann areas 9, 10, 11, 12, 46 and 47 (Finger, 2001; DeYoung, Hirsh, Shane et al. 2010). The functions carried out in prefrontal cortex are executive functions, such as planning complex cognitive behavior, personality expression, decision making, and moderating social behavior (Yang & Raine, 2009). The hippocampus is located in the temporal lobe of each cerebral cortex. Humans have two hippocampi, one in the left part of the temporal lobe and the other in the right part of the temporal lobe. As part of the limbic system, the hippocampus plays a major role in memory, spatial memory, and navigation. Basal ganglia are situated at the base of the forebrain. Principal components of the basal ganglia are the dorsal striatum, ventral striatum, globus pallidus, ventral pallidum, substantia nigra and subthalamic nucleus. The basal ganglia are primarily responsible for motor control, motor learning, executive functions and emotion (Lanciego, Luquin & Obeso, 2012).

Chaddock et al. (2010) reported that exercise influences the striatum by increasing dopamine signaling and angiogenesis. Children with higher aerobic fitness levels showed less behavioral interference to misleading and irrelevant flanking cues (Chaddock et al. 2010). Their results supported that dorsal striatum is involved in cognitive control, motor integration and response resolution (Aron, Poldrack & Wise, 2009 in Lanciego, Luquin and Obeso, 2012). Welk, Morrow and Falls (2002) reported that lower levels of aerobic fitness were associated with longer reaction time in youth and decreased response accuracy; children in higher levels of aerobic fitness were not behaviorally different. Chaddock, Erickson, Holtrop et al. (2014a) reported that children with higher aerobic fitness levels had greater white matter integrity and subcortical structures than children in lower aerobic fitness levels. White matter and subcortical structures are critical for learning and memory. Chaddock, Erickson, Holtrop et al. (2014b) were the first to demonstrate that aerobic fitness in children is positively associated with brain and cognitive health, using diffusion tensor imaging. Researchers showed that higher fit children show greater fractional anisotropy in sections of the corpus callosum, corona radiata, and superior longitudinal fasciculus, compared to lower fit children.

1.3 Quantifying physical activity

Physical activity can be quantified according to frequency (how often?), intensity (how hard?), duration (how long?), and mode (what type?) (Chen & Bassett, 2005). If the habitual physical activity is required, some variation should be taken into account, because a regular physical activity is a behavior which can occur only as a result of skeletal muscle activity that is supported by energy expenditure (Armstrong & Welsman, 2006).

Determining physical activity needs to be socially accepted, should not burden the children with major equipment and should only minimally interfere physical activity of the child (Armstrong & Welsman, 2006; Livingstone, Robson, Wallace & McKinley, 2003). Researchers in the last decade developed a series of methods for identifying and measuring physical activity for children. Based on the literature review the most commonly used scientific methods for determining physical activity are: direct observation or objectively assessed physical activity and indirect or subjectively assessed physical activity (Kohl, Fulton & Caspersen, 2000; Welk, Corbin & Dale, 2000).

The subjective measure is less reliable than objective and is more easily administered to a population of groups. Subjective methods possess various limitations regarding their reliability and validity and are most commonly used to increase validity and reliability of individual instruments (Shephard, 2003). Direct measures are believed to remove many of the issues of recall and response bias (Prince, Adamo, Hamel et al. 2008), but they are time and cost intensive and difficult to apply to large epidemiologic settings. Objective measures also require specialized training, the physical proximity of participants and there is no ¨gold standard¨ for measuring physical activity (Dishman, Washburn & Schoeller, 2001), since there is a lot of measuring equipment in the market these days.

The appropriate method for measuring physical activity depends on different aspects, such as the number of participants in the study, commercial availability and period of needed measurement.

1.3.1 Subjective assessment of physical activity

Subjective assessment of physical activity relies on a child remembering activities they participated in or recalling their perception of the intensity of the movement. Subjective assessment of physical activity is useful for measuring the activity of large groups since subjective methods are cheaper than objective.

Subjective methods or self-report of assessing physical activity involves qualitative or descriptive recall of behaviours, logbooks, self-reports, proxy reports and diaries (Armstrong & Welsman, 2006; Laggeros & Lagiou, 2007).

Subjective instruments are the most widely used type of physical activity assessment. It is very important to identify strength and limitations of their use before using them. The recognized benefit of self-report is collected data from a large number of children at low cost. Self-reports have been used in different age ranges and measures can be adapted to fit the need of particular research and population (Sallis and Saelens, 2000).

Questionnaires are the most common used tools for measuring physical activity with children and adolescents. There are generally two types of questionnaires, the self-report type where the older children and adolescents report on their PA on their own, and the proxy-report where physical activity of young children is reported by parents or teachers (Sallis & Saelens, 2000). Self-reports have been used in a range of ages, and can be either interviewer-administered or self-administered. In self-report, participants are normally asked to obtain activity participation during a recent period of time (1 hour, 1 day, 7 days, 1 month) (Kohl, Fulton & Caspersen, 2000). Disadvantage of self-report is validity and reliability of results (Shephard, 2003) due to over-reporting of physical activity (Warnecke, Johnson, Chavez et al. 1997), since recalling physical activity is very complex cognitive task (Baranowski, 1988). Disadvantage of proxy-report is reporter's ability to observe the physical activity of the subject (Sallis & Saelenes, 2000). Benefits of questionnaires are simple compilation of the results and addressing a wide range of parameters such as type, method, duration and frequency of exercise (Planinšec, 2003). It has been suggested that children younger than 12 years are unable to reliably estimate their activity and quantify the time of their activity (Pate, 1993). The main advantage of the questionnaires is simplicity, but they most often provide only minimal information about activity. Objectivity of the data collected with questionnaires is low, but they can be a very useful tool when we need quick and essential information about children's physical activity (Volmut, 2014). Questionnaires are a very good supplement to objective methods of measuring in order to assess the context and type of physical activity.

Physical activity diaries contain detailed information about various aspects of physical activity and may include information about intensity, duration, type and body position during physical activity (Ainsworth, Keller, Herrmann et al, 2013). Physical activity diaries are superior to retrospective questionnaires (Baranowski, Dworkin, Cieslik et al. 1984), but their use is unsuitable for children younger than 15 years of age (Saris, 1986). Physical activity can be monitored through physical activity diaries from one day to several weeks, depending on the purpose and interest of the research. Most of diaries are monitored via tablets, computers and smart-phones. Advantage of diaries is detailed information about specific activity, but on the other hand, disadvantage is that is does not contain all the activities that took place during the day.

Physical activity logs have checklist with tasks of activity that are completed in the end of the day, week, month or discrete period of time. Logs can include intensity and duration of physical activity. Physical activity can be monitored through activity logs from one day to multiple weeks, depending on the purpose of the assessment. Advantage of physical activity logs is simplicity of collecting the data and the biggest disadvantage is missing details of physical activity in the end of the day (Ainsworth, Cahalin, Buman & Ross, 2015).

1.3.2 Objective measures of physical activity

Objective measures of physical activity rely on information presented by another person through direct observation, measuring the temperature of the body or from a measurement device like heart-rate monitor, accelerometer or pedometer. Objective measures of physical activity are used to predict energy expenditure, which is crucial in terms of decreasing obesity and other diseases related to physical activity. Objective measures remove disadvantages associated with subjective measures, are more reliable, involve quantitative analysis of numerical data.

Objective methods can be expensive and are suitable for individuals or smaller groups.

With direct (systematic) observation we directly monitor and record children's physical activity at the same time. We can use video and special software for automatic detection of movement patterns. In the past this method was widely spread, however today it is somewhat neglected, although it has many advantages. Observation procedures are flexible, accurate, detailed and offer many descriptions of observed events (environment, equipment, conditions, behavioral…) (Trost, 2007). It was an important tool in assessment of physical activity, because it uses an objective method and provides rich data, especially in researches studying children, cognitive-behavior and effects of physical and social environments on physical activity (McKenzie, 2001).

Measuring of physical activity is nowadays increasingly directed towards measuring devices, which provide physiologically and mechanically more accurate and reliable data, compared to other techniques (Westerterp, 2009). Measuring devices referred to as ˝activity trackers˝ or ˝fitness trackers˝ are nowadays very popular for personal PA monitoring. Their popularity has risen as they became affordable, unobtrusive and useful in their application (Evenson, Goto & Furberg, 2015). Activity trackers can provide feedback and offer recommendations for individual's physical activity, but they are not reliable for scientific purpose to the same extent as accelerometers, pedometers and multiple-sensor devices. Unfortunately, there are no gold standards for measuring physical activity with wearable monitors (Freedson, Bowles, Troiano & Haskell, 2012). The choice of measuring device is left to the researcher and depends on several factors: interest, target population, cost and precision of measurement (Ainsworh et al 2015).

Measuring physical activity with accelerometers

Accelerometers are small wearable motion sensors which detect body accelerations in gravitational units (Freedson, Bowles, Troiano & Haskell, 2012). The core of accelerometer is a sensor from piezoelectric material, which produces voltage as a function of geometric deformation (Chen & Basset, 2005). Accelerations are then transferred to a lower resolution called epoch. Epoch is calibrated to a known criterion measure (e.g., oxygen consumption, doubly-labelled water). Most of existing calibration studies are then presented in unitless intensity metric called ˝counts˝

(Freedson, Bowles, Troiano & Haskell, 2012). When we have physical activity in counts, we can modify this unitless intensity to different levels of physical activity and energy expenditure. Acceleration is change in velocity over given period of time; therefore, intensity, frequency and duration of measured physical activity can be assessed (Ridgers & Fairclough, 2011). Compared to measures of oxygen consumption and METs most of accelerometer show a wide range of correlations (r=0.45 to 0.93) (Trost, McLever & Pate, 2005), which corresponds to a number of protocol-related variations such as accelerometer placement (hip, wrist, wrinkle, trunk) and investigation activities (ambulatory, non-ambulatory).

There are uni-, bi-, and triaxial accelerometers. Uniaxial accelerometer measure accelerations in one direction, biaxial in vertical and horizontal directin and triaxial in three directions: anteroposterior, mediolateral and vertical direction. Triaxial accelerometers provide more information and show the best relationship to activity-related energy expenditure (Bouten, Westerterp, Verduin et al. 1994). In physical activity research the most commonly used accelerometer is uniaxial. Researchers found comparable results between uniaxial, biaxial and triaxial accelerometers, because physical activity research prevails in vertical acceleration and this type of accelerometer is cheaper and easier for data processing (Kumahara, Tanaka & Schutz, 2004).

Accelerometers can be placed on different body parts: ankle, thigh, chest, wrist, upper or lower back, hips or belly button. In terms of reliability and validity of the data, literature encourages wearing accelerometer on the hips or in the lower back because of the proximity of the center of gravity of the body (Ekelund, Yngve, Sjöström & Westerterp, 2000).

Accelerometer collects and stores data in intervals called epochs, which is usually possible to adjust on 5, 15, 30, 45 and 60s or customized to one second or less. Shorter intervals, such as 15s epoch is more suitable for shorter and more intensive movement, because longer interval may not detect a short-lasting movement. Use of a longer epoch does not give an accurate assessment of high intensity activity, but longer epoch ensures longer data collection and storage up to three weeks or more (Nilson, Ekelund, Yngve et al 2002). The majority of the studies in children and adolescents used a 60s epoch (66%) and 15s epoch in preschoolers (42.9 %) (Cain, Sallis, Conway, Van Dyck & Calhoon, 2012).

A valid day is one of the conditions we need to take in consideration when measuring with accelerometers. The valid day is defined by a minimum number of wearing hours. Rule 70/80 provides that 70% of the sample subjects wear an accelerometer for at least 80% of the daily observation time (Catellier, Hannan, Murray et al. 2005). Minimum number of wearing accelerometer ranges from 3-10 days (Mattocks, Ness & Leary, 2008), 7 days should be reasonable standard for all ages (Ward, Evenson, Vaughn, Rodgers & Troiano, 2005). One of these days needs to be weekend day (Rowlands, 2007).

When measuring physical activity with accelerometers, we need to define non-wear time within a day, which is normally identified with summing consecutive zero counts per minute (cpm) and wear time is computed by decreasing the non-wear time from cumulative possible time. It is very important to differentiate between wearing accelerometer but being sedentary and not wearing accelerometer because of sleep time or swimming (Cain, Sallis, Conway, Van Dyck & Calhoon, 2012).

Measuring physical activity with pedometers

Pedometer is probably the oldest technique to assess physical activity and was designed by Leonardo da Vinci 500 years ago (Montoye, Kemper, Saris & Washburn, 1996). The pedometer records acceleration and deceleration of movement in one direction (Saris & Binkhorst, 1977). Pedometers provide measure of the number of steps taken during a given period of time (Kohl et al 2000). Pedometers have been used for measuring physical activity for the last two decades. Advantage of pedometers is low-cost, effectiveness (Buckworth, Lee, Regan, Schneider & DiClemente, 2007) and usefulness particularly in the epidemiological studies (Volmut, 2014). Disadvantage of pedometer is that we cannot assess intensity of movement and identify how many steps have been done in the specified intensity and the results assessed from pedometer are poorly associated with accelerometer outcome in everyday living conditions with children (Treuth, Sherwood, Butte et al. 2003). Pedometer step count is more inaccurate at speed <60m/min (Abel, Peritore, Shapiro et al 2011), therefore it is not suitable for older people and if the subject is walking faster than normally, pedometer may underestimate total distance, since step count of pedometer is influenced by stride length and speed of walking (Abel, Hannon, Eisenman et al 2009).

Measuring physical activity with heart-rate monitors

Heart rate is an indirect measurement of physical activity and it measures the physiological response of the body. Physical activity rate assessed with heart-rate monitor is closely related to oxygen consumption (VO_2), thus power consumption at different intensities of physical activity (McArdle, Katch & Katch, 2006). Heart-rate monitors record participant's heart rate at given intervals during the period of observation. They gather information about responses of the heart during exercise and physical activity, which could be interpreted as a proxy measure of acute physical activity (Kohl et al. 2000). Minute by minute information from heart-rate monitor gives us information about intensity, frequency and duration of free-living physical activity (Schutz, Weinsier & Hunter, 2001). Estimation of energy expenditure accessed via heart-rate monitor is popular, inexpensive, non-invasive and versatile; however, there are various sources in the assessment of physical activity by heart rate because factors other than exercise affect heart rate. Factors such as high ambient temperature, high humidity, and emotional stress will cause an increase of heart rate (Freedson & Miller, 2000). Beside pedometers and accelerometers heart-rate monitors are major examples of objective measurement (Sirard & Pate, 2001).

Doubly-labelled water

Doubly-labelled water (DLW) appears to be a gold standard for validating other methods to measure daily physical activity in free-living individuals (Starling, Matthews, Ades & Poehlman, 1999) and is one of the most accurate assessments of energy consumption in the implementation of activities in daily living environment. The method assesses the energy consumption with an accuracy of 1-3% depending on the results of calorimetry (Speakman, Nair & Goran, 1993) and variability of the measurement is between 4-10% (Speakman, 1998). DLW is noncalorimetric technique for measuring total energy expenditure (TEE) using an oral dose of water which contains nonradioactive isotopes of hydrogen (2H) and oxygen (18O). Derived CO2, as a product of physical activity, and indirect calorimetry formulas are used to calculate energy expenditure (Medical Dictionary for the Health Professions and Nursing, 2012). Physical activity energy expenditure can be calculated knowing total daily energy expenditure (TEE) measured by DLW, resting energy expenditure (REE) and thermic effect of consumed food (TEF), measured by indirect calorimetry (Starling et al. 1999; Plasqui & Westerterp, 2007). Measurement period normally runs from 1-3 weeks. Samples isotopes may be sampled from all body fluids, but is the most commonly used urine (Volmut, 2014).

AEE (kcal/day) = TEE (kcal/day) – REE (kcal/day)

Disadvantage of DLW technique is high cost, because of the relatively high price of the oxygen-18 water, mass spectrometer instrumentation and specific technical expertise in sample preparation and measurement (Starling et al. 1999). Despite being the criterion for gold standard, DLW does not provide specific information about daily physical activity, such as activity type, intensity and duration. Taken into consideration all these limitations, DLW is used in scientific manner to validate other techniques and approaches for the quantification of free-living energy expenditure (Westerterp, 2009).

Multi-sensor devices

Measuring all aspects of physical activity under free-living conditions is complex; the use of multiple methods of assessing physical activity simultaneously is recommended. Accelerometer and heart-rate monitor together make a powerful tool for assessing energy expenditure. Accelerometer counts verify that elevations in heart-rate are because of increased physical activity or vice versa. Technology has moved on, so new wearable devices are produced. Actiheart (CamNtech Ltd, Cambridge, UK) combines heart-rate and accelerometry (Zakeri, Adolph, Puyau et al 2008), Intelligent Device for Energy Expenditure and Activity MiniSun (LLC, Fresno, CA) combine five accelerometers which are worn on chest, thighs and feet (Zhang, Werner, Sun et al 2003) and SenseWear Armband (Bodymedia, Inc., Pittsburg, PA) combines triaxial accelerometry, skin temperature, heat flux and galvanic skin response in a single device, worn on the upper arm. These devices collect data on physiological and mechanical variables (Hills, Mokhtar & Byrne, 2014). There is no gold standard for objective measurements of physical activity, the choice is complex and it depends on many factors such as time, expertise, desired outcomes and desired physical activity outcomes (Ainsworth, Cahalin, Buman & Ross, 2015).

1.4 Status and trends of physical activity research

At National Conference of the INEFC David Kirk (2010) presented the current status and future trends in research on physical education. He reviewed current and future trends within Europe-authorised research published between 2000 and 2009. Total number of published papers from physical education and pedagogy was 665 in 4 most influenced European peer-reviewed journals (EPER, JTPE, EJPE/PESP, SE&S). In the last two decades, physical activity and its effects on health, cognition, and academics has become hot topic in the research field. Current studies indicated that majority of children and adolescents are not meeting the recommendation of 60 minutes of moderate to vigorous physical activity per day (Gortmaker, Lee, Cradock et al. 2012) and that physical activity levels are decreasing with age (Nader, Bradley, Houts, McRitchie & O'Brien, 2008). Several studies have been researching intensity of physical activity and rate of energy expenditure. It has been shown that moderate- to vigorous physical activity is important for normal growth, development, body composition and decrease in acquiring risk factors for development of chronic disease. Moderate- to vigorous physical activity is associated with physical, social and mental health benefits (Warburton, Nicol & Bredin, 2006; Janssen & Leblanc, 2010; Hallal, Victora, Azvedo & Wells, 2006) and is positively related to adult physical activity (Hallal et al. 2006; Telama, Yang, Viikari et al. 2005) and health (Hallal et al. 2006). Valid and reliable measures of physical activity are required (Caspersen, Nixon & DuRant et al. 1998; Trost, Loprinzi, Moore & Pfeifer, 2001), therefore several studies have been made determinating objective (Rowlands, 2007; Reilly, Penpraze, Hislop et a. 2008; Guinhouya, Hubert, Sourer et al. 2006; Schneider, Crouter, Bassett et al. 2004; Trost et al. 2011) and subjective measures (Sirard & Pate, 2001; Corder, Ekelund, Steele et al. 2008) of physical activity. Subjectively measured physical activity is more appropriate for large samples because it is much cheaper than objectively measured physical activity although the reliability of the measured data is better when measuring with objective assessments. In physical activity research very interesting and hot topics are also (Kohl & Cook, 2013): recess, physical education, active transport, sedentary or light intensity physical activity, state and local policies on school-based physical activity, vigorous or moderateintensity physical activity.

It is very well known that school-related physical activity must be a large contributor to overall physical activity among youth (Kohl & Cook, 2013). Overall contribution, including every segment of school day - transportation to and from school (McDonald, 2007; Bassett, Fitzhugh, Health et al., 2013), physical education (Simons-Morton, Taylor, Snider & Huang, 1993; McKenzie, Catellier, Conway et al. 2006), recess (Lee, Burgeon, Fulton et al., 2007; Bassett, Fitzhugh, Health et al., 2013), classroom time - before and after school activities. Guidelines, recommendations and policies from all national, supranational levels and from various organizations, are known to influence children's and adolescents' school physical activity. Despite excellent research and good public health surveillance systems, current monitoring of overall physical activity and all behaviours and forms included in the term physical activity, are inadequate. Differences have arisen for several reasons (Kohl & Cook, 2013). Physical activity has only recently been acknowledged as a vital public health issue. It is a behavior difficult to measure and it is not easy to understand types and quantities of physical activity relevant to health and health outcomes (Kohl & Cook, 2013). Recommendations for types and amounts of physical activity for children have changed for many times in the last two decades and schools - as the most suitable institution for the maintenance of the recommended amount of physical activity, vary considerably in size, resources, urbanization, traditions, and policies.

Very detailed and reliable overviews of physical activity for children and youth, based mostly on nationally measured data are "Report Card on Physical Activity for Children and Youth", promoted by Active Healthy Kids Global Alliance (Tremblay, Gray, Akinroye et al. 2014; Tremblay, Barnes & Cowie, 2014; Tremblay, Brownrigg & Deans, 2008; Active Healthy Kids Canada, 2005b) and Health Behavior in School-aged Children (HBSC), which is a cross-national study gaining insight into young people's well-being, health behaviours and their social context (HBSC International Coordinating Centre, 2016).

1.4.1 Physical activity rates in Slovenia

Findings show that in 2003 in Slovenia, 18% of boys and 19% of girls were overweight, and 6% of boys and 8 % of girls were classified as obese (Bučar Pajek, Strel, Kovač & Pajek, 2004). This proportion is still on the rise. Starc, Strel & Kovač (2010) found that changes in motor dimensions are gigantic, diverse and surprising. In this study, they compared generations from school year 2007/08 with previous generations. They found negative changes in motor abilities are on the average (for all eight movement skills measured in for SLOFIT data), for boys 0, 43% and for girls 0,22% lower motor abilities than the previous generation. With body weight measurements, there is also a noticeable downward trend in primary school children, when comparing to the previous generations. The greatest negative trend was noticeable with pupils between 9 and 11 years old, which gain over 1% weight compared to the previous generations. The largest increase in body weight is noticeable in 15 year old girls. Despite a sufficient number of physical education hours (3 school hours/week), and extracurricular activities connected to physical activity, there is still a negative trend, particularly when motor abilities are taken into account. It is necessary to radically change this trend towards the low-quality way of life, and promote awareness that physical activity is important - not only because of its positive effects on health but also positive effects on academic performance. According to the ACDSi data, 97% of boys and 95% girls (ages: 6-11 y) from Ljubljana are meeting WHO recommendations for daily physical activity (2010), 86% of boys and 76 % of girls (aged 6-18 y) meet physical activity guidelines. On weekends, 81% boys and 72% girls are meeting recommendation guidelines (Sember, Starc, Jurak et al. 2016).

There is no centralized registry of sports practice or participation in organized clubs for children and youth outside school system in Slovenia; although 60% boys and 47% of girls aged 6-19 years are engaged in extracurricular sport or clubs (Sember, Starc, Jurak et al. 2016). On school days only 16% of Slovenian boys and 19% of Slovenian girls play actively more than 2 hours per day, on weekends 57% boys and 59% of girls (Sember, Starc, Jurak et al. 2016). Only 3% of Slovenian children use bike and 26% walk to school. The ACDSi nationally-representative data (N=5207, Jurak, Kovač and Starc, 2013; Starc et al. 2014) indicates that active commuting to school remains relatively stable with age with ~52% of boys and ~50% girls from age 5 to 18 years actively commuting to school (Sember, Starc, Jurak et al. 2016). In Slovenia, 90% of boys and girls meet the recommendation of fewer than 2 hours of screen time per day. During weekends this percentage decreases to 37% and 45% of boys and girls, respectively. Weekend and weekday combined, 74% of boys and 79% of girls aged 6-19 years meet the recommendations for screen time (Sember, Starc, Jurak et al. 2016). In Slovenia 75% of parents encourage their children between 11 and 19 years to be physically active. Almost 90% of parents indicate they support opportunities for physical activity by buying sports equipment, driving kids to practice, etc. When asked about their parent's physical activity levels, children perceived their fathers to be 'very active' in ~30% of cases and 'moderately active' in 35% of cases. In Slovenia, physical education (PE) is a compulsory subject in all primary and secondary schools and they all follow the same PE curriculum. PE minutes vary by grade so that primary school (grades 1-5) receive a minimum of 105 hours per year, grades 7-8 receive 70 hours, and grade 9 students receive 62 hours per year. Grades 7-9 have opportunities to select additional 35 hours of elective sport classes, and 35 hours of elective dance class. Grades 4-6 may also select an additional 35 hours of elective, health-oriented sport classes (Kovač, Strel, Jurak et al. 2015). In addition to regular PE classes, primary school children have 5 sport days in each grade, each lasting 5 hours, together 25 hours of school-based physical activity in a school year. Some primary schools in Slovenia organise enhanced PE curriculum, during which children receive supplementary lessons (Jurak, Cooper, Leskošek & Kovač, 2013). Additionally, primary schools in Slovenia are allowed to have more than the prescribed minimum of 2 or 3 PE lessons per week if the school board decides so, although less than 10% of schools actually do. All primary schools are obliged to offer extracurricular sports programs, which are free of charge for all children. In the best case scenario, a 10-year old in Slovenian can receive 131 hours (or 7875 minutes) of regular PE lessons, plus 25 hours in school sports days, 35 hours of elective sport courses, and at least 35 hours of extracurricular school-based sport practice, summing to a total of 226 hours of school-based PE. Thus, Slovenian primary schools offer access to 77 min of daily in-school, professionally guided PA. In the worst case scenario a 10-year-old would participate in only the compulsory 3-weekly lessons of PE and obligatory school days, this number would drop to ~39 min per school day, still more than half the 60 min of recommended daily physical activity (Sember, Starc, Jurak et al. 2016).

In the past two decades, the national government and municipalities have invested in the reconstruction of old, and the building of new, school sports halls including other sport infrastructure. For example, from 2001-2008 public funding of sport infrastructure exceeded €300 million euros (Jurak, 2012). The policy of the Ministry of Education, Science and Sport also enforces rules related to the professional competencies of teachers and trainers in PE and youth sport, which require people with a university degree in PE for work with young athletes (Ministry of Education, Science and Sports, 1998). In addition, the Ministry currently develops strategies to implement compulsory, joint teaching of regular classroom teachers and PE teachers within the first 5 years of primary school to raise the quality and effectiveness of PE. Finally, more than 25 years ago, the government of Slovenia established the Centre for School and Outdoor Education programme which has 23 learning centres scattered throughout the country. Each of these centres employs at least one PE specialist, and offers various outdoor activities that are not available within regular school settings (Sember, Starc, Jurak et al. 2016).

A key reason for the past effectiveness of government policies related to schools, sport infrastructure, PE, and its curriculum in Slovenia is the evidence-based policy planning of the Ministry of Education, Science and Sports (Kovač et al. 2015). The Ministry has continuously supported the SLOfit monitoring system and has been using evidence on secular trends in physical and motor development of children and youth to plan its future activities and interventions, as well as evaluate their effectiveness. To wit, the Ministry introduced a health-oriented physical activity intervention program 'Healthy Lifestyle' to combat growing childhood obesity and declining physical fitness (Strel, 2013). Current evidence from SLOfit data suggest that these state-wide interventions are effective at influencing population movements (Strel, 2013), since obesity trends have been in decline since 2011, and the physical fitness of primary school children has improved significantly (Strel, 2013). Government strategies, policies and investments were graded B+ (Sember, Starc, Jurak et al. 2016).

1.5 Physical activity, growth, maturation and development

In physical activity research, pedagogy, pediatrics, human biology and biological anthropology terms like growth and maturation are often in the center of attention. Both processes are often mentioned in the same sentence. Nevertheless, each refers to particular biological activity. Natural growth and maturation of children and adolescents have been studied for more than 150 years (Malina, Bouchard & Bar-Or, 2004). Growth is linked to maturation (Hermanussen, 2010). Processes growth and maturation are very important to understand the children's and adolescents' biological variability in the phase of development. Growth and maturation are often used in conjunction with term development (Bose, 2007). Development is a widely used term, which refers to biological, psychological and emotional changes between birth and the end of adolescence.

Growth is an increase in size, cell number or hyperplasia, cell size or hypertrophy and intercellular substance or accretion. As children grow, they become taller, heavier; they increase in lean and fat mass and their organs increase in size (Malina et al. 2004). Maturation is often described as the process of becoming mature and refers to the timing and tempo toward the mature biological state. Timing refers to when some specific events occur, e.g. appearance of pubic hair and tempo refers the rate at which maturation progress youngster is. Timing and tempo of maturation are different in children at the same age and the same size. Since maturation and growth are closely related, they must be viewed as dynamic.

In the transition from childhood to adolescence children undergo many changes. Puberty occurs in girls earlier than in boys. Nowadays puberty occurs earlier than in previous years, especially in overweight children (Cheng, Buyken, Shi et al. 2012). There are various methods for determining the degree of maturity. The most accurate estimate is by the skeletal maturity but is not widely used because of the risks associated with x-ray. The maturity of the child can also be determined through the development of the teeth and on the development of secondary sexual characteristics. Often used is also the method for determining the maximum height increments, where the maximum height increase determine the ratio between the length of the legs and body (Mirawald, Baxter-Jones, Bailey & Beunen, 2002).

1.6 Recommendations for physical activity guidelines

Physical inactivity is identified as the fourth leading (6% of deaths globally) risk factor for global mortality (World Health Organisation, 2010). Physical inactivity, non-communicable diseases (NCDs) and general health problems of the population are rising worldwide. Following recommendations from World Health Organization (2010), all children aged 5-17 years should be participating in a variety of physical activities that support natural development, are enjoyable and safe. Recommendations include play, games and sports, active transportation, recreation, physical education, planned exercise, school and community activities.

Children aged 5-17 years should accumulate at least 60 minutes of moderate- to vigorous-intensity (MVPA) physical activity per day, what is more than 60 minutes provides additional health benefits. Most of the physical activities should be aerobic (World Health Organisation, 2010). Examples of MVPA include basketball, racquet sports, soccer, dance, swimming laps, skating, brisk walking, jogging, stair climbing, strength training, cross-country skiing and cycling.

1.6.1 Recommendations for physical activity in Europe

The European recommendations are based primarily on the recommendations of the World Health Organisation (World Health Organisation, 2002), which are not completely adequate for the European population since 40-60% of the people of Europe lead a sedentary life (EUPAG, 2008). Many of State Members of the European Union have national guidelines for physical activity which help health agencies and private institutions to promote the importance of physical activity. The EU Working Group "Sport & Health" (EUPAG, 2008) made recommendations that would promote increased physical activity in the European Union. These recommendations are addressed primarily to policy makers as inspiration for a formulation of national physical activity guidelines. The first guideline is based on World Health Recommendation. European Union recommended a minimum of 60 minutes of daily moderate-intensity for children and youth and at least of 30 minutes of daily moderate-intensity physical activity for adults and seniors (EUPAG, 2008). European guidelines were divided into sections sport; health; education; transport, environment, urban planning and public safety; working environment and services for senior citizens.

Kahlmeier, Wijnhoven, Alpiger et al. (2015) reviewed and systematically analyzed physical activity recommendations of the World Health Organisation for the European region. Review of the research article contains information on national recommendations and guidelines for physical activity. Information about national physical activity recommendations were found only in 37 countries (~70%). Only 21 countries developed recommendations including frequency, intensity, and duration of activity (~40%). Recommendations for children (Table 1) have been developed only in 14 European countries (~26%) and for older adults only in 6 countries (~11%). Countries with developed physical recommendations in Europe for all age groups are Austria (Titze, Ring-Dimitrou, Schober et al. 2010), Iceland (Public Health Institute, 2008), Ireland (Department of Health and Children, 2009), Netherlands (Ministry of Health, Welfare and Sport, 2005) and United Kingdom (Department of Health, 2011).

Table 1: Comparison of national physical activity recommendations from European countries for children (5-18 years old) and younger people.

Country/ Organisation	Inactivity	Duration	Intensity	Frequency
World Health Organisation		At least 60 minutes.	Moderate-to-vigorous.	Every day.
Austria	Sitting more than 60 minutes.	60 minutes.	At least moderate.	Every day.
Belgium		60 minutes.	Moderate.	Every day.
Denmark		At least 60 minutes.	Moderate.	Every day.
Finland (for children 7-18 years old).	Sitting more than 120 minutes.	60 – 120 minutes.	All-round activity.	Every day.
France		60 minutes.	Moderate-to-vigorous.	Every day.
Iceland	More than 120 minutes.	60 minutes.		Every day.
Ireland		60 minutes.	Moderate-to-vigorous.	Every day.
Luxembourg		60 minutes.	Moderate.	Every day.
Malta		30 – 60 minutes.	Moderate-to-vigorous.	Every day.
Netherlands		60 minutes.	Moderate	Every day.
Norway		60 minutes.	Moderate-to-vigorous.	Every day.

Sweden		60 minutes.	Moderate-to-vigorous.	Every day.
Switzerland	More than 120 minutes.	60 minutes.	Equivalent to brisk walking or cycling.	Every day.
United Kingdom		At least 60 minutes.	Moderate-to-vigorous.	Every day.

Source: Kahlmeier et al. 2015.

According to review article of Kahlmeier et al. (2015), physical activity recommendations were available only for about one-third of countries, mostly from central and eastern part of Europe. Around 40% of countries in the European Union did not develop national recommendations till 2015.

1.6.2 Guidelines for physical activity in Canada

Canada's first physical activity guidelines were introduced in 2002 (Health Canada, 2002). Two sets of guidelines were published, separately for children aged 6 to 9 years and youth aged 10 to 14 years (Health Canada, 2002). Canada launched new guidelines for physical activity for children, youth, adults and older adults in January 2011. The process of updating Canadian Physical Activity Guidelines lasted from November 2006 till the launch day to Canadians in January 2011. Canadian guidelines are relevant to all healthy children (aged 5-11 years) and youth (12-17 years). Children and youth should be physically active as a part of play, games, transportation, recreation, physical education or planned exercise. For health benefits, they should accumulate at least 60 minutes of moderate- to vigorous physical intensity per day and should include vigorous-intensity and activities that strengthen muscles and bones at least three times per week. Adults (18-64 years) should accumulate at least 150 minutes of moderate- to vigorous-intensity physical activity per week, which can be in sessions of at least 10 minutes. Physical activity should include activities that strengthen muscles and bones at least two days per week (Tremblay et al. 2011).

1.6.3 Recommendations for physical activity in the United States of America

Healthy People Organisation provides science-based objectives for improving health in the United States of America. The organisation developed new goals and objectives for health and disease prevention in States every 10-years for the past 30 years (US Department of Health and Human Services, 2014). Healthy People 2010 ranked physical activity as leading health indicator and developed goals to increase physical activity levels among adults, children, and adolescents and to reduce sedentary behavior among adolescents (US Department of Health and Human Services, 2000). Two most important objectives in Healthy People 2010 (US Department of Health and Human Services, 2000) are to increase the amount of moderate-to-vigorous physical activity among all population subgroups and increase opportunities and facilities where people can be physically active. Objectives for increasing physical activity for children and adolescents are seen in Table 2.

Table 2: Selected objectives for increasing physical activity for children and adolescents, Healthy People 2010.

Objective	Population	Baseline	2010 objective
At least 30 minutes of moderate physical activity >5 of previous 7 days	adolescents	27%	Increase to 35%
Vigorous physical activity that promotes the development and maintenance of cardiorespiratory fitness >3 days per week for 20 minutes	Adolescents	65%	Increase to 85%
Daily school physical education	Adolescents	29%	Increase to 50%
Walking to school <1 mile	Children and adolescents	31%	Increase to 50%
Bicycling to school < 2 miles	Children and adolescents	2,4 %	Increase to 5%

Source: US Department of Health and Human Services. Healthy People 2010. Washington, DC: US. Department of Health and Human Services, 2000.

Committee on Physical Activity and Physical Education in the School Environment from Institute of Medicine of the National Academies, Washington (2013) formulated recommendations for physical activity and divided them into six areas: whole-of-school approach, considering physical activity in all schools related policy decisions, designating physical education as a core subject, monitoring physical education and opportunities for physical education. Whole-of-school approach advocates for 60 minutes of physical activity daily and at least 30 minutes in moderate to vigorous level of physical activity in the school time in elementary school. For easier understanding, this is equivalent to 150 minutes per week. Students should engage in additional physical activities during recess, dedicated physical activity time and other opportunities (Committee on Physical Activity and Physical Education in the School Environment, 2013). With recommendation Physical Activity in All School-Related Policy Decisions scientists advocate for regular access for physical activity in the school environment as a contributing factor in children's health, development and improving academic performance. In implementation, this refers to after-school programming, participation in sports, active transport to and from school, agreements between schools and community sports objects to share places to be physically active after school-time. School Physical Education is the only opportunity for some children to make something for their health, be physically active and excess negative energy. Despite negative tendencies of daily physical activity and growing concern about physical inactivity in the United States, physical education is not treated as a core subject. United States Department of Education and health agencies need to find innovative applications of physical education as a core subject, to measure and highlight outcomes. In the fourth recommendation the committee states that all education, health and government agencies should develop data systems to monitor policies and behaviors to provide a foundation for planning, developing and implementing physical activity in schools. Next recommendation, Providing Preservice Training and Professional Development for teachers, is based on educating physical education and classroom teachers to be more professional from the field sport and physical activity and to promote physical activity across the curriculum. The last recommendation is Enduring Equity in access to Physical Activity and Physical Education, which should pursue equal access to facilities and opportunities for physical activity.

1.6.4 Guidelines and recommendations for physical activity in Slovenia

Slovenia made directives and recommendations for physical activity, but only for adults. Recommendations for physical activity in Slovenia are divided into four sectors: type, intensity, frequency and duration of physical activity (Fras & Poličnik, 2007).

Traditional recommendations advise aerobic activities, which require the use of large muscle groups and are continuous (brisk walking, jogging, cycling, swimming, ice skating, cross-country skiing). Newer guidelines recommend walking or any activities which can be carried out daily with every-day intensity, such as moderately intense housework (such as lifting or carrying devices), moderately heavy gardening, ball games and other games with children, moderately intense swimming, slow jogging (about 7 km / h). It is important that the physical activity in relation to the type of activity is balanced. Activity should be partitioned into 50% aerobic activities, 25% flexibility exercises and 25% of exercises to strengthen the muscles.

Intensity of physical activity should range between 50 – 85 % of maximum aerobic capacity (oxygen consumption) or moderate physical activity of energy consumption of 3 to 6 MET or 4 to 7 kcal/min. Daily or 5 times/week.

Duration of physical activity should range between 30 and 60 minutes; newer recommendations allow intermittent exercise in several daily sessions with shorter or longer intervals if activity cannot be carried continuously. Duration of each session should not be shorter than 10 minutes, and all sessions should sum at least 30 minutes altogether.

Bratina et al. (2013) published a scientific review article in Slovenian language with guidelines for physical activity for Slovenian children, aged 2-18 years. Authors concluded that children should accumulate at least 60 minutes of moderate- to vigorous physical activity daily and to heat before exercise and calm and relax after physical activity.

1.6.5 Comparison between American, European, Canadian and Slovenian recommendations for physical activity for adults

European recommendations are based on World Health Organisation recommendations (World Health Organisation, 2002) for physical activity. American recommendations are based primarily on policy changes and actions to increase physical activity. This approach also includes sport, health, education, environment, safety, work and services for the elderly and active transport (U.S. Department of Health and Human Services, 2008). Canadian guidelines are based on observation and systematic process of forming new guidelines for physical activity. Canadian and American recommendations provided recommendations for all age groups but in Europe only six countries of 53 (Kahlmeier et al. 2015). Irrespective of different policy in countries, all recommendations are very similar, almost identical and follow recommendations of World Health Organisation (2002). Many guidelines recommend that children and youth spend minimum of 60 minutes of moderate- to vigorous-intensity physical activity (MVPA). The importance of MVPA is crucial and could not be overstated, all intensities of physical activity may be substantial for health promotion and disease prevention (Carson et al. 2013). There are currently no recommendations that include light-intensity physical activity (LPA), which may be due to the historical focus on MVPA (Marshall and Ramirez, 2011).

Table 3: Comparison between the US (2013), EU (2008), Canadian (2011) and Slovenian (2007) recommendations on physical activity for adults.

European Union recommendations (EUPAG, 2008).	United States recommendations (U.S. Department of Health and Human Services (2008).	Canadian guidelines (Tremblay et al. 2011).	Slovenian recommendations (Fras & Poličnik, 2007).
At least 150 minutes/week of moderate-intensity physical activity or at least 60 minutes of vigorous-intensity physical activity	At least 150 minutes/week of moderate-intensity physical activity or 75 minutes of vigorous-intensity aerobic activity/week	At least 150 minutes/week of moderate- to vigorous-intensity physical activity	At least 150 – 210 minutes of moderate-intensity physical activity/week
Activity can be accumulated in blocks of at least 10 minutes.	Activity should be in episodes of at least 10 minutes and spread throughout the week.	Activity can be accumulated in blocks of at least 10 minutes.	Activity could be in sessions, which could not be shorter than 10 minutes and all sessions together at least 30 minutes.

Activities to increase muscular strength and endurance should be added 2 to 3 days per week.	Adults should also do muscle-strengthening activities of moderate or high intensity and involve all major muscle groups on 2 or more days.	Activities to increase muscular strength and endurance should be added 2 days per week.	
	For additional benefit, adults should increase their aerobic activity to 300 minutes per week of moderate intensity or 150 minutes of vigorous intensity.		All physical activity should be portioned: 50% aerobic activities, 25% flexibility exercises and 25% of exercises to strengthen the muscles.

1.7 Physical activity interventions and observations in school settings

Physical activity is important for children and adolescents. Schools and community settings are necessary for promoting physical activity (Stone, McKenzie, Welk & Booth, 1998), since children and adolescents are most of the day in the school environment. In public health and biomedical research, study design plays a major role in interpretation (Rothman, 2012). Research studies are nowadays divided into interventional and observational studies.

1.8.1 Interventional studies

The interventional study design is also called experimental study design. Interventional studies are studies where investigator is acting on participants and changing their normal behavior. Interventional/experimental study designs are: randomized controlled trial study design, crossover randomized controlled trial study design, pre-post study design, non-randomised trial study design (Thiese, 2014). Since schools have major influence on children during their childhood and adolescent time, schools are the best environment for physical activity interventions (Story, Nanney & Schwartz, 2009). Physical activity has been shown to be indirectly associated with academic performance, including better classroom behavior, self-esteem, engagement in school, on-task behavior and lower drop rate (Trudeau & Shephard, 2008). Van Sluijs, McMinn & Griffin (2007) reviewed 57 studies on the effectiveness of interventions among children and adolescents. Thirty-eight studies reported positive effect (67%) and statistical signification in 27 studies (47%) of physical activity interventions. Significant result ranged up to 42% increase in participation in regular physical activity and increase of 83 minutes of moderate-to-vigorous physical activity per week. Kahn et al. (2002) evaluated the effectiveness of various interventions to increasing physical activity; informational, behavioral, social, environmental and policy approaches. Effective interventions were: ˝point-of-decision˝ prompts to use stairs intervention and community-wide campaigns of informational interventions; school-based physical education, social support in community settings and individually-adapted health behaviour change from field behavioural and social interventions; and creation of or enhanced access to places for physical activity combined with informational outreach activities from field environmental and policy interventions.

Randomised controlled trial study design

Randomized controlled trial study design is the most used type of interventional studies (Machin & Fayers, 2010). This study design randomly divides a homogenous group of participants and implements intervention on only one group. The only difference between groups should be intervention (Thiese, 2014). Dwyer, Coonan, Leitch et al. (1983) investigated effects of daily physical activity on health in primary schools in South Australia, using randomized control trial research design. Results for students after two years of intervention in 1980 were compared against cross-sectional measures of 1978. Findings of South Australia research suggested beneficial effects on health and no loss of academic performance in spite of 45 to 60 minutes loss of teaching time every day. Metcalf, Henley and Wilkin (2012) reviewed 30 peer-reviewed studies, whether physical activity interventions affect overall activity of children. Studies had to meet the following inclusion criteria: children and adolescents younger than 16 years, studies had to be randomized controlled trials; physical activity had to be objectively measured, expressed in mean accelerometer counts/minute and intervention must have incorporated a component that aimed to increase physical activity. Thereview provided strong evidence that randomized controlled trial – physical activity interventions have had only a small effect on overall physical activity level. Intervention children had been only 4 minutes per day more active compared to control children, which may explain why such interventions have had a limited effect on body mass index or body fat.

Crossover randomised controlled trial study design

Crossover randomized controlled trial study design at first phase divides participants the same as in the randomized controlled trial study, but at the end of first treatment intervention, participants are relocated to another treatment arm. Between treatments are often wash-out periods (Thiese, 2014). Thirty-five German adolescents between 13 and 14 years of age participated in crossover study design. They were divided into higher-fit (n=17) and lower-fit (n=16) subgroups. Participants were assigned to the event-related potential (ERP) study with two recording sessions, one following 20 minutes of exercise and one following 20 minutes of rest. They participated in both conditions in a random order within an exact seven days interval at the same day of the week and same time of the day. Results indicated that higher fit-individuals showed significantly greater contingent negative variation of the event-related potential amplitudes. The research team did not found the reliable effect of acute exercise on inattention or impulsivity; however, higher-fit individuals did perform better (Stroth, Kubesch, Dieterle et al. 2009). Researchers from Scotland used a crossover design trial and randomized n=552 children into two groups. One group received a classroom-based program of physical exercise on week 1 and no physical exercise program in week 2; other group received a classroom-based program of physical exercise in week 2 and no physical exercise program in week 1. Each week all participants completed cognitive test battery. Benefits occurred only for participants who exercised during the second week. The research team interpreted that exercise intervention has a positive effect on cognitive performance possibly by facilitating practice effects, which are not moderated by sex, ADHD symptom level or BMI (Hill, Williams, Aucott, Thomson & Mon-Williams, 2011).

Non-randomised trial study design

The non-randomised trial study design is not considered as strong study design and is often subject to many types of bias and error. The non-randomised trial study compares a group where intervention was performed and a group where intervention was not performed (Thiese, 2014). Alexandrov, Maslennikova, Kulikov, Propirnu and Perova (1992) performed the non-randomized trial study. The three-year intervention consisted in primary prevention. All intervention children received counseling and lectures on prevention, and secondary prevention, where children with risk factors were invited to a single counseling session. Follow-up examinations were carried out at one and three years following baseline. After one-year intervention children had attained a greater reduction in their levels of total cholesterol, triglycerides, and systolic blood pressure.

Pre-post study design

Pre-post study design measures outcome before and after intervention has been implemented. Pre-post study has the strength to suggest that outcome is impacted by intervention; however, pre-post studies do not have control over other elements which have changed during the intervention (Thiese, 2014). Ridgers, Stratton, Fairclough and Twisk (2007) selected n=297 schoolchildren from N=26 elementary schools to wear uni-axial accelerometers during recess. Research has investigated the effects of the recess-based intervention on physical activity, investigating short-term effects of playground markings and physical structures on recess physical activity and effects of covariates on the intervention. Following legalities of pre-post study design, data were collected at baseline and 6-weeks following playground intervention. Schools were visited twice, once before the playground redesign (pre-test), and once six weeks after playground redesign (post-test). After interventions, positive but non-significant effects had been found for moderate-to-vigorous physical activity and vigorous physical activity and boys were significantly more engaged in moderate-to-vigorous and vigorous physical activity than girls.

1.8.2 Observational studies

Observational or epidemiological studies are those where the investigator is not acting on participants and changing their normal behavior but is observing the natural relationship between factors and outcomes. Observational studies are often retrospective (Thiese, 2014) and make decisions where the independent variable is not under investigator's control because of ethical or logistical concerns (Porta, 2008). Observational studies are ecological study design, proportional mortality ratio study design, cross-sectional study design, case-control study design, case-crossover study design, retrospective and prospective cohort study design, diagnostic testing and evaluation study designs.

Ecological study

The most basic observational study is ecological study, which compares clusters of people, mostly based on their geographical location (Breslow, 2014). Ecological studies are usually retrospective, and the data is derived from big databases, which is their weakness, since big databases are typically created for other purposes, not research (Friis & Sellers, 2013). The advantage of ecological study is cost effectiveness and starting point for hypotheses generation (Thiese, 2014). Joens-Matre, Welk, Calabro et al. (2008) looked for for rural-urban differences in physical activity, physical fitness and overweight prevalence of children. The sample included n=3416 Iowa children from grades 4, 5 and 6 with main age 10.6 $\pm$ 0.96. Data were obtained from the Physical Activity and Nutrition Among Rural Youth (PANARY) project and level of urbanization was determined by 1993 Rural-Urban Continuum Codes (RUCC), which distinguish metropolitan counties by size and degree of urbanization and proximity to metro areas (U.S. Dept. of Agriculture, 2005 in Joens-Matre et al. 2008). Physical activity was assessed using the Physical Activity Questionnaire for Children-PAQ-C (Kowalski, Crocker & Kowalski, 1997 in Joens-Matre et al. 2008) and body mass index was measured by trained physical education teachers. Prevalence of overweight was higher among rural children (25%; P<0,001) than children from urban areas (19%) and small cities (17%). Urban children were the least active overall (Cohen's d=0,4).

Proportional mortality ratio study design

Proportional mortality ratio studies design is used in occupational epidemiology (Delgado, Sillero & Gálvez Vargas, 1994) and equals the cause-specific standardized mortality ratio divided by overall proportionate mortality ratio (Hansen, 1990). These type of studies are limited to death (Stolley & Lasky, 1995) as an outcome and give us cause-specific information between exposure categories (Monson, 1974).

Cross-sectional study design

Cross-sectional study design or transversal is a type of observational study that involves the analysis of a representative data at one specific point in time. Cross-sectional study is also called prevalence study because one of the main variables is population prevalence (Woodward, 2013). The advantage of this study design is low cost and major disadvantage that investigators cannot normally answer the causation of the effect. Robinson, Hammer, Wilson et al. (1993) conducted a cohort study among female adolescents (n=971 sixth- and seventh-grade) with follow-up assessments 7, 14 and 24 months after baseline, where n=671 girls had sufficient data for baseline cross-sectional analyses. Hours of television watching, physical activity and stage of sexual maturation were assessed with self-report instruments; height, weight and triceps skinfold were measured and body mass index was calculated. Among adolescent girls, television viewing time had weak associations with adiposity and physical activity. Andersen, Harro, Sardinha et al. (2006) assessed the associations of objectively measured physical activity (accelerometer Actigraph) with clustering of cardiovascular disease risk factors in children. Researchers did a cross-sectional study of n=1732 randomly selected 9-year old and 15-year old school children from Denmark, Estonia and Portugal. The primary sampling units were schools; secondary sampling units were children on the school register. Key findings of this study were graded with negative association between clustering of risk factors and physical activity. The first to the third quintile of physical activity has had a raised risk in all analyses.

Case-control study design

Case-control study design was originally developed in epidemiology and compares people with an outcome of interest (case) with people without the specific outcome of interest (control), i.e. diseased or not diseased. The outcome is measured before exposure and controls are selected by not having the outcome. The disadvantage of this study is increased risk for bias due to known case study of participants. Advantages of this type of study are low cost, fast execution of data compared to cohort studies, collection of individual participants' data, control for multiple confounders and access to multiple exposures of interest (Thiese, 2014). This study design is the most efficient when researching rare diseases. Case-control studies increased the risk for bias, particularly recall bias (Rothman, Greenland & Lash, 2008; Wacholder, Silverman, McLaughlin & Mandel, 1992). The strength of case-control studies is that study is most efficient for rare diseases, its low cost, fast execution compared to cohort studies and ability to assess multiple exposures of interest (Mann, 2003; Thiese, 2014). Da Costa Ribeiro, Taddei and Colugnatti (2003) researched obesity among children attending elementary public schools in Sao Paulo, Brazil. They measured n=223 obese and n=223 eutrophic schoolchildren, aged 7-10 years. Parents of n=446 schoolchildren all together were interviewed about children's eating behaviors and habits. They concluded that children with a birth weight of 3500 g or more or whose parents are obese should receive special attention in the prevention of obesity.

Case-crossover study design

Case-crossover studies are retrospective and the case serves as his/her own control for some comparison issues (Woodward, 2013). These studies are good where the outcome is acute and well defined (Rothman & Greenland, 2008). The disadvantage of case-crossover studies is risk for having recall bias. Case-crossover studies require careful selection of period and careful selection of timing and the length of the windows. Experience has shown that case-crossover design applies best if the exposure is intermittent (Maclure & Mittleman, 2000). Broderick, Herbert, Latimer et al. (2012) searched associations between physical activity and risk of bleeding in children with hemophilia. A case-crossover study nested within prospective cohort study design was conducted on n=104 schoolchildren. Children with hemophilia were monitored for bleeds up to 1 year. Physical activity was assessed according to expected frequency and severity of collisions. The risk of bleeds associated with physical activity was estimated 8 hours before the bleed and two times for 8hour control window. Children with hemophilia were more exposed to the risk of bleeding in vigorous physical activity.

Cohort studies

Cohort studies identify a group of people and follow them for some time with a desire to see how their exposures affect their outcomes and are normally used in cases that cannot be controlled experimentally. Cohort studies are the only ones of observational studies that can calculate cumulative incidence and an incidence rate (Rothman & Greenland, 2008; Ahrens & Pigeot, 2005; Aschengrau & Seage, 2013) between prospective and retrospective studies.

Prospective study design watches for outcome during the period of study and involves observation of subjects over a long period and is considered as a gold standard of observational research (Aschengrau & Seage, 2013). Maffeis, Talamini and Tato (1998) researched the influence of diet, physical activity and parents' obesity on children's adiposity. Anthropometric measures of n=112 prepubertal children were initiated in 1992 and follow-up measurements in 1996. Obesity was defined as relative body mass index > 120%. Parents' obesity was the main risk factor for children's' obesity and sedentary behavior was independently associated with overweight at the age of 8 years. Retrospective study watches for outcome backward and examines exposures about an outcome that is established at the beginning of the study (Mann, 2003; LaMorte, 2015). Retrospective study or historic cohort study is a longitudinal cohort study that researches a cohort of individuals with common exposure in determining influence and is compared to another group, which was not exposed to exposure factor (Doll, 1980). A retrospective study looks backward and examines exposures to suspected risk about an outcome, established at the beginning of the survey. In retrospective studies there is a higher risk for obtaining bias than in prospective studies, this is why retrospective studies are often criticized. Data from the Cardiovascular Risk in Young Finns Study (n=2309); longitudinal research project from the beginning of 1980 (Telama, Yang, Viikari et al. 2005) were used for investigation of stability of physical activity from childhood and adolescence to adulthood and how physical activity in adulthood could be predicted from variables measured in childhood and adolescence. Physical activity was assessed with self-report, and medical examinations were made. It was concluded that high level of physical activity in childhood affects physical activity in adulthood (Telama, Yang, Viikari et al. 2005).

1.9 Physical fitness

Physical fitness is a general state of health and well-being and capacity to perform in physical activity, daily activities and sports and refers to a full range of physiological and psychological qualities. It is defined as the quality or state of being fit (fitness, 2016). Physical fitness is set of attributes associated with the capacity to perform physical activities (Ortega, Ruiz, Castillo & Sjostorm, 2008), which consists of three components: muscle strength, endurance and motor skills (Malina & Katzmarzyk, 2006). Physical fitness could also be thought as an integrated measure of almost all body functions (cardiorespiratory, hemato- circulatory, psychoneurological and endocrine-metabolic) involved in daily physical activity and exercise (Ortega et al. 2008).

Cardiorespiratory function is assessed using maximal oxygen consumption (VO2max). Principal components of muscle strength are maximum power (static and dynamic), explosive strength, durability, power and isokinetic strength. Most appropriate tests for the assessment of muscle strength are shaking fists, Standing Long Jump and Bent Arm Hang. Speed is the ability to move the body or body parts as quickly as possible and agility is a combination of speed, balance, strength and coordination (Ortega et al., 2008). It has been shown that physical fitness is strongly correlated with total adiposity (Ruiz, Rizzo, Hurtig-Wennlöf et al. 2006; Ara, Vincente-Rodriguez, Jimenez-Ramirez et al. 2004; Lee & Arslanian, 2007), abdominal adiposity (Ortega, Tresaco, Ruiz et al. 2007; Hussey, Bell, Bennett & Gomrley, 2007), cardiovascular disease (Hurtig-Wenloff, Ruiz, Harro & Sjostorm, 2007; Ara et al. 2008; Chomistek, Chasman, Cook et al. 2014; Berry, Pandey, Gao et al. 2013), skeletal health (Ginty, Rennie, Mills et al. 2005), and mental health (DiLorenzo, Bargman, Stucky-Roop et al. 1999; Castelli, Hillman, Buck & Erwin, 2007). Ortega et al. (2008) found out that physical efficiency during childhood and adolescence is a good indicator of health. Several health benefits are associated with physical fitness. Better physical fitness reduces the risk of cardiovascular disease, colon cancer, diabetes, dying prematurely and obesity (US Department of Health and Human Services, 1996), improves bone function, musculoskeletal function and psychological variables such as depression, anxiety, stress and self-confidence (American College of Sports Medicine, 2006).

1.9.1 Quantifying physical fitness

Assessment of physical fitness has a longer history than assessment of physical activity (Malina & Katzmarzyk, 2006). Over the past 50 to 60 years the concept of physical fitness has evolved from a primary focus on motor and strength components to more emphasis on health in the 1970s (AAHPERD, 1980), and morphological and metabolic components have been added to the more traditional muscular strength and endurance, motor, and cardiovascular components (Bouchard & Shephard, 1994). Caspersen, Powell and Christenson (1985) identified the differences between physical activity, exercise and physical fitness and their importance in health research. Physical activity is any bodily movement produced by skeletal muscles that results in energy expenditure and could be measured in kilocalories. Components of physical fitness include strength, endurance, speed, power, agility, flexibility, coordination, morphological and metabolic components (Malina & Katzmarzyk, 2006), overall physical fitness is set of attributes that people have or achieve (Caspersen, Powell & Christenson, 1985). The ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy in activity means being physically fit. Things such as vigor, alertness, fatigue and enjoyment are hard to measure, on the other hand, health-related physical fitness is easier to measure (Caspersen, Powell & Christenson, 1985). Definition of exercise is more restrictive than definitions of physical activity and physical fitness. Exercise is intended to improve or maintain an established level of physical fitness (Caspersen, Powell & Christenson, 1985). From 1980 several physical fitness tests have been used (Table 3). Caspersen, Powell and Christenson (1985) divided physical fitness to capabilities related to health and capacity related to skills. Health-related capabilities are cardiorespiratory durability, muscle durability, muscular strength, body composition and flexibility. Skills related capabilities are agility, coordination, balance, reaction time, power and speed.

Bös (1994) made a clear and transparent model of motor abilities, which represents the links between different impairments and their interdependence. Motor abilities are under different influences as the features of energy and information components of movement are intertwined. Model of motor abilities (Bös, 1994) distinguishes between fitness (power, durability) and information capabilities (speed, coordination). Physical abilities are organized at different levels (Magil, 1998) and different categories (Fleishman, 1972). In the first category there are perceptive-motor abilities, while others are skills that relate to the capacity of the body. The group of perceptive-motor abilities includes: coordination of movement, control precision, choice of response, reaction time, coordination, hand movement, control the speed and direction of movement, dexterity, finger dexterity, precision movements with your hands, wrists and fingers speed and targeting. The group of abilities that define the capacity of the body includes static power, dynamic power (repetitive power), explosive strength, and the strength of the hull, flexibility, coordination of movement of the whole body, the whole body balance and endurance. Magill (1998) added the following capabilities: static balance, dynamic balance, movement coordination of eye-hand coordination and eye-foot movement.

Pišot and Planinšec (2005) investigated the physical structure of the early childhood population on five-, five- and a half and six- year old children. In the group of five-year old children, using PB-criterion (Štalec & Momirovič, 1971), four latent motor dimensions were isolated and appointed: coordination of movement, speed of the reciprocating movement, static balance and coordination of movements of the extremities. In the group of six- and a half-year-old children and using GK-criterion, seven factors were isolated: coordination of movements, realization of rhythmic structures, static balance, explosive leg strength, and coordination of hand movement, speed of simple movements, precision and balance. In the group of five- and a half year old children they found that the structure of motor abilities identified eight factors. Comparison between sexes shows that the factor structures are partially similar, as were the female and male sex equally defined balance, explosive power and agility.

Table 3: Overview of physical fitness tests

Test	Children age	Test items
AAHPER Youth Fitness Test (AAHPER, 1958)	9 – 17 yrs	50-yard dash, Standing Long Jump, Shuttle run, Pullups, Flexed arm hang, Situps, Distance throw, 600-yard run, 1-mile run, 9-min run, 1,5-mile run, 12-min run
Sports educational chart – Slofit (Strel, 1996)	6 – 18 yrs	Weight, Height, Skinfold, Arm plate tapping, Standing Long Jump, Polygon backward, Situps, Bent arm hang, Forward bend and touch on the bench, 60-m run, 600-m run
AAHPERD Health – Related Physical Fitness and Sports (AAPHERD, 1980)	5 – 17 yrs	1-mile run, 9-min run, 1,5-mile run, 12-min run, Situps, Sit and reach, Sum triceps, Subscapular skinfolds
International Physical Fitness Test (Bullard, 2015)	9 – 19 yrs	50-m sprint test, Fixed Arm Hang, 10-m shuttle run, Back throw, 1000-m run, Standing Long Jump, Grip Strength, Body Composition
Prudential Fitnessgram (Plowman, Sterling, Corbin et al., 2006)	5 – 17 yrs	% fat, BMI, 1-mile run, 20-m shuttle run, curl-up, push-up, modified pull-up, pullup, flexed arm hand, trunk lift, Sit and Reach, Shoulder stretch
CAHPER Fitness Performance (CAHPER, 1966)	7 – 17 yrs	50-yard dash, shuttle run, Standing Long Jump, speed situps, flexed arm hang, 300-yard run, PWC170
Canada Fitness Survey (Fitness Canada, 1983)	7 + yrs	Step test, Right Grip, Left grip, Push-ups, Speed situps, Sit and reach,
EUROFIT – European Test of Physical Fitness (EUROFIT, 1988)	6 – 18 yrs	Endurance shuttle run, PWC170, Flamingo stand, Plate tapping, Sit and Reach, Standing long jump, Hand grip, Situps, Flexed Arm Hang, Shuttle run
Asia Council for the Standardization of Physical Fitness Tests (To, 1985)	9 – 18 yrs	1000-m, 800-m, 600-m, 50-m dash, Shuttle run, Standing Long Jump, Pullups, Flexed arm hang, Flexed leg situps, Grip strength, Forward trunk flexion

The area of motor abilities is organized hierarchically. It is possible to identify two regulatory dimensions that define the structure of a wide area of motor abilities. The first dimension is related to the mechanisms for receiving and processing information and is crucial for motor tasks, where structuring movement, movement control and central control of movement is essential for their implementation. The second dimension is related to mechanisms that regulate energy and is critical for tasks where physical experience is associated with control of intensity and duration of excitation (Matejek, 2012).

1.9.2 Physical fitness rates in Slovenia

In Slovenia physical and motor development of children and youth has been monitored (Strel, 1996) for more than 30 years (Sember, Starc, Jurak et al., 2016). Every April there are physical fitness benchmarks which are evaluated together; this initiative is called ˝Športno-vzgojni karton˝ - the SLOfit card. SLOfit or the National System for Monitoring Physical and Motor Development of children and youth includes all Slovenian primary and secondary schools. For more than 30 years, this system has given teachers, researchers, and policy-makers access to high-quality, standardized data on physical fitness, which in turn allows for relatively responsive evidence-based policy adjustments when needed. For example, based on more recent evidence of declining physical fitness from the SLOfit database, Slovenia introduced a health-oriented physical activity intervention program called Healthy Lifestyle in the school year 2010/2011, offering children 2 optional, additional hours of physical activity per week. Healthy Lifestyle is considered as part of a school's regular extracurricular health-oriented physical activity program. This project currently includes more than 30% of the entire primary school population. Before this initiative, Slovenian children had been experiencing negative trends in motor and physical fitness for over two decades, but since 2011, physical fitness in 6- to 14-year-olds has been steadily improving (Sember, Starc, Jurak et al., 2016). In 2015, Slovenia also started new tests among the student population. Indeed, with such a massive, state-sponsored program, Slovenian children have better physical characteristics compared to most European countries (SLOfit, 2016). Nevertheless, the Slovenian youth population is not immune to changes in lifestyle, and with access to this longitudinal data, Slovenian researchers are now also noticing negative trends in child motor development (SLOfit, 2015).

SLOfit card provide children, teachers, youth, and others with the following (Strel, 1996): information on their achievements in sports education, graphical representation of physical and motor development of a child or a young person for the entire period of schooling, advice on which sport activity a child should take part in and usefully spend his or her leisure time, advice on problems on physical or motor development, advice on what sport equipment to buy for schools and parents.

Establishment, evaluation and monitoring of physical characteristics and motor abilities are carried out by means of the following measuring procedures (Strel, 1996): body height, body weight, triceps skinfold, arm plate tapping, standing long jump, polygon backwards, sit-ups, forward bend and touch on the bench, bent arm hang, 60-m run, 600-m run. The SLOfit system measures physical development, motor development, and motor abilities.

Physical development is measured through physical growth, defined by body height, weight and skinfold of the upper arm. Body Mass Index is calculated using height and weight and is used to assess nutritional status. Triceps skinfold is the anthropometric indicator of peripheral fat distribution (SLOfit, 2016).

Motor development in SLOfit system is monitored through the development of various motor abilities, which are divided into health-related fitness indicators and physical performance indicators (SLOfit, 2016). Indicators of health-related fitness are aerobic power, muscular strength, muscular endurance and flexibility. Highly developed aerobic abilities reduces the risk of heart disease, diabetes and stroke. Properly developed flexibility, muscular strength and muscular endurance are important for injury prevention, proper posture and overall functioning of the body. Indicators of physical performance are speed, explosive strength and body coordination (SLOfit, 2016).

SLOfit measurement procedures are the same throughout primary and secondary school period, which allows direct comparison of individual outcomes of physical and motor development from 6 to 18 years of age. Selection of appropriate tests is based on several pilot and experimental studies (SLOfit, 2016). In the last 30 years, SLOfit system measured more than 1 million children and youth. Slovenian children between 1995 and 2015 became higher by 0,8 %, heavier by 4,6 % and their triceps skinfold increased for 14 % (SLOfit, 2016).

1.10 Physical activity, physical fitness and academic performance

Many experts note that additional hours of physical education have a positive impact on the academic success (Shephard, 1997) since learning of complex movements stimulates the frontal cortex in the brain, which is also active in learning and problem solving (Jensen, 2005). The results of studies suggest a positive relationship between physical and academic achievement (Singh, Uitjtdewilligen, Twisk, Van Mechelen & Chinapaw, 2012). More physically active children are also more efficient at learning, compared to less active children (Kirkendall, 1985). However, researchers are aware that the increased volume of physical education in school alone cannot compensate the lack of physical activity in daily life.

Educational experts intuitively believe that individuals who are physically active perform better in school. Some studies have found positive relationships between physical activity and academic performance (Dwyer, Coonan, Leitch, Hetzel & Baghurst, 1983; Hollar, Lombardo, Lopez-Mitnik et al. 2010; Donnelly, McKiel & Hwang, 2009; Shephard, 1997), whereas other studies found no difference, or even negative outcomes between physical activity and academic performance (Ahamed, Macdonald, Reed, Naylor, Liu-Ambrose & McKay, 2006; Sallis, Alcaraz, McKenzie, Kolody, Faucette & Hovell, 1997). Many experts from the field of physical activity and physical education have found positive effects on health, musculoskeletal development, behavior and increased motivation to learn. In addition to adverse conditions correlated with physical inactivity (i.e. high blood pressure, anxiety, depression, risk of certain type of cancer, coronary heart disease…); there are also positive outcomes of physical movement in the school environment. Advocates of quality daily physical education for prepubescent children frequently encounter the argument that such initiatives will harm academic progress (Shephard, 1997).

It was found that physical education affects some factors which are predictors to raising academic performance in children. Some of these factors are higher self-esteem, body image, concentration and better behavior in the classroom. Caterino and Polak (1999) were interested in the effects of physical activity on concentration. They made a comparison between passive and directed physical education activities. They used the Woodcock-Johnson Test of Concentration. Children from 4th grade were significantly more concentrated in school after engaging in physical activity (Caterino & Polak, 1999). Evans, Evans, Schmid and Pennypacker (1985) reported a lower rate of inappropriate behavior of children, who were a part of physically active programs (football and jogging). Using a meta-analysis, they came to the conclusion that the most physically active interventions led to significantly reduced disruptive behavior (Allison, Faith & Franklin, 1985). Raising academic achievement can be as a result of the better classroom climate, or better attitudes of teachers towards students. For example, in an Australian quasi-experimental study, and in a separate Trois-Rivieres study, academic achievement was a result of a better classroom environment. Improved self-esteem and body image (Nelson & Gordon-Larsen, 2006) are often associated with high levels of physical education. Investigators have found links between school physical education and psychosocial factors such as satisfaction, integration of students in the classroom and self-esteem. These psychological factors should also prevent dropout from school and help raise learning abilities (Libbey, 2004).

Additional physical activity in school curricula does not adversely affect children's academic achievement in the elementary school; on the contrary, there is a positive trend between increased physical activity and academic performance. There are some excellent studies which have investigated this connection, and some are summarized herein. To begin, in the suburb of San Diego, California, researchers looked at the effects of a 2-year Physical Education Program (SPARK) in Elementary Schools. In the Spark study, there were seven elementary schools which participated. Pupils who took part in the SPARK program (n=759, 5th and grade-6rs), were divided into three different groups which were assigned to one of three conditions. In the first condition, kids were taught by a physical educator (80min/week of PE), in the second condition, by a classroom teacher (65min/week), and in the third condition, by an untrained classroom teacher (control group, 38min/week). The group taught by the physical educator achieved greater cardiovascular and muscle endurance, slight declines in academic performance, but no negative effects on academic achievement. The decline in academic performance and achievement was smaller in the other two groups (Sallis, McKenzie, Alcaraz, et al. 1997). Similarly, in British Columbia, experts made an intervention called Action Schools! BC (AS! BC) with the desire to raise student physical activity levels, to determine the gender differences in academic performance and to maintain academic performance despite a corresponding decrease in overall academic time, which was partially replaced with physical activity. Finally, another Canadian study lasted 16 months and included 10 Canadian elementary schools. Two of the schools did not carry out the research properly, so they were excluded. In the end, the intervention study had a sample of 143 girls and 144 boys in the 4^{th} and 5^{th} grade. Physical activity in intervention schools was increased by 47 minutes per week, and it was determined with the Physical Activity Questionnaire for Children (PAQ-C). Academic performance, evaluated by Canadian Achievement Test (CAT-3), remained unchanged. Despite an overall reduction of academic time, the researchers indicated a positive trend towards an enhanced academic performance (Ahamed et al. 2006). Similarly, in the Australian longitudinal study SHAPE (School Health; Academic Performance and Exercise), researchers came to the conclusion that school kids who were given almost 60 minutes of physical activity/day, had after 14 weeks of study better ability to work and reduce body fat. Although curriculum hours of Mathematics and Reading were transferred to Physical Education, experts found positive trends in improving knowledge of mathematics and reading, body composition and positive changes in behavior after two years (Dwyer et al. 1983). The PASS & CATCH study examined n=932 children from eight elementary schools from Texas. Experts were interested in the correlation between increased school physical activity during the school day and academic performance (Murray, Garza, Diamond, Hoelscher, Kelder & Ward, 2008). Children from experimental group significantly improved math and reading scores. From baseline to three years of study, classroom realized significant improvements in academic performance (Donnelly, McKiel & Hwang, 2009), measured with Wechsler Individual Achievement Test (Wechsler, 2001). Pupils from sports classes achieved statistically higher GPA and higher scores in mathematics and foreign languages. Finally, the HOPS (Healthier Options for Public Schoolchildren) project was an obesity prevention intervention, conducted in Florida, USA. This project examined the results of n=1197 students, divided into experimental and control group. The intervention components included: integrated and replicable nutrition, physical activity and lifestyle educational curricula, matched to the state curricula standard. Examinees took Florida Comprehensive Achievement Test (FCAT). Intervention children had significantly higher FCAT scores in mathematics than children from the control group (Hollar et al. 2010). In many studies, it was found that physical education affects some elements which are supposed to be the effects that raise academic performance of children. These factors are higher self-esteem, body image, concentration and better behavior in the classroom. Factors that lead to better academic performance are reflected in Grade point average (GPA).

Modern, fast lifestyle, unhealthy food choices and lack of exercise are increasingly destroying the health of the younger population worldwide. With increases in sedentary activities (watching television, use of computer, learning), there is a corresponding decrease in overall physical activity. Because of large academic breadth of school curricula in many school environments, there remains less time dedicated to children's physical activity. A satisfactory amount of physical activity does not only make a positive effect on children's health but also affects elements (self-esteem, body-image, concentration and better behavior in the classroom) which lead to better academic performance. Physical activity in elementary schools as a part of physical education (Sallis, McCkenzie, Kolody et al. 1999), afternoon sports related activities (Marsh, 1993), extracurricular activities (Eccles, Barber, Stone & Hunt, 2003), physical exertion in school curriculum and recess periods (Verstraete, Greet, Dirk, Ilse & Bourdeaudhuij, 2006) have a significant impact on classroom behavior, self-esteem, self-image, body image and cognitive function in elementary school children. All these factors have an impact on learning outcomes, which lead to better academic performance.

Parents are often concerned that increased physical activity and participation in sport affect academic achievement negatively because not enough time is perceived to be devoted to the reading material and homework. In addition to the negative effects of watching TV, there is also a greater decline in academic performance (Sharif & Sargant, 2006). In primary education, it should be imparted to children that body movement is part of everyday life. A successful way to achieve sufficient daily movement is by adding extracurricular minutes to physical education in school, or by adding some extracurricular physical activities before or after school.

1.10.1 Physical fitness, physical activity and academic performance in Slovenia

Physical activity is muscle movement where energy consumption is the case. It is very important to distinguish between physical activity, sports activity and physical fitness. Sports activity is unlike physical activity, planned, structured and designed to improve at least one part of body’s condition. Progress in technology leads to less unplanned movements (Strniša & Čagran, 2015) so it is really important to perform as many planned activity to maintain physical fitness and health (Starc & Sila, 2007). Physical activity is one of the important segments in healthy lifestyle since it reduces the possibility of various diseases. The less physically active children, the bigger the exposure to diseases (Boreham & Riddoch, 2011).

Leskošek, Strel and Kovač (2007) investigated differences in physical fitness between normal-weight, overweight and obese children and adolescents. About a fifth of Slovenian schoolchildren is overweight; this proportion is higher in boys than in girls. They found that almost all physical fitness tests are in negative correlation with obesity. The highest correlation was found in tests requiring the whole body (Standing long jump, Obstacle course backwards, 60-m run, 600-m run and Bent arm hang). Smaller influence was found in test situps, hand-tapping and forward bench fold where tests do not require the moving of the whole body. Matejek and Starc (2013) investigated the relationship between children's physical fitness and gender, age and environmental factors. Physical fitness was assessed with 12 physical fitness tests and physical activity was assessed through self-report. Most of the differences in physical fitness can mainly be explained by age and gender. Place of residence, physical activity, academic performance and parental education has less influence on physical fitness development and serve as an additional impulse to stimulate physical development of children.

Planinšec (2006) searched links between learning success and the volume of average daily physical activity of younger schoolchildren (1^{st} – 5^{th} grade) and whether there are differences in physical activity regardless of gender, school grade of school stratum. Children were divided into 3 school performance groups (below average, average, above average). Physical activity was measured with questionnaires. The most physically active children had above the average school performance, and the least active children had below the average school performance. The most active were children from 5^{th} grade and the least active were children from 2^{nd} Grade; children from rural areas were less active than children from urban areas of Slovenia. It is encouraging that physical activity was positively correlated with academic achievement. Planinšec, Pišot and Fošnarič (2006) found out that children from suburban areas of Slovenia were the most active (87min/day), then children from urban areas (85min/day). The least active were children from rural areas (82min/day). Physical activity was measured with questionnaires. There are statistically significant differences between academic achievement and physical activity duration. Children who were above the average in academic achievement were physically active for 90,91 min/day; average children were active for 84,73 min/day and below the average children in academic achievement were active for 83,71 min/day (Planinšec, 2006). Zurc (2011) assessed physical activity of Slovenian schoolchildren with self-report. From the sample of n=1660 schoolchildren, 746 is active for more than 1 hour per day. Boys are statistically significantly more active and more involved in organized physical activity groups than girls.

Strniša and Čagran (2015) reviewed 15 Slovenian articles in journals Sport (slo. Šport), Sport Healthcare (slo. Zdrasvtveno varstvo), Journal for elementary education (slo. Revija za elementarno izobraževanje), Education horizons (slo. Pedagoška obzorja), Medical journal (slo. Zdravstveni vestnik), Annales Kinesiologiae and anthologies Child in motion. All reviewed articles were published between 2003 and 2014. The examined studies included 52 to 182386 children between age 5 and 18 years. Most Slovenian researchers were interested in the difference between genders, differences between organized and unorganized physical activity of primary schoolchildren and differences between urban and non-urban children. They found out that higher levels of physical activity are more frequent with boys, with children in urban areas and children whose parents are more physically active. Organized form of physical activity was found out to prevail compared to non-organized. Very small proportion of primary schoolchildren were found out to be inactive.

In Slovenia, there is a National testing program for academic performance, called"Nacionalno preverjanje znanja - NPZ˝, which is part of the Elementary School Act - Article 64. In the grades 6^{th} and 9th students' knowledge is verified by˝NPZ˝, which reviews the standards of knowledge of specified Slovenian Curriculum. The Government examines mathematics, Slovenian language and a third subject, which is individually chosen from school to school. In addition to the ongoing SLOFIT data, from 2010, Slovenia has been part of a project called Zdrav življenjski slog – ZŽS *(eng. Healthy Lifestyle*), where children can select the option to be active up to 2 additional school hours per week. ZŽS is part of a school's extracurricular activities. Five years after, this project is running in more than 100 schools across Slovenia. Despite the fact that Slovenia has relatively robust data on physical activity in the school curriculum, data on the motor development of children, and NPZ. no researcher has yet investigated a relationship between academic performance and objectively measured physical activity.

Pišot and Zurc (2003) investigated the influence of out-of-school sports on school success on a sample of 2023 elementary school 4-grade students (age=10.5 $\pm$ 0.5 yrs) in the Gorenjska region. They used questionnaire (Petrovič, Ambrožič, Sila & Doupona, 1996) which included the following variables: gender, age, frequency or level of participation in out-of-school sports activities. The majority of children (42.1 %) achieved excellent (grade-5) general school success. The majority of children with excellent and very good school success (grade-4) participated in out-of-school sports activities at least two to three times per week. Children involved in organized forms of sports achieve better learning success compared to children engaged in non-organized forms of sports. Peternelj, Škof and Strel (2009) investigated if there were any differences in learning achievements between pupils who attended sports classes and those who attended regular classes. This study was conducted in Postojna, Slovenia, and was one of rare studies to query whether there was a link in increased physical activity and learning achievements. In the experimental group (sports departments) they tested n = 68 students; in the control group (regular classes) there were n = 66 pupils (all from one Slovenian school). For eight years of schooling, the children in the sports department group received increased physical activity and physical education lessons, which were delivered by two teachers. All other educational contents were identical between sports and control classes. Pupils from the sport department had grades 14% higher in mathematics and 16% higher in Slovenian language. Analysis of covariance demonstrated that parental education and the impact of the home environment can play an influential role in academic performance. Meško, Videmšek, Videmšek et al. (2013) investigated whether there are differences in learning achievements and self-esteem according to the amount of sports participation in 9th grade schoolchildren. 67.9 % of schoolchildren participated in organized sports groups, and one fourth participated in physical activity in non-organized groups. They found statistically significant differences in academic performance in grade-9 pupils according to their amount of sport participation. Children who are more involved in sport have better academic performance. Planinšec and Fošnarič (2006) found out that grades in mathematics, Slovene language, natural science and general point average are positively correlated with the amount of physical activity in third school cycle. The most physically active children also performed better in academics, but not necessarily better in physical education.

Indeed, in family environments where knowledge and higher education are recognized as valuable, it is hypothesized that there would also be a greater interest in promoting an overall healthy lifestyle. Unfortunately, no study has been developed to investigate the possible link between increased physical activity and academic performance across all of Slovenia.

2 METHODS

This doctoral dissertation expands the body literature by investigating the relationship between academic performance, physical activity and physical fitness in Slovenian elementary schoolchildren. All four studies are unique due to specific focus on relationships between academic performance, physical fitness and physical activity measured objectively and subjectively. Because of greater transparency and easier understanding, Pilot study was named "Elementary school girls' physical activity and academic performance study", Study 1 was renamed into "Self-reported physical activity and Academic performance study", Study 2 was named "Objectively measured physical activity and Academic performance of elementary school children study" and Study 3 was named "Longitudinal study".

2.1 Problem

Children in Slovenia are becoming more physically inactive and currently, however, an epidemiological link between physical activity and academic performance has not been established in Slovenia.

2.2 Objectives and hypotheses

2.2.1 Elementary school girls' physical activity and academic performance study

Objective
To determine the extent to which increased physical activity counts will correlate to enhanced academic performance in school-aged girls in Slovenia.

2.2.2 Self-reported physical activity and Academic performance study

Objectives

To determine daily physical activity levels in elementary school children (questionnaires, self-report).

To determine elementary school children motor development, physical development and motor abilities.

To determine elementary school children academic performance.

To index elementary school children academic performance outcomes to physical activity levels.

To index elementary school children academic performance outcomes to physical fitness outcomes.

Hypotheses

H 1.1: Children who are more physically active will score higher on indexes on physical fitness.

H 1.2: Children who are more physically active will score higher on indexes of academic performance.

H 1.3: Children with higher index of academic performance have better motor abilities.

2.2.3 Objectively measured physical activity and Academic performance study

Objectives

To determine daily physical activity levels in 6-grade children with an accelerometer.

To determine 6-grade children motor development, physical development and motor abilities.

To determine 6-grade children academic performance.

To index 6-grade children academic performance outcomes to physical activity levels.

To index differences in physical activity levels among children living in urban or rural areas in Slovenia.

To index effect of maturity on physical activity levels.

Hypotheses

H 2.1: Children who are more physically active will score higher on indexes of physical fitness.

H 2.2: Children who are more physically active will score higher on indexes of academic performance.

H 2.3: Urban school children will have higher daily physical activity levels than rural children.

H 2.4: Urban school children will have better academic performance than children from rural areas.

2.2.3 Longitudinal study

Objectives

To compare daily physical activity levels in grade-6 children and three years after.

To compare physical fitness in grade-6 children and three years after.

To determine grade-9 children's academic performance.

To compare children's academic performance outcomes to physical activity levels and physical fitness outcomes.

Hypotheses

H 3.1: Children's physical activity duration is lower in grade-9 comparing to physical activity duration in grade-6.

H 3.2: Children who are more physically active will score higher on indexes of academic performance.

H 3.3: Rural school children will have higher physical activity duration compared to urban children.

2.3 Participants

2.3.1 Elementary school girls' physical activity and academic performance study

20 elementary school girls participated in the study, but 4 of them were due to the rules (illness, rule 70/80) excluded from this study. Participants were required to be 11-12 years of age. They were excluded if they were taking any medications or had any medical condition or if their parents did not sign formal consent.

2.3.2 Study 1, Study 2 and Study 3

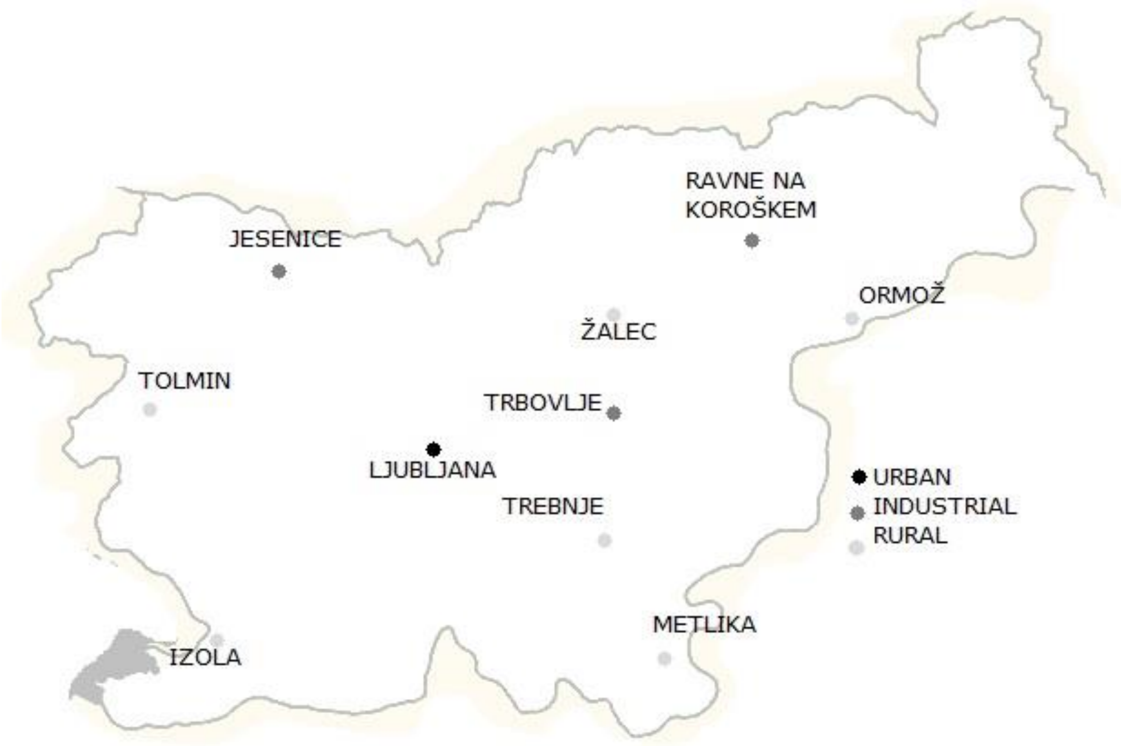
The sample was defined by the initial platform research, conducted by Šturm in 1970 (Šturm, 1972). Its purpose was to establish key parameters of motor abilities of schoolchildren (Šturm, 1970), the same procedure was used for participants' selection in Study 1, Study 2 and Study 3. The analysis focuses on pupils from grade-1 to grade-9 of selected elementary schools. A number to be measured by individual schools deviate +/- 5% from the theoretical projected sample to be measured. Measurements were performed only on the pupils who have not been permanently or temporarily excused from physical education classes due to health reasons. Parents of measured subjects gave their written consent to the inclusion in the study.

The whole sample was divided according to regions in the Republic of Slovenia and randomly within regions from a non-selected population and is representative for the Republic of Slovenia. The selected schools were from large and small centers (Metlika, Trebnje, Žalec, Trbovlje, Ormož, Ljubljana, Izola, Tolmin, Jesenice, Ravne na Koroškem) in which measurements have been ongoing since 1970.

Areas of schools were chosen and divided based on some economic and socio-demographic characteristics of Republic of Slovenia (*Image 1*): RURAL (Ormož, Trebnje, Metlika), INDUSTRIAL (Jesenice, Ravne na Koroškem, Trbovlje), RURAL-INDUSTRIAL (Tolmin, Žalec, Izola), URBAN (Ljubljana).

In the sample of schools there are major cities like Ljubljana, which is the only urban city in Slovenia and the administrative center of Slovenia; industrial centers of Slovenia (Jesenice, Ravne na Koroškem, Trbovlje) and places with a strong rural hinterland and various industrial plants (Tolmin, Žalec, Izola, Ormož, Trebnje, Metlika).

Image 1: Selected areas of elementary schools in Republic of Slovenia for Study 1, Study 2 and Study 3.



The sample size for Study 1 comprises n=3726 (n_{boys}=1896, n_{girls}=1830) elementary school children, aged 6-15 years from N=11 Slovenian elementary schools from 10 different economic and socio-demographic areas of Republic of Slovenia. A sample of children from Study 1 was measured in September and October 2013.

The sample size for Study 2 comprises n=166 (n_{boys}=87, n_{girls}=79) elementary school children, aged 11 years (grade-6) from N=11 Slovenian elementary schools from 10 different economic and socio-demographic areas of Republic of Slovenia. A sample of children from Study 2 was measured in September and October 2013.

The sample size for Study 3 comprises n=123 (n_{boys}=61, n_{girls}=62) elementary school children from Study 2, aged 14 years (grade-9) from N=11 Slovenian elementary schools from 10 different economic and socio-demographic areas of Republic of Slovenia. A sample of children from Study 3 was measured in September and October 2016.

2.4 Measurement procedures

2.4.1 Motor abilities

Motor abilities were determined using the same fitness tests in all studies, except in Elementary school girls' physical activity and Academic performance study. All tests have been performed on a sample of Slovenian population and have appropriate dimensional characteristics and are suitable for use. Physical fitness tests which determine motor abilities and associated physical fitness indicators are shown in *Table 4*. Descriptions of the tests are found in the research project of Strel, Štihec and Videmšek (1992). Chosen physical indicators were divided following SLOfit (2016) classification into health-related indicators and physical performance indicators. For each physical fitness indicator one physical fitness test was used.

Table 4: Chosen fitness test and associated physical fitness indicator, test label and units in which physical fitness indicator is expressed.

Physical fitness indicator	Physical fitness type	Physical test	Test label	Units
Aerobic strength	Health-related indicator	Shuttle run	SHUTTLE	Nr. of repetitions
Muscle strength	Health-related indicator	Hand grip	GRIP	Kilograms
Repetitive strength	Health-related indicator	Situps	SITUP	Nr. of repetitions
Explosive strength	Physical performance indicator	Standing long jump	SLJ	Centimeters
Coordination	Physical performance indicator	Polygon backwards	POLYGON	Decisecond
Balance	Health-related indicator	Flamingo test	FLAMINGO	Nr. of repetitions
Flexibility	Health-related indicator	Sit and reach	SAR	Centimeters
Rhythmic implementation of movement structures	Physical performance indicator	Hand tapping	HAND_TAP	Nr. of repetitions

2.4.2 Physical dimensions

Physical dimensions (Table 5) were determined using the same fitness tests in all studies. Physical fitness tests which determine physical dimensions of the body are shown in *Table 5*.

Table 5: Physical dimensions of the body test label and units in which physical dimension is expressed.

Hypothetical physical dimension of the body	Physical test	Test label	Units
Longitudinal dimension	Height	HEIGHT	Mm
Voluminosity	Weight	WEIGHT	Kg
Body mass index	Body mass index	BMI	Kg/m^2

2.4.3 Physical activity

Physical activity was assessed objectively with accelerometers for all studies except in Self-reported physical activity and Academic performance study. Physical activity assessed with the accelerometer is one of the most common and reliable methods for determining children's physical activity. Physical activity in "Self-reported physical activity and Academic performance study" was assessed subjectively through questionnaires, which enables working with larger samples. Physical activity in "Objectively measured physical activity and Academic performance of elementary school children study" was assessed objectively with a SenseWear Armband and through self-report.

In Pilot study Actigraph GT3X (Actigraph LLC, Pensacola, FL) was used, in Study 2 and Study 3 a SenseWear Armband accelerometer (Bodymedia, Pittsburgh, Pennsylvania) was used. Both devices are frequently used to estimate levels of daily physical activity. Both devices use piezoelectric accelerometers, which measure the body accelerations in 3-axes (i.e. triaxial activity monitors). The location of wearing an Actigraph monitor is on the waist (right hip) and the SenseWear Armband upper left arm at the level of the triceps (Van Remoortel, Raste, Louvaris et al. 2012). Many accelerometers function by integrating signal over defined time interval, which is commonly referred to as an epoch (Gabriel, McClain, Schmid et al. 2010). The choice of epoch length is very important when assessing activity intensity. Accelerometers are often set on one-minute epochs (Cooper, Page, Fox & Misson, 2000). Epoch is the amount of time over which activity counts. However, Nilson, Ekelund, Yngve et al. (2002) have shown that longer epochs did not capture high-intensity activity accurately. Shorter epochs more accurately record intermittent activity (Reilly, Penpraze, Hislop et al. 2008). Therefore, the number of minutes recorded in high activities decreases as the epoch setting increased from smaller to higher epoch (Rowlands, Powell, Humphries & Eston, 2006). This study, therefore, used a minute epoch to assess longer period of children's physical activity. Data was processed with programs Actilife (for accelerometer ActiGraph) and SenseWear Professional 6.1 and SenseWear Professional 8.1 (for accelerometer SenseWear Armband). ActiGraph and SenseWear Pro were worn for at least three weekdays and two days during weekend (Esliger & Tremblay, 2007), following the 70/80 rule (Catellier, Hannan, Murray et al. 2005) and non-wear time within day (Troiano, Berrigan, Dodd et al. 2008).

In "Elementary girls physical activity and academic performance study" (pilot study) physical activity counts were measured with MTI ActiGraph accelerometers, model GT1M for five days, of which 3 school days (Wednesday, Thursday, Friday) and two weekend days (Saturday, Sunday). The ActiGraph has a single-axis accelerometer to record vertical accelerations ranging in magnitude from 0,5-2,0 G, with frequency response 0,25-2,5 Hz. Counts were measured in 15-second epochs in this study. 15-second accelerometer data were first retrieved visually to determine whether the number of days with accelerometer matched study protocol. Sleep and awake time were logical and coincide with diary logs, if any accelerometer count is >16,000 counts/minute (these were removed, because is assumed to be beyond biologically plausible range (Masse, Fuemmeler, Anderson et al. 2005) or counts >0 and constant for 10 minutes (these were also removed, because is assumed to be accelerometer malfunction) (Schmidt, Freedson & Chasan-Taber, 2003). Next, the wear time was calculated regarding the rule 70/80.This rule provides that 70% of subjects must wear the monitor for 80 % of measured time (Catellier, Hannan, Murray et al. 2005). Weekday and weekend day were defined as 7.00 AM-9.30 PM (870 minutes), so accepted wear time in this study was 609 minutes or more per day. The sequences of 20 consecutive minutes of zeros were cleaned, because it was considered that ActiGraph was not worn (Evenson, Catellier, Gill et al. 2008) and the zeros were changed to missing data.

Physical activity in "Self-reported physical activity and academic performance study" (Study 1) was obtained subjectively (self-report and parent-report) with CLASS (Telford, Salmon, Jolley et al. 2004) and SHAPES (Leatherdale, Manske, Wong et al. 2008) questionnaires. CLASS was used for children from grade-1 to grade-5 of elementary school and SHAPES was used to quantify physical activity of children from grade-6 to grade-9 of elementary school. Parents of children from 1st to 5th grade of elementary school were asked about their children's physical activity, sedentary behaviors, active transportation, children's social-economic environment and family support for physical activity. Children from 6th to grade-9 were asked for their sex, age, the educational structure of parents, parent's workplace, parental income, their physical activity and physical activity of peers in minutes. Questionnaires for assessing physical activity in ARTOS study from 2013/14 cover expanded version of SHAPES questions and gave us an overall output of overall physical activity of children during weekdays and weekends. Physical activity obtained from questionnaires is expressed in minutes/day.

Physical activity in "Objectively measured physical activity and academic performance study" (Study 2) was assessed with a SenseWear Armband accelerometer (Bodymedia, Pittsburgh, Pennsylvania) and with SHAPES (Leatherdale, Manske, Wong et al. 2008) questionnaire. In "Objectively measured physical activity and academic performance study" (Study 3) was physical activity assessed with a SenseWear Armband accelerometer (Bodymedia, Pittsburgh, Pennsylvania). A sample of objectively measured physical activity consisted only of those children who wore the device at least for three days during weekdays and two days during weekends for more than 90 % of time – 21 hours and 20 minutes. Metabolic equivalent (MET) levels for the physical activity detection algorithm was set at 4.0 METs and activity levels were defined in 5 levels: inactivity, sedentary, low, moderate and vigorous (Table 6). Physical activity is expressed as active energy expenditure (AEE) in kilojoules (kJ) and minutes of physical activity/day (duration).

Table 6: SenseWear activity levels.

	Lower (METs)		Label		Upper (METs)
1.	0.0	≤	Inactivity	<	1.0
2.	1.0	≤	Sedentary	<	1.5
3.	1.5	≤	Low	<	4.0
4.	4.0	≤	Moderate	<	7.0
5.	7.0	≤	Vigorous	<	∞

2.4.4 Academic performance

Academic performance was used to describe different factors that may influence pupils ' success in school. These factors are Grade point average (GPA) and Math grades.

For Pilot study, academic performance was shown through grades in Maths, Slovene language, English language, Physical Education and Grade point Average (GPA) during the school year 2014/2015. Grade point average (GPA) has been calculated

For Study 1, Study 2 and Study 3, only Math Grade was used to describe children's academic performance. In Slovenia math grades follows next order: 1 (inadequate), 2 (sufficient), 3 (good), 4 (very good) and 5 (excellent). Based on the assessment in mathematics children were divided into three groups: low academic performance, medium academic performance and high academic performance (*Table 7*).

Table 7: Academic performance groups based on Math grades.

Academic performance group	Group label	Math grade
Low academic performance	LAP	<3
Normal academic performance	NAP	≥3<4
High academic performance	HAP	≥4

2.4.5 Place of residence

Information about the place of residence of children was collected as part of wider research on bio-psycho-social foundations of child development, where comparisons between the years 1973-1983-1993 and 2003 (Strel et al. 1992) were carried out. Areas of schools were chosen and divided based on some economic and socio-demographic characteristics of the Republic of Slovenia (Image 1). Urban Audit provides that medium-sized cities have between 50.000 and 250.000 inhabitants; large cities have 250.000 and more inhabitants. Ljubljana and Maribor are classified as medium cities, but since only Ljubljana meets the criteria of 250.000 inhabitants

(Klement, 2006), with a total of 288.307 inhabitants (Statistični urad RS, 2016), Ljubljana will be treated as an urban city. In this study, all schools from Ljubljana will be treated as urban schools and all other schools will be treated as rural schools. For the needs of Study 3 N=11 elementary Slovenian schools were divided into two groups: rural areas and urban areas (Table 8).

Table 8: Classification of urban and rural schools depending on children's place of residence.

Type of residency place	City	Group label
Urban	Ljubljana	US
Industrial	Ravne na Koroškem, Trbovlje, Jesenice	IS
Rural	Žalec, Izola, Trebnje, Metlika, Ormož, Tolmin	RS

2.4.6 Maturation, biological age

The degree of maturity was calculated using equation (Mirwald, Baxter-Jones, Bailey & Beunen, 2002) which determines maximum height increments from the ratio between the length of the torso and the length of the leg. Different body parts of the body grow with different speed and legs normally grow faster than the torso. Destruction between both body proportions is a sign of entering puberty. Equation (Mirwald et al. 2002) for calculating maximum height increments and determining age at maturity is specific and different for boys and girls.

Age at maturity $_{boys}$ = - 9,236 + 0,0002708 x leg length x sitting height – 0,001663 x age x leg length + 0,007216 x age x sitting height + 0,02292 x (weight / height).

Age at maturity $_{girls}$ = - 9,376 + 0,0001882 x leg length x sitting height + 0,0022 x age x leg length + 0,005841 x age x sitting height – 0,002658 x age x weight + 0,07693 (weight / height).

2.5 Data collection

Data for pilot study were collected in Elementary school Ivana Groharja Škofja Loka. Physical fitness data for pilot study were assessed from School's SLOfit data and physical activity was assessed with accelerometer ActiGraph from Wednesday to Sunday in June 2014. For measuring physical activity, 15sec epoch was used. Academic performance was assessed from school documentation, using average grades in Mathematics, Slovene language, English language, Physical Education and GPA was calculated using average grade from all school subjects.

Data for »Self-reported physical activity and Academic performance study«, »Objectively measured physical activity and Academic performance of elementary school children study« and »Longitudinal study« were collected in the research project Analysis of development trends of children and youth in Slovenia (ARTOS). ARTOS is a cross-sectional study, which has been running at least every 10 years, since 1970 (1983, 1993/4, 2003/4, 2013/2014, 2016/17) and is one of the oldest secular trends in the research of physical fitness in the world. The leading research institution was the Faculty of Sport from University of Ljubljana. The study is based on an interdisciplinary approach that includes physical anthropology, kinesiology, psychology and sociology. The aim of the ARTOS research is to monitor secular trends in physical and motor development of children in terms of psychological, social and health factors that shape their modern lifestyles. An impressive database with the results of 17 different physical tests and tests of aerobic capacity, over 25 anthropometric dimensions and variables of other fields: psychology, socio-economic status, parents' opinion about physical activity, allows the variety of comparisons and links between all these variables (Jurak, Kovač & Starc, 2013). For measurements of every child, parental consent was obtained. Children participated voluntarily and anonymously with the option to freely withdraw from the measurements at any time. At location (11 elementary schools – Image 1) research team divided into 3 parts: anthropometry (measurement of physical characteristics in a separate area), kinesiology (majority of fitness tests were carried out in school gym, running (60m and 600m) were carried out outside), psychology (children solved questionnaires via internet in computer labs under the control of one or two members of the research team).

Data for »Self-reported physical activity and Academic performance study« and »Objectively measured physical activity and Academic performance of elementary school children study« were collected in fall 2013 and data for »Longitudinal study« were collected in fall 2016. Data for »Elementary school girls' physical activity and academic performance study« were collected in spring 2014.

2.4 Data processing

Collected data were processed using IBM SPSS Statistics 20.0, IBM SPSS Statistics V22.0, Microsoft Excel 2013, ActiLife, SenseWear Professional 6.1 and SenseWear Professional 8.1.

2.4.1 Elementary school girls' physical activity and academic performance study

All statistics were made in Microsoft Excel 2007 and IBM SPSS, 20.0. Microsoft Excel 2007 was used for removing the artifacts, counts > 16.000 and sequences of zeroes, where sequence was 20 or more zeroes. Testing for distributions of Normality was checked visually (histogram) and with Kolmogoro–Smirnov test using IBM SPSS Statistics 20.0. Descriptive statistics was calculated for all variables. Associations between derived estimates of grades, physical fitness and counts from accelerometer data were computed using Pearson correlation.

2.4.2 Self-reported physical activity and Academic performance study

Descriptive statistics, normal distribution, and correlation were checked using IBM SPSS 22.0. Normal distribution was checked visually and with Shapiro-Wilk test. For all parameters of physical fitness (motor abilities and physical dimensions of the body) and physical activity, correlation coefficients were checked using nonparametric Spearman's rho test. To determine differences between groups of physical activity (very low PA, low PA, normal PA, high physical activity and extreme

PA) and indicators of physical fitness, nonparametric Kruskal-Wallis test was performed, which is used when assumptions of normality are not satisfied. Where Sig. level is higher than 0,05 the differences between medians are not statistically significant. Therefore we fail to reject null the hypothesis. To determine differences between groups of physical activity (very low PA, low PA, normal PA, high physical activity and extreme PA) and Academic performance, nonparametric Kruskal-Wallis test was performed, which is used when we operate with ordinal data. Since Sig. level is higher than 0.05, no difference exists. Where significance level was <0.05, Mann-Whitney U test was performed to find out between which groups of physical activity (very low, low, normal, high and very high physical activity) differences in physical fitness indicators exist. For all post hoc comparisons, Bonferroni correction was performed and, effect size was calculated using the following formula: $r = \frac{Z}{\sqrt{N}}$

2.4.3 Objectively measured physical activity and Academic performance study

All statistics were made in IBM SPSS 22.0 with the assistance of software SenseWear Professional 6.1 and SenseWear Professional 8.1. SenseWear software platforms were used for collection and general treatment of the data collected on measuring devices SenseWear Pro 2 and SenseWear Pro 3. In IBM SPSS 22.0 descriptive statistics, normal distribution and correlation were checked. Normal distribution was checked visually and with Kolmogorov-Smirnov test, because we have dataset bigger than 2000 elements. For all parameters between physical fitness (motor abilities and physical dimensions of the body) and physical activity and physical activity and academic performance, correlation coefficients were checked using nonparametric Spearman's rho test.

To determine differences between groups of physical activity (low PA, normal PA, high PA) and indicators of physical fitness, nonparametric Kruskal-Wallis test was performed. To determine differences between groups of physical activity (very low PA, low PA, normal PA, high physical activity and extreme PA) and Academic performance, nonparametric Kruskal-Wallis test was performed, which is used when we operate with ordinal data. Since Sig. level is higher than 0.05, no difference exists. Where significance level was <0.05, Mann-Whitney U test was performed to find out between which groups of physical activity differences in academic performance exist. For all post hoc comparisons, Bonferroni correction was performed and effect size was calculated using the followingformula: $r = \frac{Z}{\sqrt{N}}$

2.4.4 Longitudinal study

All statistics were made in IBM SPSS 22.0 with the assistance of software SenseWear Professional 6.1 and SenseWear Professional 8.1. SenseWear software platforms were used for collection and general treatment of the data collected on measuring devices SenseWear Pro 2 and SenseWear Pro 3. In IBM SPSS 22.0 descriptive statistics, normal distribution and correlation were checked. Normal distribution was checked visually and with Shapiro - Wilk test. For all research parameters (academic performance, place of residence, physical activity) correlation coefficients were checked using nonparametric Spearman's rho test.

Due to violation of assumptions about normality of distribution, non parametric test was used. To determine differences between physical activity duration (grade-6 and grade-9), non parametric Wilcoxon Signed Ranks Test was used. To find differences between urban and rural children, non parametric Mann Whitney test was performed. Where results were statistically significant, effects size was calculated using the following formula: $r = \frac{Z}{\sqrt{N}}$.

3 RESULTS AND DISCUSSION

This chapter is organized considering the four main studies: »Elementary school girls's physical activity and academic performance study«, »Self-reported physical activity and Academic performance study«, »Objectively measured physical activity and Academic performance of elementary school children study« and »Longitudinal study.«

3.1 Elementary school girls' physical activity and academic performance study

"Elementary school girls' physical activity and academic performance study" was the first study to answer questions about the relationship between academic performance and physical activity and plays the role of pilot study in this doctoral dissertation.

From 20 schoolgirls, 16 valid measurements were obtained and analyzed further. Four were excluded for not wearing the accelerometer enough time. Table 9 presents physical activity during the week, weekend and combined physical activity of elementary school girls.

Table 9: Physical activity (PA) descriptive statistics for 16 schoolgirls from Škofja Loka.

	PA (counts/min)	SD
combined daily physical activity	538.52	± 228.24
weekday physical activity	553.54	± 199.36
weekend PA	516.10	± 328.34

Average daily physical activity for sample n=16 schoolgirls was measured and calculated to be 538.52 ± 228.24 counts/minute. Average physical activity counts during weekends were lower compared to physical activity counts during schooldays. The amount of dispersion around average physical activity counts during weekends was ± 328.34, which indicates significant differences between physical activity intensities during weekends in elementary school girls. Average physical activity counts during weekdays are 553.53 ± 199.36, which indicates a more uniform pattern of physical activity of schoolgirls during school days, since the dispersion around average physical activity is lower compared to the standard deviation during weekends. Average grades for school year 2014/2015 were calculated. All grades for a single school subject in school year 2014/15 were taken into account for calculating Mean grade. All grades and descriptive statistics for Academic performance (AP) are presented in Table 10.

Table 10: Average Academic performance grades for schoolgirls participating in Pilot study.

	Mean grade	SD
Grade point average (GPA)	4.1	±0.64
Mathematics	3.44	±0.93
Slovene language	3.78	±0.8
English language	3.34	±1.02
Physical education	3.56	±0.7

Note: SD – standard deviation.

To find links between academic performance and physical activity, Pearson's correlation was used. Table 11 presents correlation between physical activity and academic performance for n=16 schoolgirls.

Table 11: Correlation between Academic Performance (AP), Physical activity (PA) and Physical Fitness (PF).

PA and PF/AP	GPA	Mathematics	Slovene	English	PE
PA (cpm)	0.830	0.765	0.727		
SLJ	0.661	0.746		0.787	0.925
SR	0.682	0.701	0.700	0.845	
SITUP				0.660	0.856
RUN_600m		-0.723			
RUN_60m					-0.791

PA – physical activity; PF – physical fitness; SLJ – Standing long Jump; SR – Sit and Reach; PE – physical education grade.

Note: Correlation is significant at the 0.01 level (2-tailed).

Correlation between academic performance, physical fitness and physical activity has been detected using Pearson's correlation coefficient. Statistically significant relationships at 0.01 significance level between physical activity and academic performance grades were found. The Pearson's r for the correlation between physical activity and GPA in Pilot study is 0.83, between physical activity and Math Grades 0.77 and between physical activity and Slovene language 0.73. Math grade is statistically significantly associated with the physical fitness variables (Standing Long Jump, Polygon backwards, Sit and Reach and Running 600m) at significance level 0.01. Following the results of this Pilot study we can say that there is a significant correlation between academic performance, physical activity and physical fitness in certain outcome measures. However, before outlining physical activity and physical fitness benefits on academic performance it is important to note that many factors influence academic performance. Among these are socioeconomic status, parental involvement, attendance and other demographic factors, such as place of residence.

After analysis of the pilot study, many questions arose, and several new issues opened, such as what is cause and what is effect in the relationship between academic performance, physical activity and physical fitness. All issues that have emerged in the pilot study will be analyzed in the following studies.

3.2 Self-reported physical activity and Academic performance study

3.2.1 Participants

After examination of the data (and eliminating unfitted measurements from sample due to missing results), descriptive statistics were made. In this study, n=3728 (1896 boys and 1830 girls) schoolchildren participated. The average age of children involved in "Self-reported physical activity and Academic performance study" was nine years of age, the youngest was five and oldest 15. In Slovenia primary education is divided into three educational cycles (referred as period). The first period runs from grade-1 to grade-3; the second period lasts from grade-4 to grade-6 and the third period lasts from grade-7 to grade-9. Training under a special program is divided into stages. Each stage lasts three years (Zakon o osnovni šoli, 2006). Table 12 presents distribution of study participants according to school grades.

Table 12: »Self-reported physical activity and Academic performance study« participants' descriptive statistics.

Triade	Grade (age)	n (boys/girls)	%
1st period	grade-1 (6)	531 (260/271)	14.2
	grade-2 (7)	457 (223/234)	12.3
	grade-3 (8)	446 (215/231)	12.0
2nd period	grade-4 (9)	420 (210/210)	11.3
	grade-5 (10)	381 (187/194)	10.2
	grade-6 (11)	385 (201/184)	10.3
3rd period	grade-7 (12)	367 (203/164)	9.8
	grade-8 (13)	330 (162/168)	8.9
	grade-9 (14)	411 (237/174)	11.,0

n – number of participants; % - percentage of the participants.

3.2.2 Motor abilities

Table 13 presents the basic statistical characteristics for each motor ability separately: arithmetic mean ($\bar{x}$), standard deviation (SD), minimum (MIN) and maximum (MAX) result, variance (VAR), and normal distribution by Kolmogorov-Smirnov Test. All results are merged together for all school grades, except situps. Situps have been tested differently for children in the third school period, compared to children in the first and the second period because children in the third period were performing situps for 60 seconds and children from first and second period for only 20 seconds.

Table 13: Motor abilities descriptive statistics for children aged 6 – 15.

	$\bar{x}$	MIN	MAX	SD	VAR	KS	p	Skewness/ kurtosis
Standing long Jump (cm)	146.5	49	250	31.22	974.45	0.041	0.00	0.25/-0.21
Hand grip (kg)	18.6	3	60	8.53	72.78	0.103	0.00	0.92/0.83
Flamingo (nr.)	14.9	1	32	7.50	56.3	0.087	0.00	0.62/-0.13
Situps 60s (nr.)	37.8	4	72	10.71	114.56	0.037	0.00	0.06/0.06
Situps 20s (nr.)	13.0	1	30	4.0	16.02	0.06	0.00	0.09/0.49
Hand tapping (nr.)	35.0	12	63	10.18	65.72	0.07	0.00	-0.042/-0.90
Polygon backwards (s)	12.3	6,9	75,4	8.11	596.06	0.11	0.00	1.76/4.78
Shuttle run	43.17	1	137	24.41	596.06	0.089	0.00	0.78/0.03

N-sample size; $\bar{x}$ - arithmetic mean, MIN – minimum value of daily PA; MAX – maximum value of daily PA; SD – standard deviation; VAR-variance; KS – Kolmogorov – Smirnov test

Standing Long Jump measures explosive strength of legs. Explosive strength is the ability of the maximum acceleration when moving your body or functioning on the objects in the environment. It is the ability of activating the greatest number of motion units in the shortest possible time. It occurs in jumps, throws, kicks and short sprints (Ušaj, 2003). The arithmetic mean of the Standing Long Jump test was 146.5 cm for schoolchildren attending elementary school classes. Standard deviation for Standing Long Jump is low, which indicates smaller dispersion of the results. Skewness coefficients show, that the results are skewed to the right, therefore in the direction of the better individuals. Normal distribution of this test significantly deviates from the theoretical distribution (Table 13).

Muscle strength was assessed as hand grip strength, measured with Jamar dynamometer. Grip strength is often neglected, but it plays a key role in the prevention of injury and development of the overall strength (Smith, Smith, Martin et al. 2006; Yasuo, Daisaku, Nariyuki, 2005). Hand grip is in practice also used as an indicator of overall strength of the individual. It has been shown that hand grip is moderately associated with overall strength (Smith, Smith, Martin et al. 2006; Fry, Ciroslan, Fry, 2006). The arithmetic mean of the Hand Grip test was 146.5 kg. Standard deviation for Hand grip is high, what shows bigger dispersion of the results. Skewness coefficients show that the results are skewed to the right, therefore in the direction of the better individuals. Normal distribution of this test significantly deviates from the theoretical distribution (Table 13).

For balance indicator, Flamingo test was used (Table 13). Flamingo balance test also assesses the strength of the leg, pelvic and trunk muscles as well as dynamic balance. It depends on the involvement of the visual analyzer, the size of the surface on which it is necessary to retain in the equilibrium position, the static strain, which retains the position, or the resistance force which upsets the equilibrium position. In Flamingo test, lower attempt numbers represent a better result (Matejek, 2012). The arithmetic mean of the Flamingo test was 14.9 repetitions. The standard deviation for Flamingo test is high, which shows a larger dispersion of the results. Skewness coefficients show, that the results are skewed to the left, therefore in the direction of the better individuals. Normal distribution of this test significantly deviates from the theoretical distribution.

For repetitive strength indicator, situp test was used (Table 13). Repetitive strength is the ability to provide long-term muscle strain on the basis of alternate muscle contractions and relaxations. Children from grade-1 to grade-5 were performing the test for 20 seconds and children from grade-6 to grade-9 were performing the test for 60 seconds. The arithmetic mean of the situps for children from 1^{st} – 5^{th} grade was 13 repetitions in 20 seconds. Skewness coefficients show that the results are skewed to the right, therefore in the direction of the better individuals. Normal distribution of this test significantly deviates from the theoretical distribution. The arithmetic mean of the situps for children from grade-6 to grade-9 was 37.8 situps in 60 seconds. Skewness coefficients show, that the results are skewed to the left, therefore in the direction of the worst individuals. Normal distribution of this test significantly deviates from the theoretical distribution.

For the Rhythmic implementation of movement structures, Hand tapping test was used (Table 13). Hand tapping test measures the ability of fast implementation of alternative movements and is dependent on the speed of information transmission in the physical centers and on coordinated regulation of alternating contractions and relaxations (Matejek, 2012). In Hand tapping test it is necessary to implement fast moves and touch the objective. The arithmetic mean of the Flamingo test was 35 repetitions. Skewness coefficients show that the results are skewed to the left, therefore in the direction of the worst individuals. Normal distribution of this test significantly deviates from the theoretical distribution.

For coordination, polygon backwards test was used (Table 13). Coordination is the ability to effectively engage in implementation of complex motorical tasks and is the results of optimal coordination on all levels of the central neural system and skeletal muscles (Lasan, 2004). The arithmetic mean of Polygon backward was 12.3 seconds. Lower time represents better result in this test. Skewness coefficients show that the results are skewed to the right, therefore in the direction of the worst individuals. Normal distribution of this test significantly deviates from the theoretical distribution.

For aerobic strength indicator, Shuttle run test was used (Table 13). Shuttle run is a very useful method for measuring aerobic power and calculate the maximum oxygen uptake. The test was made in 1982 at the University of Montreal under the direction of Luc Leger (1988) and was officially announced in 1983 with initial speed of 8 km/h and stages of 2 minutes duration. The test was re-published in 1988 (Leger, Mercier, Gadoury et al. 1988) with initial speed of 8.5 km/h and stages of 1-minute duration. Since then the test is known a "The multistage 20 meter shuttle run test for aerobic fitness." Cumulative number of all stages in this test is 246. Higher the stage, better the result is. The arithmetic mean of Shuttle run was 43.2 stages. Standard deviation is large, what shows big dispersion of the results. Skewness coefficients show that the results are skewed to the right, therefore in the direction of better individuals. Normal distribution of this test significantly deviates from the theoretical distribution.

3.2.3 Physical dimensions

Table 14 presents the basic statistical characteristics for each physical dimension separately: arithmetic mean ($\bar{x}$), standard deviation (SD), minimum (MIN) and maximum (MAX) result, variance (VAR), and normal distribution by Kolmogorov-Smirnov. All the results for physical dimensions of the participants are computed together.

Table 14: Physical dimensions descriptive statistics results.

	N	$\bar{x}$	MIN	MAX	SD	VAR	KS	p	Skewness/ kurtosis
Height (cm)	3461	142.42	106.0	189.8	16.69	278.592	0.06	0.00	0.18/-0.89
Weight (kg)	3461	38.91	15,8	109.0	14.75	217.8	0.09	0.00	0.87/0.45
Body Mass index	3461	18.47	11	35	3.57	12.72	0.1	0.00	1.13/1.36

N-sample size; $\bar{x}$ - arithmetic mean, MIN – minimum value of daily PA; MAX – maximum value of daily PA; SD – standard deviation; KS – Kolmogorov – Smirnov test.

Average height in our representative sample of Slovenian elementary school children and youth was 142.42 $\pm$ 16.69 cm, average weight 38.91 $\pm$ 14.7 kg and Body mass index 18.4 $\pm$ 3.57 kg/m^2. All skewness coefficients show, that the results are skewed to the right, therefore in the direction of smaller and lighter and smaller children with smaller Body fat index. Normal distributions of all physical dimensions significantly deviates from the theoretical distributions.

3.2.4 Physical activity

Table 15 presents the basic descriptive statistics for daily physical activity of elementary schoolchildren. Physical activity was assessed subjectively, with questionnaires and is expressed in minutes/day.

Table 15: Physical activity descriptive statistics.

	$\bar{x}$ + SD
Physical activity weekday (min/day)	178.66 ± 164.72
Physical activity weekend (min/day)	134.03 ± 98.71
Physical activity combined	146.78 ± 103.81

$\bar{x}$ - arithmetic mean; SD – standard deviation.

Slovenian children are approximately 40 minutes more physically active during weekdays than on weekends. Average daily physical activity, including weekends and weekdays for Slovenian elementary school population is 146 ± 103,81 min/day. All children with physical activity greater than 500 min/day have been identified as outliers and were deleted for further analysis. With the assistance of statistical equations 1,5*IQR>Q3 and 1,5*IQR>Q1 we identified the upper limit for outstanding values in our database. In table 16, basic parameters for determining normality of distribution are shown. The results of "Elementary school girls' physical activity and academic performance study" have shown that girls are more physically active during the week and less physically active during the weekend, which indicates more uniform patterns of physical activity of schoolgirls during school days, since dispersion around average physical activity is lower compared to physical activity standard deviation during weekends. The Republic of Slovenia seems to have very good PE curriculum compared to other nations. Physical education in the Republic of Slovenia is a standardized, compulsory subject in all primary and secondary schools (Sember, Starc, Jurak et al. 2016), which is also seen when comparing overall activity counts during weekdays and weekends in "Elementary school girls' physical activity and academic performance study" and in "Self-reported physical activity and Academic performance study". According to the results of both studies, where the physical activity was measured objectively and subjectively, we can say that Slovenian elementary school children are more physically active during weekdays (Rowlands, Eston & Ingledew, 1999; Wilkin, Mallam, Metcalf et al. 2006; Sember, Starc, Jurak et al. 2016). Decreases at weekends are largely due to a drop-off in the intensity of light intensity bouts (Rowlands, Pilgrim & Eston, 2008). Removal of the structured school environment on weekends is attributed to various physical activity levels and patterns, the difference being particularly noticeable in girls (Mota, Santos, Guerra, Ribeiro & Duarte, 2003).

Table 16: Overall physical activity descriptive statistics.

	N	$\bar{x}$	MIN	MAX	SD	KS	p	Skewness/kurtosis
PA	3461	146.78	20	497.14	103.81	0.07	0.00	0.73/0.37

N-sample size; $\bar{x}$ - arithmetic mean, MIN – minimum value of daily PA; MAX – maximum value of daily PA; SD – standard deviation; KS – Kolmogorov – Smirnov test; p – significance level.

Standard deviation for overall physical activity is high, which shows big dispersion of the results. For overall physical activity normality was checked using Kolmogorov-Smirnov test. Skewness coefficients show that the results are skewed to the right, therefore in the direction of better individuals. Normal distribution of this physical activity significantly deviates from the theoretical distribution. Based on the purified values of physical activity, five groups of physical activity were made (Table 17).

Table 17: Physical activity groups.

Group	Levels of physical activity	Values for levels of physical activity (min)	N
1.	Very low physical activity	up to 60 min/day	557
2.	Low physical activity	from 61 to 120 min/day	861
3.	Normal physical activity	from 121 to 180 min/day	827
4.	High PA	from 181 to 240 min/day	522
5.	Extreme PA	More than 241 min/day	602

3.2.5 Academic performance

Mathematic grade was used as Academic performance indicator. Arithmetic mean of Math grade for n=1406 Slovenian elementary schoolchildren is 3.75 $\pm$ 1.00. For Academic performance normality was checked using Kolmogorov-Smirnov test. Normal distribution of academic performance significantly deviates from the theoretical distribution. Skewness coefficients show that the results are skewed to the left, therefore in the direction of worst individuals. For academic performance, 3 groups were made (Table 7).

3.2.6 Parental education

Parents were asked about their education. They identified one level of offered levels of education: elementary school (1), secondary vocational school (2), secondary school (3), two-year college (4), faculty (5), Master or Ph.D. (6). Average education levels are shown in Table 18.

Table 18: Parental education descriptive statistics and correlation coefficients between children's physical activity, academic performance and parental education.

	N	$\bar{x}$	SD	rap	rpa
Mother's education	4146	3.50	1.44	rap=**0.262** p=0.00* N=2366	rpa=**0.096*** p=0.00 N=4386
Father's education	4146	3.27	1.48	rap=**0,218** p=0.00* N=2216	rpa=0.21 p=0.18 N=4134

N – sample size; $\bar{x}$ -arithmetic mean; SD – standard deviation; r_{ap} – correlation coefficient between parental education and children's academic performance, r_{pa} – correlation coefficient between parental education and children's physical activity, p – significance level

*Note: *correlation is significant at 0,01 level.*

The family as an environment can be reflected as a cofactor (Yang, Telama and Laakso, 1996) for better or worst influence affecting children's academic performance and physical activity. Some studies have indicated that parental education plays a major role in their children's sport and physical activity participation (Yang, Telama & Laakso, 1996). Hockey players parents' from Ontario, Canada are in general more highly educated than the general population (Clark, 1980 in Yang et al. 1996) and Finland highly-educated parents lay less stress on children's success in sport (Silvennoinen, 1987 in Yang et al. 1996). Based on the results of the study, mother's education (r_{ap}=0.26, $p<0.05$) and father's education (r_{ap}=0.22, $p<0.05$) are statistically significantly correlated to children's academic performance. Parents with higher levels of education have children who performed better in mathematics. Results of the "Self-reported physical activity and academic performance study" are consistent with the findings of Davis-Kean (2005), who found that parental education duration is an important socio-economic factor in relation to children's academic performance. Mother's educational levels are also significantly correlated to children's overall physical activity duration (r_{pa}=0.10, $p<0.05$). There is no statistically significant link between father's educational level and children's physical activity.

3.2.7 Hypothesis 1.1

H 1.1 Children who are more physically active will score higher on indexes on physical fitness.

H0, 1.1: There is no difference between physical activity and indexes of physical fitness.
HA, 1.1: There is a difference between physical activity and indexes of physical fitness.

For physical fitness, nine motor abilities and three physical dimensions indicators were selected, and correlations between physical fitness and physical activity were calculated (Table 19).

Table 19: Correlation coefficients for physical fitness indicators and physical activity.

Physical fitness test/ Physical activity	Correlation coefficient	p (2-tailed)
Standing Long Jump	0.01	0.47
Flamingo	-0.09*	0.01
Hand Grip	-0.06**	0.00
Situps 60s	0.14**	0.00
Situps 20s	0.03	0.09
Hand tapping	-0.02	0.33
Polygon backwards	-0.01	0.50
Shuttle run	0.04*	0.01
Sit and Reach	0.02	0.24
Height	-0.09**	0.00
Weight	-0.09**	0.00
Body mass index	-0.07**	0.00

*Note: *Correlation is significant at the 0, 05 level (2-tailed); **Correlation is significant at the 0, 01 level (2-tailed).*

Statistically significant correlations were detected between physical activity and the following indicators of physical fitness: Flamingo test, Hand grip, Situps 60s, Shuttle run, height, weight and Body mass index. Insignificant correlations were found between variables (Table 20). To determine differences between physical activity and indicators of physical fitness, nonparametric Kruskal-Wallis test was performed. Not enough evidence is available to suggest the null hypothesis can be rejected at the 95% confidence level for following physical fitness tests: Flamingo test, Situps 20s, Hand tapping, Polygon backwards, Shuttle run and sit and reach (Table 20).

Table 20: Physical fitness and physical activity duration results.

Physical fitness / Physical activity	Kruskal Wallis test	p
Standing Long Jump	**14.59**	**0.01**
Flamingo	8.53	0.07
Hand Grip	**17.33**	**0.00**
Situps 60s	**49.86**	**0.00**
Situps 20s	25.34	0.09
Hand tapping	2.76	0.60
Polygon backwards	7.14	0.13
Shuttle run	7.67	0.11
Sit and Reach	4.98	0.29
Height	**27.67**	**0.00**
Weight	**27.67**	**0.00**
Body mass index	**13.51**	**0.01**

Table 21: Mann Whitney U Test results.

Physical fitness Indicator	Mann-Whitney U test									
	12	13	14	15	23	24	25	34	35	45
Standing Long jump μ=146.52 cm	MR_1=609.46 MR_2=663.02 N=1284 U=178578 Z=-2.517 p= 0.01	**MR_1=586.18** **MR_3=658.89** **N=1260** **U=167122.5** **Z=-3.461** **p= 0.00** **ES=0.10**	MR_1=475.92 MR_4=511.97 N=987 U=112873.0 Z=-1.99 p= 0.047	MR_1=512.98 MR_5=529.12 N=1042 U=131109.5 p= 0.39	MR_2=768.55 MR_3=792.83 N=1560 U=294662.0 p= 0.29	MR_2=645.93 MR_4=640.91 N=1287 U=194490.5 p= 0.81	MR_2=686.06 MR_5=650.54 N=1342 U=206269.5 Z=-1.65 p= 0.01	MR_3=641.65 MR_4=617.03 N=1263 U=182671.5 p= 0.24	MR_3=682.64 MR_5=627.19 N=1318 U=193430 Z=-2.61 p= 0.01	MR_4=534.77 MR_5=512.41 N=1045 U=130299 p= 0.23
Hand grip μ=18.58 kg	MR_1=639.89 MR_2=647.38 N=1288 U=193987 p= 0.72	MR_1=636.47 MR_3=628.29 N=1262 U=187370.5 p= 0.7	MR_1=511.07 MR_4=473.7 N=984 U=1101836 Z=-2.064 p= 0.04	**MR_1=553** **MR_5=495.01** **N=1044** **U=120787** **Z=-3.11** **p= 0.00** **ES=0.10**	MR_2=788.53 MR_3=772.2 N=1560 U=297750 p= 0.47	MR_2=660.62 MR_4=610.5 N=1282 U=178729,5 Z=-2.36 p= 0.02	MR_2=701.82 MR_5=627.71 N=1342 U=193638.5 Z=-2.45 p= 0.00	MR_3=643.36 MR_4=605.19 N=1256 U=176134.5 Z=-1.82 p=0.07	MR_3=684 MR_5=622.9 N=1316 U=190982.5 Z=-2.88 p=0.00	MR_4=527.74 MR_5=512.16 N=1038 U=130201.5 p=0.40

Situps 60s μ=37.78	**MR_1=283.74** **MR_2=367.6** **N=667** **U=39980** **Z=-5.507** **p= 0.00** **ES=0.21**	**MR_1=263.63** **MR_3=355.93** **N=633** **U=34612.0** **Z=-6.275** **p= 0.00** **ES=0.25**	**MR_1=212.59** **MR_4=283.98** **N=489** **U=20984** **Z=5.565** **p=0.00** **ES=0.25**	**MR_1=221.48** **MR_5=280.95** **N=497** **U=23357** **Z=-4.61** **p=0.00** **ES=0.21**	MR_2=373.45 MR_3=394.49 N=766 U=69179 p= 0.19	MR_2=304.42 MR_4=324.25 N=622 U=41569 p= 0.19	MR_2=314.34 MR_5=317.52 N=630 U=188643 p=0.83	MR_3=293.61 MR_4=295.96 N=588 U=40301.5 p=0.87	MR_3=303.3 MR_5=290.87 N=596 U=40335 P=0.39	MR_4=231.85 MR_5=221.33 N=452 U=24342 p=0.39
Height μ=142.4 cm	MR_1=648.63 MR_2=664.63 N=1316 U=199650.5 p= 0.46	MR_1=654.9 MR_3=630.31 N=1279 U=187791.5 p= 0.12	MR_1=522.26 MR_4=479.08 N=1001 U=114530 Z=-2.34 ES=0.07	**MR_1=569.67** **MR_5=492.65** **N=1058** **U=119360** **Z=-4.01** **p=0.00** **ES=0.12**	MR_2=817.21 MR_3=769.68 N=1587 U=295802 Z=-3.18 p=0.04 ES=0.10	**MR_2=681** **MR_4=612.74** **N=1309** **U=180670.5** **Z=-3.18** **p= 0.00** **ES=0.09**	**MR_2=728.18** **MR_5=618.01** **N=1366** **U=192733.5** **Z=-5.07** **p=0.00** **ES=0.14**	MR_3=648.04 MR_4=618.51 N=1272 U=183646 p=0.16	**MR_3=694.09** **MR_5=624.3** **N=1329** **U=192128.5** **Z=-3.27** **P=0.00**	MR_4=542.11 MR_5=511.54 N=1051 U=283395.5 Z=-3.27 p=0.10

Weight μ=38.9 kg	MR_1=655.07 MR_2=660.63 N=1316 U=202897 p= 0.8	**MR_1=660.21** **MR_3=626.86** **N=1279** **U=185114,5** **Z=-1.163** **p= 0.00** **ES=0.03**	MR_1=525.58 MR_4=476.08 N=1001 U=112858 Z=-5.565 p=0.01	**MR_1=568.66** **MR_5=493.88** **N=1058** **U=119873.5** **Z=-3.98** **p=0.00** **ES=0.12**	MR_2=816.49 MR_3=770.44 N=1587 U=296390.5 Z=-3.16 p=0.045	MR_2=680.87 MR_4=612.74 N=1309 U=180779.5 Z=-3.16 p= 0,00	**MR_2=723.14** **MR_5=625.39** **N=1366** **U=192733.5** **Z=-4.5** **p=0.00** **ES=0.12**	MR_3=648.23 MR_4=618.22 N=1272 U=18350 Z=-1.34 p=0.016	MR_3=690.08 MR_5=629.91 N=1329 U=195235.5 Z=-2.82 P=0.01	MR_4=536.88 MR_5=516.24 N=1051 U=132262.0 p=0.27
BMI μ=18.47	MR_1=662.21 MR_2=656.2 N=1316 U=202754.5 p= 0.78	MR_1=660.03 MR_3=626.97 N=1279 U=185203.5 p= 0.12	MR_1=522.98 MR_4=478.71 N=1001 U=114164.5 Z=-2.423 p=0.02 ES=0.08	MR_1=555.61 MR_5=505.75 N=1058 U=126450.5 Z=-2.65 p=0.01 ES=0.08	MR_2=811.1 MR_3=776.08 N=1587 U=300765 p=0.13	MR_2=675.33 MR_4=621.79 N=1309 U=185275 Z=-2.49 p= 0.01 ES=0.07	MR_2=708.08 MR_5=647.47 N=1366 U=204961 Z=-2.79 p=0.01 ES=0.08	MR_3=646 MR_4=621.68 N=1272 U=185222.5 p=0.25	MR_3=677.88 MR_5=646.99 N=1329 U=204696.5 P=0.15	MR_4=528.21 MR_5=524.01 N=1051 U=136569 p=0.82

N-sample size; μ – physical fitness arithmetic mean, MR – physical fitness indicator mean rank between two groups of physical activity; U – Mann Whitney U test value; Z – Z value; p –significance level; ES – effect size.

Note: Lower mean rank in weight and BMI represents better result; Mann Whitney test is significant after performing Bonfferoni correction at 0.005.

Kruskal-Wallis test for nonparametric data showed statistically significant differences between physical activity and physical fitness indicators (Table 20): Standing long jump, Hand Grip, Situps, Height, Weight and BMI. As the data was skewed, the most appropriate statistical test for finding differences between physical fitness and groups of physical activity (very low PA, low PA, normal PA, high physical activity and very high PA) was Mann-Whitney U test. Descriptive statistics showed that very low physical activity group (mean rank = 586.16) performed worse in Standing long jump than normal physical activity group (mean rank = 658.89). Mann-Whitney U value was found to be statistically significant U = 178578(Z=2.52), $p_b<0.005$ and the difference effect between very low and low physical activity groups was low (ES=0. 07). Very low physical activity group (mean rank =283.74) performed worse than low physical activity group (mean rank = 367.6) in Situps 60s. Mann-Whitney U value was found to be statistically significant U = 39980 (Z=5.507), $p_b<0.05$ and the difference effect between very low and low physical activity group was medium (ES=0.21). Very low physical activity group performed worse than Normal physical activity group in Situps 60s (U=34612.0; Z=-6.275), $p_b<0.005$ (ES=0.25) and weight (U=185114, 5; Z=-1.163), $p_b<0.005$ (ES=0.03). High physical activity group performed better in Hand grip (U=1101836; Z=-2.064), $p_b<0.05$ (ES=0.07) than Very low physical activity group. The biggest differences were found between Very low physical activity and Very high physical activity group. Very low physical activity group performed worse than Very high physical activity group in Hand grip (U=120787; Z=-3.11), $p_b<0.005$ (ES=0.10), Situps (U=23357; Z=-4.61), $p_b<0.05$ (ES=0.21), height (U=119360; Z=-4.01), $p_b<0.005$ (ES=0.12) and weight (U=119873,5; Z=-3.98) $p_b<0.005$ (ES=0.12).

Hypothesis 1.1 has been accepted. Children with higher physical activity duration performed better in following indexes of physical fitness: explosive strength (Standing long Jump), repetitive strength (situps 60s) and physical dimensions of the body (height, weight, BMI).

3.2.8 Hypothesis 1.2

H 1.2 Children who are more physically active will score higher on indexes of academic performance.

H0, 1.1: There is no difference between physical activity groups and academic performance.
HA, 1.2: There is a difference between physical activity groups and academic performance.

To find a link between physical activity and academic performance, nonparametric Spearman's rho coefficient was performed (Table 22).

Table 22: Correlation coefficients for physical activity and academic performance.

Academic performance	Correlation coefficient	Sig. (2-tailed)
Physical activity	0,05	0,07

There is no significant relationship between overall physical activity and academic performance.

Table 23: Kruskal-Wallis test results for Academic performance and Physical activity.

Academic performance	Kruskal-Wallis test	Sig.
Physical activity	6,05	0,20

To determine differences between groups of physical activity (very low PA, low PA, normal PA, high physical activity and extreme PA) and Academic performance, nonparametric Kruskal-Wallis test was performed, which is used when we operate with ordinal data. Since significance level is higher than 0.05 (Table 23) the differences between medians are not statistically significant; therefore we fail to reject null hypothesis. Not enough evidence is available to suggest the null hypothesis can be rejected at the 95% confidence level. **Hypothesis 1.2 has been rejected.**

3.2.9 Hypothesis 1.3

H 1.3 Children with higher index of academic performance have better motor abilities.

H0, 1.2: There is no difference between academic performance and motor abilities.
HA, 1.3: There is a difference between academic performance and motor abilities.

For motor abilities and physical activity, correlation coefficients were checked using nonparametric Spearman's rho test (Table 24).

Table 24: Correlation coefficients between motor abilities and academic performance.

Physical fitness test/ Academic performance	Correlation coefficient	Sig. (2-tailed)
Standing Long Jump	**0.07***	**0.02**
Flamingo	**-0.13****	**0.00**
Hand Grip	**-0.01****	**0.00**
Situps 60s	**0.18****	**0.00**
Situps 20s	**0.13****	**0.00**
Hand tapping	-0.03	0.38
Polygon backwards	**-0.09****	**0.00**
Shuttle run	-0.02	0.51
Sit and Reach	**0.09****	**0.00**

*Note: *Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).*

Statistically significant correlation was detected between academic performance and the following motor abilities: Standing long jump, Flamingo test, Hand grip, Situps 60s, Situps 20s, Polygon backwards, Sit and reach.

To determine differences between motor abilities and Academic performance, nonparametric Kruskal-Wallis test was performed, which is used when assumption of normality is not satisfied. Where Sig. level is higher than 0.05 (Table 25) the differences between medians are not statistically significant; therefore we fail to reject null hypothesis. Not enough evidence is available to suggest the null hypothesis can be rejected at the 95% confidence level for following motor abilities: Standing long jump and Shuttle run.

Table 25: Kruskal Wallis Test for Motor abilities Academic performance differences.

Motor abilities / Academic performance	Kruskal-Wallis Test	Sig.
Standing Long Jump	8.45	0.08
Flamingo	**11.56**	**0.02**
Hand Grip	**20.7**	**0.00**
Situps 60s	**46.53**	**0.00**
Situps 20s	**25.68**	**0.00**
Hand tapping	**11.45**	**0.02**
Polygon backwards	**12.25**	**0.02**
Shuttle run	7.31	0.12
Sit and Reach	**12.72**	**0.01**

*Note: *Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).*

Table 26: Mann Whitney test results.

Motor abilities/academic performance	12	13	23
Flamingo μ=14.98	MR_1=260.96 MR_2=237.08 N=499 U=27955.5 p= 0.07	**MR_1=268.38** **MR_3=225.95** **N=497** **U=25413** **Z=-3.285** **p= 0.00** **ES=0.15**	MR_2=236.52 MR_3=220.41 N=456 U=24154.5 p= 0.19
Hand Grip μ=18.58 kg	**MR_1=490.32** **MR_2=435.49** **N=931** **U=94367** **Z=-3.096** **p= 0.00** **ES=0.10**	**MR_1=476.26** **MR_3=426.83** **N=909** **U=90254** **Z=-2.815** **p= 0.01** **ES=0.21**	MR_2=399.74 MR_3=405.42 N=804 U=79600 p= 0.73
Situps 60s μ=37.78	**MR_1=444.7** **MR_2=493.42** **N=932** **U=96150.5** **p= 0.01** **Z=-2.75** **ES=0.09**	**MR_1=403.08** **MR_3=513.93** **N=900** **U=74717.5** **p= 0.00** **Z=-6.33** **ES=0.21**	**MR_2=373.4** **MR_3=431.93** **N=802** **U=68556** **Z=-6.33** **p= 0.00** **ES= 0.22**
Hand tapping μ=34.98	MR_1=463.05 MR_2=476.51 N=937 U=104837 p= 0.45	MR_1=471.45 MR_3=442.11 N=917 U=96125 p= 0.1	**MR_2=417.17** **MR_3=380.92** **N=798** **U=72322.5** **Z=-1.66** **p= 0.03** **ES=0.17**

Polygon backwards μ=19.23	MR_1=476.51 MR_2=444.08 N=923 U=97915 p= 0.07	**MR_1=469.91** **MR_3=416.49** **N=893** **U=85979** **Z=-3.064** **p= 0.00** **ES=0.10**	MR_2=408.03 MR_3=388.22 N=796 U=75152.5 p= 0.22
Sit and Reach μ=19.6 cm	MR_1=458.19 MR_2=480.13 N=935 U=102983 p= 0.22	MR_1=434.15 MR_3=481.42 N=908 U=90548 Z=-2.69 p=0.01 ES=0.09	MR_2=393.91 MR_3=416.79 N=809 U=77110 p= 0.17

MR – median ranks; N- sample size; U – Mann-Whitney U test; Z – Z value; ES – effect size; p – significance level.

Note: Lower mean rank in flamingo and polygon backwards represents better result; Mann-Whitney test is significant after performing Bonferroni correction at 0.0167.

Kruskal-Wallis test for nonparametric data showed statistically significant differences between academic performance and the following motor abilities (Table 26): Flamingo, Hand grip, situps 20s, situps 60s, hand tapping, polygon backwards and sit and reach. As the data was skewed, the most appropriate statistical test for finding differences between academic performance groups (low, normal, high) was Mann-Whitney Test. Descriptive statistics showed that low academic performance group (mean rank=490.32) performed significantly better (Z=-3.096), p<0.0167 in hand grip than low academic performance group (mean rank=435.49). The difference effect between low and normal academic performance group is small (ES=0.10). Normal academic performance group (mean rank=493.42) performed significantly better (Z=-2.75), p<0.0167 (ES=0.09) in situps 60s than low academic performance group (mean rank=447.7). High academic performance group performed significantly better (p<0.0167) in flamingo test (ES=0.15), situps 20s (ES=0.21), situps 60s (ES=0.16) and polygon backwards (ES=0.10) compared to low academic performance group (Table 26). Low academic performance group performed significantly better (p<0.0167) in hand grip than high academic performance group

(ES=0.21). High academic performance group performed significantly better ($p<0.0167$) in situps 20s (ES=0.17) and situps 60s (ES=0.22) than normal academic performance group (Table 26).

Hypothesis 1.3 has been partly accepted. Children with a higher index of academic performance are better in some motor abilities (balance and repetitive strength and coordination) compared to children with lower index of academic performance. Children with lower index of academic performance performed better in muscle strength (hand grip). There is a significant difference between all groups of academic performance and repetitive strength (situps 60s), where children with better mathematics grade do more repetitions in designated test.

3.2.10 Discussion

Results from the "Elementary school girls' physical activity and academic performance study" have shown that the girls are more physically active during the week and less physically active during the weekend, which indicates more uniform patterns of physical activity of schoolgirls during school days, since dispersion around average physical activity is lower compared to physical activity standard deviation during weekends. The Republic of Slovenia has very good physical education curriculum compared to other nations. Physical education in the Republic of Slovenia is a standardized, compulsory subject in all primary and secondary schools (Sember, Starc, Jurak et al. 2016), which is also confirmed when comparing overall activity minutes during weekdays and weekends in Pilot study and Study 1. According to the results of both studies, where the physical activity was measured objectively and subjectively, we can say that Slovenian elementary school children are more physically active during weekdays (Rowlands et al. 1999; Wilkin et al. 2006; Sember, et al. 2016). Indeed, all schools in Slovenia offer physical activity opportunities to their students, and the majority of Slovenian students are physically active for at least 200 min per week during school curriculum. Decrease at weekends is largely due to a drop-off in the intensity of light intensity bouts (Rowlands et al. 2008) and the removal of the structured school environment at weekends is determined to some physical activity levels and patterns, being particularly noticeable in girls (Mota et al. 2003). Children with higher physical activity duration are better in explosive strength (standing long Jump), repetitive strength (situps) and physical dimensions of the body (height, weight, BMI). Children with a higher index of academic performance are better in some motor abilities (balance, repetitive strength and coordination) compared to children with lower index of academic performance. Situp test showed significant correlations between academic performance and physical activity duration and the biggest differences among groups of physical activity and academic performance in way of better individuals. Children who perform better in academics are also more physically active and their repetitive strength is better than in children with lower levels of physical activity and academic performance. Results in "Self-reported physical activity and academic performance study" are in contrary with findings of the systematic review of 850 articles (Strong et al. 2005). They found out that comparisons between physical activity and muscular strength give ambiguous results. Longitudinal studies indicate positive impact of physical activity on muscular endurance and experimental studies with additional physical activity showed improvements in muscular strength and endurance in children. Results should be interpreted with caution and can not be presented as that increased motor abilities cause academic performance to improve or vice versa. Situp test is an endurance test and for academic performance, learning effort and endurance are the most important. Children who have more knowledge are also more familiar with the importance of physical activity on their development and overall health. Hand grip test showed significant correlations in direction of worse individuals. Muscularly stronger children perform worse in academics and in physical activity, which could be the result of lower socio-ecnonomic status, parental education and place of residence. Children living in rural areas devote more time working around the house than studying, and static work based on the muscular strength is not included as a part of physical activity in self-reported questionnaires. The family as an environment can be reflected as a cofactor (Yang et al. 1996) for better or worst influence affecting children's academic performance and physical activity. Some studies have indicated that parental education plays a major role in their children's sport and physical activity participation (Yang et al. 1996). Hockey players' parents from Ontario are in general more highly educated than the general population (Clark, 1980 in Yang et al. 1996) and Finland highly-educated parents lay less stress on children's success in sport (Silvennoinen, 1987 in Yang et al. 1996). Based on the results of the study, mother's education (r_{ap}=0.26, p<0,05) and father's education (r_{ap}=0,22, p<0,05) are significantly correlated to children's academic performance. Parents with higher levels of education have children who performed better in mathematics; therefore parental education duration is an important socio-economic factor in relation to children's academic performance. Parental education level is also an important factor for choosing living environment due to better jobs opportunities in urban areas.

After analysis of the "Self-reported physical activity and academic performance study," many questions arose, and several new issues came to light, namely what is the effect of parental education on children's physical activity duration and academic performance and how important is the effect of the place of residency on children's academic performance. Self-reported results should be interpreted carefully regarding validity and reliability (Shephard, 2003) of the measured data and objective measurement of physical activity should be considered, to satisfy accuracy of the results. All issues that have emerged in the present study will be analyzed in the following studies.

3.3 Objectively measured physical activity and Academic performance study

To avoid limitations of subjective measures, objective measures of physical activity were used in the present study. Since no single device or technique can quantify all aspects of the habitual physical activity, multiple combined methods are recommended (Schutz, Weinsier & Hunter, 2001). A combination of heart rate monitor and accelerometer is a powerful approach to quantify energy expenditure (Ainslie, Reilly & Westerterp, 2003); therefore a complex device SenseWear Armband was used. The strength of SenseWear Armband is collection of the data from multiple sensors and assessment of physical activity type and intensity by means of proper algorithms (Casiraghi, Lertwattanarak, Luzi et al. 2013).

3.3.1 Participants

In "Objectively measured physical activity and Academic performance study", n=356 schoolchildren participated. All children who participated in study were 11 years old (grade-6 of Elementary school).

3.3.2 Physical activity

Table 27 presents the basic descriptive statistics for daily physical activity of 6th-grade schoolchildren. After the data was cleaned, n=166 children carried the device in a proper way for at least five consecutive days.

Table 27: SenseWear physical activity descriptive statistics.

	$\bar{x}$ ± SD
Physical activity (kJ/day)	2386.42 + 166.892
Physical activity (min/day)	141.825 ± 7.37

Slovenian grade-6 children are in average physically active 141.825 + 7.37 min/day and spend 2386.42 + 166.892 kJ of energy daily.

In Table 27 Descriptive statistics for SenseWear Armband is shown. Standard deviation for AEE and duration of physical activity is low, which is showing small dispersion of the results. Shapiro-Wilk test showed that both parameters (AEE and duration) are not normally distributed. Skewness coefficients showed that results are skewed to the left, therefore in the direction of worse individuals.

Table 28: SenseWear physical activity descriptive statistics.

	N	MIN	MAX	SD	SW	p	Skewness/kurtosis
AEE	166	343	24708	2150.25	0.17	0.00	70.32/0.38
Duration	166	21	915	94.97	0.13	0.00	3.57/25.82

AEE – active energy expenditure; N-sample size; MIN – minimum value of PA; MAX – maximum value of PA; SD – standard deviation; SW – Shapiro-Wilk test

Based on the purified value of physical activity, four groups of physical activity were made (Table 29).

Table 29: Physical activity groups for »Objectively measured physical activity and Academic performance of elementary school children study«.

Group	Levels of physical activity	Values for levels of physical activity (min)	N
1.	Low physical activity	Up to 60 min/day	24
2.	Normal physical activity	from 61 to 120 min/day	46
3.	High physical activity	from 121 to 180 min/day	57
4.	Very high physical activity	From 180 min/day and more	39

3.3.3 Academic performance

Academic performance is expressed as an average math grade. Average math grade for n=166 grade-6 children is 4.11 $\pm$ 0.89.

3.3.4 Hypothesis 2.1

H 2.1: Children who are physically more active will score higher on indexes of physical fitness.

H0, 2.1: There is no difference in physical fitness between more or less physically active children.

HA, 2.1: There is a difference in physical fitness between more or less physically active children.

For physical fitness, eight motor abilities and three physical dimensions indicators were selected, and correlations between physical fitness and physical activity were calculated (Table 30).

Table 30: Correlation coefficients for physical fitness and physical activity.

Physical fitness test/ Physical activity	Correlation coefficient	p (2-tailed)
Standing Long Jump	0.12	0.13
Flamingo	-0.01	0.95
Hand Grip	0.15	**0.05**
Situps 60s	0.01	0.93
Hand tapping	-0.06	0.74
Polygon backwards	0.14	0.44
Shuttle run	0.19	0.30
Sit and Reach	-0.04	0.84
Height	0.00	0.10
Weight	-0.10	0.58
Body mass index	-1.26	0.50

*Note: *Correlation is significant at the 0, 05 level (2-tailed); **Correlation is significant at the 0, 01 level (2-tailed).*

There is statistically significant relationship between hand grip and objectively measured physical activity.

Table 31: Kruskal-Wallis Test for physical fitness and objectively measured physical activity.

Physical fitness test/ Physical activity	Kruskal Wallis Test	p (2-tailed)
Standing Long Jump	120.0	0.33
Flamingo	42.02	0.38
Hand Grip	116.52	0.41
Situps 60s	56.25	0.71
Hand tapping	116.97	0.33
Polygon backwards	104.55	0.68
Shuttle run	123.34	0.20
Sit and Reach	129.33	0.16
Height	115.64	0.44
Weight	120.374	0.32
Body mass index	127.23	0.19

To determine differences between groups of physical activity (low physical activity, normal physical activity, high physical activity and very high physical activity) and Physical fitness, nonparametric Kruskal-Wallis test was performed, which is used when we operate with not normally distributed data. Where significance level is higher than 0.05 (Table 31) the differences between medians are not statistically significant; therefore we fail to reject null hypothesis. Not enough evidence is available to suggest the null hypothesis can be rejected at the 95% confidence level. **Hypothesis 2.1 has been rejected.**

3.3.5 Hypothesis 2.2

H 2.2: Children who are more physically active will score higher on indexes of academic performance.

H0, 2.2: There is no difference in academic performance between more or less physically active children.

HA, 2.2: There is a difference in academic performance between more or less physically active children.

Table 32: Relationship between Academic performance and objectively measured physical activity.

Academic performance	N	Sig.	Correlation coefficient
Physical activity	**166**	**0.046**	**0.24**

N- sample size; Sig. – significance level

Note: Correlation is significant at the 0, 05 level (2-tailed).

Spearman's rho (Table 32) coefficient ($r=0.24$) showed statistically significant ($p<0.05$) correlation between academic performance and objectively measured physical activity in 6th-grade schoolchildren. Correlation coefficient showed small correlations between variables. Independent-Samples Kruskal-Wallis test showed statistically significant differences between the distributions of objectively measured physical activity and academic performance at Sig. 0.04, $p<0.05$. As the data were skewed, the most appropriate test to find the differences between physical activity groups and academic performance, Mann-Whitney U test was used (Table 33). Descriptive statistics showed that normal physical activity group (mean rank = 22.19) performed worse in Academic performance compared to high physical activity group (mean rank = 14.47).

Table 33: Mann-Whitney U test for objectively measured physical activity groups and Academic performance.

Mann Whitney U test					
MR_1=11.25	MR_1=17.31	MR_1=16.69	MR_2=23.28	**MR_2=22.19**	MR_3=25.73
MR_2=13.13	MR_3=17.56	MR_4=112.87	MR_3=20.40	**MR_4=14.47**	MR_4=19.26
N=24	N=34	N=27	N=42	**N=35**	N=45
Z=-0.656	Z=-0.064	Z=-1.18	Z=-0.78	**Z=-2.3**	Z=-1.69
p= 0.51	p= 0.95	p= 0.24	p= 0.44	**p= 0.02**	p= 0.09
				ES= 0.39	

Note: MR_1 represents Mean Rank for low physical activity group, MR_2 represents Mean Rank for normal physical activity group, MR_3 represents Mean Rank for high physical activity group and MR_4 represents Mean rank for very high physical activity group.

Mann-Whitney U value (Table 33) was found to be statistically significant Z=-2.3, p<0.05 and the differences between groups were large (ES=0.39). Statistically significant difference in academic performance was found between normal (60 – 120 min/day) and high (180 and more min/day) physical activity group. Normal physical activity group performed significantly better in academic performance than high physical activity group. In terms of better academic performance, recommendation for physical activity should be between 60 – 120 min/day. **Hypothesis 2.2 has been partly rejected.**

3.3.6 Hypothesis 2.3

H 2.3: Urban school children will have higher daily physical activity levels than rural children.
H0, 2.3: There is no difference in physical activity levels between urban and rural children.
HA, 2.3: There is a difference in physical activity levels between urban and rural children.

Table 34: Urban and rural children's physical activity descriptive statistics.

PA	N	$\bar{x}$	MIN	MAX	SD	SW	p	Skewness / kurtosis	Mann-Whitney Test
U	28	162.07	24	915.0	157.7	0.52	0.00	4.25/20.8	MRu=88.68
R	138	137.7	21	390.0	75.6	0.95	0.00	0.82/0.57	MRr=82.45 U=1787.00 Z=-0.625 P=-0.625

PA – physical activity (min/day); U – urban children; R – rural children; N-sample size; $\bar{x}$ - arithmetic mean, MIN – minimum value of daily PA; MAX – maximum value of daily PA; SD – standard deviation; SW – Shapiro-Wilk test, MR – median ranks; N- sample size; U – Mann Whitney U test; Z – Z value; ES – effect size; p – significance level

Note: Mann Whitney test is significantafter performing Bonfferoni correction at 0.025

Average daily physical activity expressed in minutes is higher in urban ($\bar{x}$ =162.07 $\pm$ 157.7 min/day) than in rural areas of Slovenia (137.7 $\pm$ 75.6 min/day). Skewness coefficients show that the results are skewed to the left, therefore in the direction of less active children. Normal distributions of urban and rural physical activity duration significantly deviate from the theoretical distributions. Nonparametric Mann-Whitney test (U=1727) did not show statistically significant difference between rural and urban children's physical activity duration (Table 34). **Hypothesis 2.3 has been rejected.**

3.3.7 Hypothesis 2.4

H 2.4: Urban school children will have better academic performance than children from rural areas.
H0, 2.4: There is no difference in academic performance between urban and rural children.
HA, 2.4: There is a difference in academic performance between urban and rural children.

Table 35: Urban and rural children academic performance descriptive statistics and Mann Whitney U test results.

AP (math grade)	N	$\bar{x}$	SD	SW	p	Skewness/ kurtosis	Mann-Whitney Test
Urban	24	4.25	0.85	0.80	0.00	-1.0/-0.57	MRu=42.26
Rural	45	3.56	1.16	0.85	0.00	-0.05/-1.45	MRr=30.97 U=358.5 Z=-2.38 p=0.02 ES=0.29

N-sample size; $\bar{x}$ - arithmetic mean; SD – standard deviation; SW – Shapiro-Wilk test; U – Mann Whitney U test; Z – Z value; ES – effect size; p – significance level

Urban grade-6 children average math grade is 4.25 $\pm$0.85 and 3.56 $\pm$ 1.16 in rural grade-6 children. Skewness coefficients for urban areas show that results of academic performance are skewed to the right, therefore in the direction of children who perform better in mathematics. Skewness coefficients for rural areas shows that results of academic performance are skewed to the left, therefore in the direction of the worst mathematics grades. Normal distributions of urban and rural academic performance statistically significantly deviate from the theoretical distributions. Non parametric Mann-Whitney test (U=358.5) showed statistically significant Z=-2.38, $p<0.05$ and the difference between rural and urban children in academic performance was medium (ES=0.29). Urban schoolchildren (MRu=42.26) performed better in mathematics compared to rural schoolchildren (MRr=30.97) (Table 35).

Hypothesis 2.4 has been accepted: Children from urban areas have better academic performance than children from rural areas.

3.3.8 Discussion

With objectively measured physical activity it was found that there is a positive link between academic performance and physical activity. Children following WHO (2010) recommendations for physical activity, perform better in academics, but it must be emphasized that only within certain limits of physical activity. Very low physical activity and the activity over 120 minutes/day did not show significant difference in academic performance in favor of more active children. Since it has been shown that increased physical activity has apositive impact on children's overall health, WHO (2010) recommendations are needed to be raised in terms of better cognitive and physical health of children. Children from urban areas perform significantly better in mathematics, compared to children from rural areas of Slovenia. In contrary with the findings of the present study, researchers found that children in rural areas perform better in academics, such as reading and mathematics (Alspaugh, 1992; Alspaugh & Harting, 1995). No links between objectively measured physical activity and physical fitness were found, which originates from a very good school system for physical education in the Republic of Slovenia (Tremblay, Gonzalez, Katzmarzyk et al. 2016; Sember, Starc, Jurak et al. 2016) and classes narrated towards improvement in motor abilities and physical fitness. Compulsory monitoring in Slovenian schools allowed policy-makers to identify and act on decreasing levels of physical fitness quickly. Since a greater emphasis has been placed on in-school physical education and fitness, there has been a correction of this downward trend and children and youth are on upwards progression towards better health and fitness (Tremblay et al. 2016; Sember et al. 2016). For this study, only Ljubljana, the capital, has been treated as an urban city of Slovenia. Factors for potential differences in academic performance between rural and urban settlements in Slovenia could be the availability of resources, differences in socioeconomic status of families, community influence and parental expectations. Ljubljana is in comparison with other regions of Slovenia visibly developed, which is shown in the exceptionally rapid growth of the gross domestic product, good jobs and the reduction of unemployment. This is also connected to the positive migration balance of highly educated people. The reason for higher academic performance in urban children is in the parental educational structure. Referring to the results in chapter 3.2.6, mother's ($r_{ap}=0.26$, $p<0.05$) and father's education ($r_{ap}=0.22$, $p<0.05$) are significantly correlated to the children's academic performance. Since more educated parents are moving to the capital (Rebernik, 2003), there may be a greater percentage of children who perform better in academics.

After analysis of the "Objectively measured physical activity and academic performance study" new issues came to light, namely what is the effect of growth and maturity on children's levels of physical activity and academic performance. Do increase in physical size and acceleration of growth influence physical activity and academic performance? What happens with physical activity of children entering the period of puberty? How does physical activity change during puberty between boys and girls? All issues that have emerged in the present study will be analyzed in the "Longitudinal study."

3.4 Longitudinal study

3.4.1 Participants

After examination of the data and eliminating unfit measurements from the sample due to missing results, n=123 (62 boys and 61 girls) schoolchildren participated in objective measurements of physical activity.

Table 36: Participant's maturity descriptive statistics and Mann Whitney U test for gender difference effect.

Gender	N	$\bar{x}$	N	MR	Mann-Whitney
Boys	195	13.59	0.88	250.56	U=1225.5 Z=-3.51
Girls	180	12.19	0.98	120.23	P=0.00 ES=0.18

N – sample size; $\bar{x}$ - arithmetic mean; SD – standard deviation; MR – mean rank; U – Mann Whitney U test; Z – Z value; ES – effect size; p – significance level

Average age of children was 11 ± 0.5 years at baseline measurements and 14 ± 0.5 years at follow up measurements. Children measured at baseline measurements were attending grade-6 and in follow up measuremets grade-9 of elementary school.

From the results in Table 36 it can be concluded that physical growth and maturity of boys (mean rank=250.56) engage significantly later (U=1225.5; Z=-3.51), p=0.00; than with elementary school girls (mean rank=120.23. Difference in age at maturity between boys and girls is medium (ES=0.18).

3.4.2 Physical activity

Physical activity was measured objectively, with accelerometer SenseWear Armband and is expressed in minutes/day (Table 37). Physical activity arithmetic mean for children in grade-6 represents 138.89 ± 73.19 min/day and for the same children 61.97 ± 144.04 min/day in grade-9.

Table 37: Objectively measured physical activity descriptive statistics.

	N	$\bar{x}$	SD	MIN	MAX	Skewness/ kurtosis	SW	p
PA grade-6	123	138.89	73.19	21	390	0.71/ 0.47	0.96	0.00
PA grade-9	123	61.97	144.04	13	440	4.64/ 24.76	0.45	0.00

*N-sample size; $\bar{x}$ - arithmetic mean; SD – standard deviation; SW – Shapiro-Wilk test; N-sample size**;** p – significance level*

Standard deviation for physical activity is high in both grades, which shows bigger dispersion of the results. For overall physical activity normality was checked using Shapiro-Wilk test. Normal distribution of physical activity significantly deviates from the theoretical distribution.

3.4.3 Academic performance

Academic performance was expressed as math grade (Table 38). Average math grade of sample in grade-6 is 4.17± 1.05 and 3.54 ± 0.97 in grade-9 for the same children. In both grades, standard deviations were high, which means that the sample of measured children have many outliers.

Table 38: Academic performance descriptive statistics.

Academic performance	N	$\bar{x}$	SD	SW	p
Grade-6	123	4.14	0.99	0.75	0.00
Grade-9	123	3.64	1.01	0.88	0.00

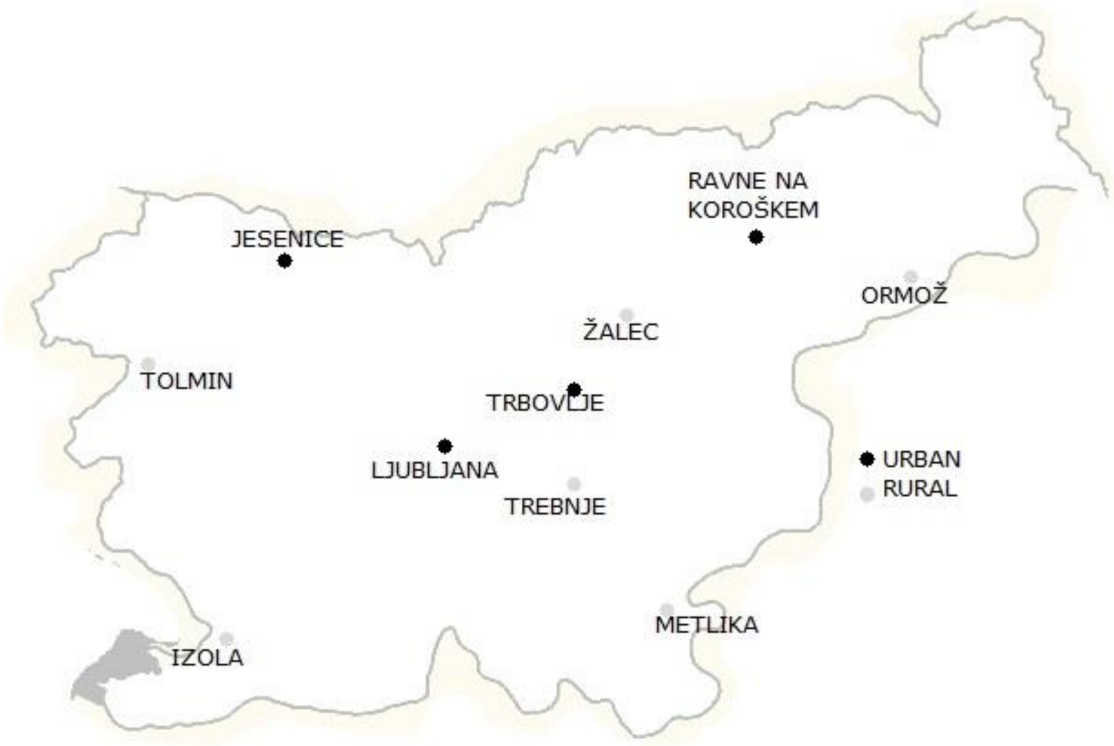
Note: N-sample size; $\bar{x}$ - arithmetic mean; SD – standard deviation; SW – Shapiro-Wilk test; N- sample size, p – significance level

For academic performance normality was checked using Shapiro-Wilk test (Table 38). Normal distribution of academic performance significantly deviates from the theoretical distribution.

3.4.4 Place of residence

For the use of "Longitudinal study", N=11 elementary schools were divided into urban and rural parts of Slovenia. The sample was defined by the initial platform research, conducted by Šturm in 1970 (Šturm, 1972). For greater context, Slovenia is a country on the Balkan Pennisula, and was part of the Social Federal Republic of Yugoslavia untill 1991. Slovenia became an independent state in 1991, so also the nature of its cities changed, evidently. Towns and other urban settlements represent the backbone of Slovenian settlement system. Urban centers form the backbone of a polycentric system and represent a significant support to their functional hinterland. Slovenia is characterized by a large number of small settlements and have only 2 settlements with more than 50.000 inhibitants (Ljubljana and Maribor), with 90% of all settlements having fever than 500 inhabitants (Mesta in urbana območja, 2017). Following initial platform research (Šturm, 1972) from 1970, Ljubljana as capital and all industrial centers, including: Jesenice, Ravne na Koroškem and Trbovlje, were assigned to the group of urban areas whereas all other settlements were assigned to the group or rural areas (Image 2).

Image 2. Development of Cities and Other Settlements in Republic of Slovenia.



Source: MESTA IN URBANA OBMOČJA, Ministry of Environment and Spatial Planning (2017).

3.4.5 Hypothesis 3.1

H 3.1: Children's physical activity duration is lower in grade-9 comparing to physical activity in grade-6.

H0, 3.1: There is no difference in children's physical activity duration in grade-6 and in grade-9.
HA, 3.1: There is a difference in children's physical activity duration in grade-6 and in grade-9.

Wilcoxon Signed Ranks Test (Table 39) showed statistically significant differences between physical activity duration in grade-6 and grade-9 ($Z=-7.343$, $p=0.00$). Overall, 104 kids were more physically active in grade-6 and 19 kids were physically more active in grade-9. This is also supported by the average value of actively spent minutes grade-9 (61.97 $\pm$ 144.04 min/day) and in grade-6 (138.89 $\pm$ 73.19 min/day).

Table 39: Wilcoxon Signed Ranks Test results.

Physical activity	Negative ranks	Positive ranks	MR
Grade-6	104a		64.63
Grade-9		19b	47.58

MR – mean ranks;

Note: a - Physical activity in grade-9 < physical activity in grade-6;

b - Physical activity in grade-9 > physical activity in grade-6.

Hypothesis 3.1 has been accepted. Physical activity duration is lower in grade-9 compared to physical activity in grade-6.

3.4.6 Hypothesis 3.2

H 3.2: Children who are more physically active will score higher on indexes of academic performance.

H0, 3.2: There is no difference in academic performance between more and less active children.
HA, 3.2: There is difference in academic performance between more and less active children.

Spearman’s Rank-Order correlation (Table 40) did not show statistically significant correlation between academic performance and physical activity in 6th and in grade-9. Results showed negative significant correlation ($r=-0.22$, $p<0.05$) between physical activity in grade-6 and Academic performance in grade-9. Negative significant correlation between girls’ physical activity in grade-6 and academic performance 3 years later ($r=-0.35$, $p<0.05$) was found.

Table 40: Correlation coefficients for academic performance and physical activity

PA / academic performance	AP 6thGrade	p	AP grade-9	p
PA boys grade-6	-0.19	0.12	-0.01	0.91
PA girls grade-6	-0.10	0.40	**-0.35**	**0.00**
PA boys grade-9	0.01	0.92	-0.10	0.91
PA girls grade-9	-0.03	0.77	-0.19	0.84
PA grade-6	-0.16	0.07	**-0.22**	**0.02**
PA grade-9	-0.01	0.86	-0.01	0.83

Note: academic performance – academic performance; physical activity – physical activity

Hypothesis 3.2. has been rejected. There is no difference between more or less active children in academic performance.

3.4.7 Hypothesis 3.3

H 3.3: Rural school children will have higher physical activity duration compared to urban children.

H0, 3.3: There is no difference in physical activity between urban and rural children.
HA, 3.3: There is a difference in physical activity between urban and rural children.

To find differences between urban and rural children, Mann Whitney test was performed. From results in Table 41, it can be concluded that rural school children are significantly more physically active in grade-6 (U=1518.5; p=0.00) and in grade-9 (U=1042.5; p=0.02) than urban children. Effect size for difference of groups in both grades is small.

Table 41: Mann Whitney test results for urban and rural objectively measured physical activity.

Grade	PR	N	MR	SW
PA grade-6	Urban	123	59.22	U=1518.5
	Rural		79.39	Z=-2.958
				p=0.00
				ES=0.27
PA grade-9	Urban	107	46.81	U=1042.5
	Rural		61.33	Z=-2.421
				p= 0.02
				ES=0.23

N-sample size; $\bar{x}$ - arithmetic mean, MIN – minimum value of daily PA; MAX – maximum value of daily PA; SD – standard deviation; SW – Shapiro-Wilk test, Sig. – significance level.

Hypothesis 3.3 has been accepted. Rural children are more physically active than urban children.

3.4.8 Discussion

For the purpose of "Longitudinal study", a complex device SenseWear Armband (Bodymedia, Pittsburgh, Pennyslvania) was used. Children are significantly more active at the age of 11 than at the age of 14 and there is no correlation between objectively measured physical activity and academic performance. Reduction of daily physical activity minutes in Grade-9 is due to the reduction of physical education classes in third educational cycle and school physical education accounts for a large proportion of children's physical activity (EUPAG, 2008). From grade-1 to grade-6, children accumulate 105 school hours of physical education per year (3 hours/week), and only 64 hours in grade-9 (2 hours/week) (Kovač et al. 2011). Results showed differences in physical activity duration between urban and rural children. Rural children are more active than urban children before and after puberty, which is contrary to the results of Planinšec (1997), Matejek and Planinšec (2008), and Planinšec, Pišot and Fošnarič (2006), who found out that the children from rural areas were the least active in Slovenian area. All studies mentioned above were assessing physical activity using self-report and the uncertainty of the results can be expected due to over-reporting of physical activity (Warnecke, Johnson, Chavez et al. 1997), since recalling physical activity is a very complex cognitive task (Baranowski, 1988). All comparative studies in the Slovenian environment, comparing rural and urban children's physical activity, were conducted only in one geographical environment, making it clear that results can not be generalized to the whole Slovenian population. Findings in "Longitudinal study" are in agreement with Matre, Welk, Calabro et al. (2008) who reported that urban children were the least active children in a global 51-country survey in physical inactivity. Results also show that girls' physical activity minutes in grade-6 are positively related to their academic performance in grade-9, which could be due to level of maturity and growth of boys and girls, which normally occurs between grade-6 and grade-9. Results showed that physical growth and maturity of boys engage significantly later compared to their girl companions. After analysis of the "Longitudinal study" a new issue for future research emerged.

4 LIMITATIONS AND FUTURE RESEARCH

4.1 Limitations

There are methodological limitations to be considered in the current doctoral dissertation: sample size, subjective assessment of physical activity, objectively measured physical activity, the indicator of academic performance and external factors.

4.1.1 Sample size

The sample sizes were different in all four studies. Because of the time limit, the Pilot study was conducted only on a small sample size (n=16) of schoolchildren; therefore to generalize the results to larger groups, the pilot study should have involved more participants. Study 1 was conducted on n=3728 schoolchildren. Notwithstanding a very small margin error and more useful measurable results, we are unaware of how exactly study variables were measured and low reliability of some measured variables can be expected. Results from Study 1 should be interpreted critically since statistical tests in big datasets reported significant results almost always. Thus, estimates of correlations and effect size are attenuated by measurement error.

4.1.2 Subjective assessment of physical activity

In Study 1, subjective assessment of physical activity encounters several limitations regarding validity and reliability of results (Shephard, 2003). Major limitations regarding subjective assessment in Study 1 were: i) inadequate length of assessment and failure to account for weekday versus weekend differences in physical activity (Baranowski, 1988) ii) over-reporting of physical activity (Warnecke, Johnson, Chavez et al. 1997) iii) the desire for a particular outcome and language and cultural differences when physical activity was assessed on population, which differs from the one that questionnaires were validated for (Argiropoulou, Michalopoulou, Aggeloussis et al. 2004).

4.1.3 Objectively measured physical activity

Physical activity measured with accelerometer

Physical activity in Pilot study was measured with accelerometer Actigraph GT3X. Limitations regarding accelerometry use in Pilot study were: i) children knew they were monitored (Dencker & Anderesen, 2011), therefore we did not measure their habitual physical activity and results cannot be generalized as a totally realistic measure of physical activity ii) accelerometers are unable to recognize static exercise (Bouten, Sauren, Verduin et al. 1997) and the devices might underestimate overall physical activity iii) high-cost of device and insufficient number of accelerometers did not allow the measurements of all the girls in the same time interval, so there might be differences in physical activity duration due to different weather conditions.

Physical activity measured with multi-sensor device SenseWear Armband

Despite the fact that SenseWear Armband is one of the most reliable monitors for measuring physical activity, some limitations should be considered in Study 2 and Study 3, where physical activity was measured using multi-sensor device: i) children knew they were monitored (Dencker & Anderesen, 2011), therefore we did not measure their habitual physical activity and the results cannot be generalized as a totally realistic measure of physical activity ii) high-cost of device and insufficient number of accelerometers did not allow the measurements of all the children in the same time interval, so there might be differences in physical activity duration due to different weather and seasons conditions iii) due to lack of battery life and memory of the device, one-minute epoch was used; therefore we did not detect short-lasting movements and the device might have underestimated overall physical activity duration.

4.1.4 Indicator of academic performance

Academic performance was assessed through mathematics, Slovene language, natural sciences grades and grade point average in the pilot study, and only with the mathematics grade in Study 1, 2, and 3. The math grade seems to be only a modest indicator of overall academic performance, but it is the best one in Slovenian settings (r=0,50) with the highest predictive value of overall academic performance (Flere, Klanjšek, Musil et al. 2009), including higher levels of reliability (0,89 – 0,94) (Carlson, Fulton, Lee et al. 2008). Academic performance grades were based on ratings by school teachers, therefore any potential 'rater bias' might have been introduced. Nevertheless, although the strongest relationships were found between aerobic fitness and achievement in mathematics (Fedewa & Ahn, 2011), grade point average and math grade were the only two instruments of academic performance used in the larger studies; thus results can only be generalized to those instruments that measure academic performance.

4.1.5 External factors

Finally, the longitudinal design of the "Longitudinal study" enabled us to observe children's academic performance and physical activity duration between grade-6 and grade-9 in Elementary school; however, children may be exposed to other factors that influence physical activity duration or academic performance score. These could include family issues, peer problems, nutrition habits, changes in school curriculum and different stages of growth and maturity among children attending the same school grade.

4.2 Future research

It is important for research on this topic to continue since the quality physical activity in schools has the potential to impact cognitive and health outcomes of children in Slovenia. In the future it is necessary to pre-determine the sample sizes of studies and future work should focus on understanding dependencies between physical activity and their positive effect(s) on physical fitness and health. For example, it is necessary to determine the lever of increased academic performance, whether it is the impact of socio-economic factors which are consistently associated with increased physical activity or whether it is the awareness of the benefits of physical activity which impact for better academic performance. Understanding the interactions between physical activity and academic performance, using regression models to predict children's physical activity, physical fitness and academic performance during secondary school. Considering the maturation process and how this differs between young boys and girls and connections found between physical activity and physical fitness regarding their maturity stages. The next stage could be research that will explore the cumulative effect of physical fitness and learning during longer periods of time, since physical fitness showed more connections with academic performance than physical activity and the effect of inside versus outside physical activity on academic performance.

5 CONCLUSION

This doctoral dissertation is the first series of studies conducted in Slovenia which determined the relationship between physical activity and academic performance in elementary school children. It provides results by assessing physical activity using two different methods: objectively, using two types of physical activity monitors, and subjectively, using school records of achieved physical activity and self- reported questionnaires. The results determined that the children living in urban or rural areas were different regarding the link between physical activity and academic performance.

The thesis provides evidence for the Ministry of Education and Sport of the Republic of Slovenia that there is sufficient attention to rural and poorer areas of Slovenia, but not enough attention is devoted to older children finishing elementary school. Physical activity at the end of elementary school was almost halved compared to the physical activity levels of the same children before entering the period of adolescence, which represents a huge future health risk for the development of younger generations. Slovenia reported the highest grade for overall physical activity in comparison with 38 countries (Tremblay et al. 2016; Sember et al. 2016), since the majority of Slovenian schoolchildren meet the recommendation of at least of 60 minutes of moderate-to-vigorous physical activity per day (WHO, 2010). The Republic of Slovenia has the most active schoolchildren and a very good school system (Tremblay et al. 2016), compared to the other countries in the world. However, the sobering fact is that despite these high levels of overall physical activity and a robust school system, Slovenia has room to improve further, and give children more physically-narrated classes in the school system than it was in 2004. The situation elsewhere in the world is more frightening compared to Slovenia, so it is necessary to inform policy makers that physical activity programs in the school system are beneficial to academic performance, and lead as an example to ensure proper physical and psychological development of the children around the world. Onone hand there are links between academic performance and physical activity but on the other hand we can not ignore the fact that many cofactors are responsible for such positive links between these two variables, such as parental education, place of residence and children's maturity levels. Education will be ineffective unless children's health is made a priority and school may be the only place where health inequities can be addressed (Basch, 2010). Children are nowadays extremely sedentary

(Tremblay, 2016) and unfit, which is related to an earlier onset of several chronic diseases such as diabetes type II and obesity. Not only health benefits of physical activity are important, the academic performance, which is affected by many factors such as socioeconomic status, parental involvement and participation, is also influenced by physical activity. Following literature review and results of the thesis, academic performance is a mixture of interrelated factors, which are closely intertwined and interdependent one of another.

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POVZETEK V SLOVENSKEM JEZIKU

1 UVOD

Vsesplošno znano je, da gibalna aktivnost ugodno vpliva na psihosocialno zdravje, funkcionalne sposobnosti in splošno kakovost življenja (Powell & Pratt, 1996). Dokazano je, da se z gibalno aktivnostjo znižujeta krvni tlak in verjetnost obolenj za nekaterimi vrstami raka (Batty & Thune, 2000), zmanjša se tveganje za koronarno srčno bolezenijo (Batty & Lee, 2004) ter se kardiorespiratorne funkcije dvignejo (Strauss, Rodzilsky, Burack idr. 2001). Gibalna aktivnost je vsaka dejavnost, kjer se poveča srčni utrip in se lahko izraža v športu, igranju s prijatelji, družino, aktivnim transportom, plesom in z drugimi dejavnostmi (Roberts, Tynjälä & Komkov, 2004). S fiziološkega vidika je gibalna aktivnost vsak dogodek, ki ga proizvaja krčenje skeletnih mišic, te pa zahtevajo porabo energije (Bouchard idr. 1990). Telesna dejavnost ima pozitiven vpliv na otrokov razvoj, če se izvaja pogosto, kakovostno in v daljšem časovnem obdobju. Gibalna aktivnost skrbi za integriran razvoj otroka (Grissom, 2005), ki združuje fizične in duševne procese, zato le gibalna aktivnost sama po sebi ne more neposredno vplivati na učni uspeh otrok. Stanja, povezana z gibalno neaktivnostjo, vključujejo debelost, hipertenzijo, sladkorno bolezen, bolečine v hrbtu, slabo gibljivost in psihosocialne težave (World Health Organisation, 1997). V naslednjih dveh desetletjih v Združenih državah Amerike pričakujejo 40 % stopnjo debelosti pri otrocih (Kopelman, 2000). Šolska športna vzgoja predstavlja velik delež otrokove gibalne dejavnosti ter pozitivno vpliva na razvoj gibalnih sposobnosti (EUPAG, 2008). Ob primerjavi učencev, ki obiskujejo športne oddelke, in tistih, ki nimajo dodatnih ur športne vzgoje, lahko ugotovimo, da so pri prvih opazne pozitivne spremembe predvsem pri gibalnih razsežnostih, na katere je moč vplivati s procesom vadbe (Jurak, Kovač & Strel, 2007). Mnogi raziskovalci ugotavljajo, da dodatne ure športne vzgoje pozitivno vplivajo na učni uspeh (Shephard, 1997), saj z učenjem kompleksnih gibov stimulirajo prefrontalni korteks, ki je dejaven pri učenju in reševanju problemov (Jensen, 2005). Bolj gibalni otroci in bolj gibalno učinkoviti otroci so tudi boljši učenci (Kirkendall, 1985).

Gibalna aktivnost pozitivno vpliva na dejavnike, ki izboljšujejo učni uspeh otrok v osnovni šoli. Ti faktorji so: boljša samopodoba, samozavest, koncentracija in motivacija za učenje. Caterino in Polak (1999) sta ugotovila, da so bolj gibalno aktivni otroci bolj koncentrirani pri pouku. Evans idr. (1985) poročajo, da bolj gibalno aktivni otroci povzročajo manj nevšečnega vedenja pri pouku, prav tako pa so ugotovili, da je gibalna aktivnost močno povezana z višjo samopodbo in samozavestjo pri šoloobveznih otrocih (Nelson & Gordon-Larsen, 2006). Raziskave, izvedene v Franciji (Vanves), Avstraliji in Kanadi (Trois-Rivières), poročajo, da velik sorazmerni delež časa (14–26 %), ki ga namenimo gibalni aktivnosti, ni povezan z upadom akademskih sposobnosti. Ne le da ni prisotnega pada akademskih sposobnosti, raziskave so nakazale celo pozitiven trend – bolj gibalno aktivni otroci so tudi bolj uspešni v šoli. Pri bolj gibalno aktivnih otrocih se poveča pretok krvi, pride do večje cerebralne vzburjenosti, spremembe ravni hormonov, okrepljenega vnosa hranil, spremembe telesne strukture in večje samozavesti (Shephard, 1997). Prva kvazi-eksperimentalna študija je bila izvedena v Kanadi, v regiji Trois-Rivières (Québec) med letoma 1970 in 1977, v katero je bilo vključenih 546 učencev. Ugotovili so, da imajo učenci, ki sodelujejo pri poskusnih petih urah športne vzgoje na teden, višji učni uspeh kot njihovi sošolci iz kontrolne skupine, ki so bili vključeni le v eno uro športne vzgoje na teden (Shephard, Volle, Lavallée idr. 1984). V korist dodatni gibalni aktivnosti je bilo v šolskem predmetniku potrebno odvzeti nekaj minut nekaterim drugim predmetom (povprečno 14 %), ki bazirajo na teoretičnem poučevanju. V Južni Avstraliji so na vzorcu 500-ih učencev, starih 10 let, izvedli raziskavo, v kateri so bili učenci deležni dodatnih 60 minut športne vzgoje dnevno. Po prvih štirinajstih tednih raziskave je eksperimentalna skupina pokazala boljše delovne sposobnosti in zmanjšanje telesne maščobe v primerjavi s kontrolno skupino. Kljub temu da so zmanjšali čas poučevanja pri matematiki in branju ter ga prerazporedili k športni vzgoji, učenci niso bili prikrajšani za učne dosežke. Po dveh letih (n=216) so učenci nakazali trende izboljšanje znanja aritmetike in branja, izboljšanje telesne sestave in pozitivne spremembe obnašanja v razredu (Maynard, Coonan, Worsely idr. 1987). Projekt *Action School BC!* je potekal med britansko-kolumbijskimi osnovnošolci, starimi od 9 do 11 let (n=287). Športno vzgojo so poučevale razredne učiteljice. Učenci intervencijskih skupin so bili deležni 47 minut športne vzgoje na teden več kot učenci v kontrolnih šolah. Kljub krajšemu času, ki je namenjen usvajanju teoretičnih znanj, pa se znanje matematike in drugih predmetov pri kontrolni skupini ni spremenilo, pri eksperimentalni pa se je znanje akademskih predmetov izboljšalo. Znanje so izmerili s *Canadian Achievement test-om* (Ahamed, Macdonald, Reed idr. 2007). Presečne študije na splošno kažejo pozitivno povezavo športne vzgoje z učno uspešnostjo. Nelson in Gordon-Larsen (2006) sta analizirala rezultate iz nacionalne longitudinalne raziskave o zdravju najstnikov. Bolj aktivni učenci, ki dodatno obiskujejo športne in gibalne interesne dejavnosi, dosegajo v šoli boljše rezultate. Predvsem opazen je bil dvig ocen pri predmetih v povezavi z matematiko, logiko in maternim jezikom. S prečno študijo na vzorcu 89-ih učencev so ugotovili, da so učenci z višjim povprečjem ocen tudi gibalno bolj aktivni (Field, Diego & Sanders, 2001).

V Sloveniji se vsako leto izvaja Nacionalno preverjanje znanja – NPZ, ki je namenjeno preverjanju šestošolcev in devetošolcev iz znanja matematike, slovenščine in tretjega predmeta. Vsako šolsko leto se v aprilu izvajajo tudi meritve motoričnih sposobnosti otrok, imenovane Športno-vzgojni karton. Od leta 2010 v Sloveniji poteka projekt, imenovan Zdrav življenjski slog, ki je del izbirnih interesnih vsebin v slovenskem šolskem prostoru. Otroci, vključeni v projekt, imajo lahko do 3 ure tedensko več gibalne aktivnosti kot otroci, ki v projekt niso vključeni. Peternelj, Škof in Strel (2009) so ugotavljali ali obstajajo razlike med akademsko uspešnostjo otrok, ki so vključeni v športne razrede, in med tistimi, ki so vključeni v navadne oddelke. Otroci iz športnih oddelkov so imeli na urniku vsak dan športno vzgojo, njihovo znanje matematike in slovenščine pa je bilo boljše glede na kontrolno skupino. Analiza kovariance je pokazala začetne razlike v skupinah, zato so prišli do zaključka, da je boljši učni uspeh lahko posledica okolja in višje izobrazbe staršev. Meško idr. (2013) so poročali statistično značilne razlike med bolj in manj gibalno aktivnimi devetošolci. Otroci, ki so bolj gibalno aktivni, dosegajo boljši učni uspeh. Planinšeč in Fošnarič (2006) poročata o boljših ocenah iz matematike, slovenščine in naravoslovja pri bolj gibalno aktivnih otrocih.

2 METODE

Namen doktorske disertacije je raziskati povezanost gibalne aktivnosti, gibalnega fitnesa in učnega uspeha slovenskih osnovnošolcev. Disertacija je razdeljena na štiri dele. Prvi del predstavlja pilotno študijo, ki je bila zaradi boljše preglednosti preimenova v »Gibalna aktivnost in učni uspeh slovenskih osnovnošolk«, drugi del predstavlja študija »Subjektivno izmerjena gibalna aktivnost in učni uspeh«, tretji del predstavlja študija »Objektivno izmerjena gibalna aktivnost in učni uspeh« in četrti del predstavlja »Longitudinalna študija.«

1.1 Cilji

1.1.1 Gibalna aktivnost in učni uspeh slovenskih osnovnošolk

Cilj je ugotoviti, kako sta gibalna aktivnost in gibalni fitnes povezana z učnim uspehom deklet v Sloveniji.

1.1.2 Subjektivno izmerjena gibalna aktivnost in učni uspeh

Cilj je izmeriti povprečno gibalno aktivnost slovenskih osnovnošolcev (vprašalniki); izmeriti gibalne sposobnosti, gibalni razvoj in antropometrične vrednosti slovenskih osnovnošolcev; izmeriti in določiti akademsko uspešnost slovenskih osnovnošolcev; poiskati povezave med akademsko uspešnostjo in gibalnim fitnesom slovenskih osnovnošolcev ter poiskati povezave med akademsko uspešnostjo in gibalno aktivnostjo slovenskih osnovnošolcev.

1.1.3 Objektivno izmerjena gibalna aktivnost in učni uspeh

Cilj je izmeriti gibalno aktivnost šestošolcev z merilnikom pospeška; izmeriti gibalne sposobnosti, gibalni razvoj in antropometrične vrednosti slovenskih šestošolcev; poiskati povezave med akademsko uspešnostjo in gibalno aktivnostjo šestošolcev; poiskati razlike v gibalni aktivnosti otrok iz urbanih in ruralnih delov Slovenije ter določiti stopnjo zrelosti in rastnega pospeška na vzrocu slovenskih šestošolcev.

1.1.4 Longitudinalna študija

Cilj je izmeriti gibalno aktivnost otrok v šestem razredu osnovne šole in tri leta kasneje; primerjati povprečno gibalno aktivnost otrok v šestem razredu in tri leta kasneje; izmeriti in izračunati akademsko uspešnost otrok v devetem razredu osnovne šole; primerjati gibalno aktivnost otrok v šestem razredu in 3 leta kasneje; primerjati gibalno aktivnost otrok z učno uspešnostjo ter ugotoviti razlike v akademski uspešnosti in gibalni aktivnosti med otroci iz mest in ruralnih območij Slovenije.

1.2 Hipoteze

1.2.1 Subjektivno izmerjena gibalna aktivnost in učni uspeh

H 1.1: Bolj gibalno aktivni otroci imajo boljše parametre gibalnega fitnesa.

H 1.2: Bolj gibalno aktivni otroci imajo boljši učni uspeh.

H 1.3: Akademsko bolj uspešni otroci imajo boljše motorične sposobnosti.

1.2.2 Objektivno izmerjena gibalna aktivnost in učni uspeh

H 2.1: Bolj gibalno aktivni otroci imajo boljši gibalni fitnes.

H 2.2: Bolj gibalno aktivni otroci imajo boljši učni uspeh.

H 2.3: Otroci iz urbanega okolja so bolj gibalno aktivni kot otroci iz ruralnih območij.

H 2.4: Otroci iz urbanega okolja imajo boljši učni uspeh kot otroci iz ruralnega okolja.

1.2.3 Longitudinalna študija

H 3.1: Otroci so manj gibalno aktivni v 6. razredu kot pa v 9. razredu osnovne šole.

H 3.2: Bolj gibalno aktivni otroci imajo boljši učni uspeh.

H 3.3: Otroci iz ruralnih območij so bolj gibalno aktivni kot otroci iz urbanih območij Slovenije.

1.3 Preiskovanci

V raziskavi »Gibalna aktivnost in učni uspeh slovenskih osnovnošolk« je sodelovalo n=16 deklet, starih 11 in 12 let. Meritve so potekale na Osnovni šoli Ivana Groharja Škofja Loka. V raziskavi »Subjektivno izmerjena gibalna aktivnost in učni uspeh« je sodelovalo n=3728 osnovnošolcev, v »Objektivno izmerjena gibalna aktivnost in učni uspeh« je sodelovalo n=166 otrok in v zadnji, »Longitudinalni študiji« je sodelovalo n=123 otrok. Vzorec zadnjih treh raziskav temelji na začetni platformi raziskave, ki je bila izvedena leta 1970 (Šturm, 1972). Njen namen je bil ugotoviti ključne parametre gibalnih sposobnosti slovenskih šolarjev na reprezentativnem slovenskem vzorcu. Vzorec zajema 11 slovenskih šol iz desetih mest Republike Slovenije: Metlika, Trebnje, Žalec, Ormož, Jesenice, Trbovlje, Izola, Tolmin, Ravne na Koroškem in Ljubljana.

1.4 Postopki

1.4.1 Merski postopki

Motorične sposobnosti učencev so bile izmerjene z motoričnimi testi: stopnjevalni test, stisk pesti, dvig trupa, skok v daljino z mesta, poligon nazaj, flamingo test, predklon sede in dotikanje plošče z roko. Telesne razsežnosti osnovnošolcev so bile določene z merjenjem višine, teže in izračunom indeksa telesne mase. Gibalna aktivnost je bila izmerjena subjektivno z vprašalniki CLASS in SHAPES ter objektivno z merilnikom pospeška ActiGraph GTX3 (ActiGraph LLC, Penascola, FL) in multi-senzorskim merilnikom SenseWear Armband (Bodymedia, Pittsburgh, Pennsylvania). Objektivno merjenje gibalne aktivnosti je potekalo en teden, rezultat pa je bil vključen v nadaljnjo obdelavo, v kolikor je otrok nosil merilnik zaporednih pet dni; od tega dva med vikendom in tri čez teden. Pri objektivnem merjenju gibalne aktivnosti smo sledili pravilom 70/80 (Catellier, Hannan, Murray idr. 2005) in »non-wear time within day« (Troiano, Berrigan, Doddet al. 2008). Metabolični ekvivalent za detekcijo zmerne gibalne aktivnosti je bil nastavljen na 4 MET-e. Akademska uspešnost v raziskavi »Gibalna aktivnost in učni uspeh slovenskih osnovnošolk« je bila določena z oceno iz matematike, slovenščine in naravoslovja, s povprečnim učnim uspehom, v ostalih treh študijah pa samo z oceno iz matematike.

1.4.2 Zbiranje podatkov

Podatki za pilotno študijo so bili zbrani na Osnovni šoli Ivana Groharja Škofja Loka. Podatki o gibalnem fitnesu so bili pridobljeni iz šolske dokumentacije – iz zbirke športno-vzgojnih kartonov. Gibalna aktivnost deklic je bila izmerjena s pospeškometron ActiGraph. Meritve gibalne aktivnosti so potekale en teden, in sicer od srede do srede. Za merjnje gibalne aktivnosti je bila uporabljena 15 sekundna epoha. Akademska uspešnost je bila pridobljena iz šolske dokumentacije, pridobljene pa so bile ocene iz matematike, slovenščine, naravoslovja ter vseh ostalih predmetov z namenom izračuna povprečnega učnega uspeha.

Podatki za študije »Subjektivno izmerjeno gibalno aktivnost in učna uspešnost«, »Objektivno izmerjena gibalna aktivnost in učna uspešnost« ter »Longitudinalna študija« so bili zbrani v sklopu projekta ARTOS. Projekt ARTOS je presečna študija, ki poteka že od leta 1970 (1983, 1993/4, 2003/4, 2013/14, 2016/17) in je ena najstarejših presečnih študij s področja gibalnega fitnesa na svetu. Vodilna raziskovalna ustanova je Fakulteta za šport Univerze v Ljubljani. Študija ARTOS temelji na interdisciplinarnem pristopu, ki vključuje antropologijo, kineziologijo, psihologijo in sociologijo. Velika baza podatkov z rezultati 17-ih različnih fizičnih testov in testov aerobne zmogljivosti, več kot 25-ih testov antropometričnih dimenzij in spremenljivk na področjih psihologije, socialno-ekonomskega statusa ter mnenja staršev o gibalni aktivnosti omogoča različne povezave in primerjave med vsemi spremenljivkami. Za meritve vsakega otroka je bilo pridobljeno soglasje staršev.

1.4.3 Statistična analiza

Zbrani podatki so bili analizirani s programom IBM SPSS Statistics 20.0, IBM SPSS Statistics V22.0, Microsoft Excel 2013, Actilife, SenseWear Professional 6.1 in SenseWear Professional 8.1.

Normalnost porazdelitve je bila pregledana vizualno in s Shapiro-Wilkovim ali Kolmogorov-Smirnovim testom. Za vse spremenljivke so bile izračunane frekvence in deskriptivna statistika. Med spremenljivkami gibalna aktivnost, gibalni fitnes, telesne razsežnosti in akademska uspešnost je bil izračunan korelacijski koeficient. V kolikor je bilo zadoščeno parametričnim testom, je bil uporabljen Pearsonov koeficient korelacije, v nasprotnem primeru pa je bil uporabljen Spearmanov koeficient korelacije. Za določanje razlik med skupinami gibalne aktivnosti, gibalnega fitnesa in akademske uspešnosti je bil uporabljen neparametrični Kruskal-Wallisov test. Mann Whitneyjev test in Bonferronijeva korekcija sta bila uporabljena za določitev medsebojnih razlik testnih skupin. Za ugotavljanje razlik med gibalno aktivnostjo šestošolcev in devetošolcev je bil uporabljen test Wilcoxon Signed Ranks Test in za ugotavljanje razlik med urbanimi in ruralnimi otrocij je bil uporabljen Mann Whitneyjev test.

2 REZULTATI

1.5 Gibalna aktivnost in učni uspeh slovenskih osnovnošolk

Pearsonov koeficient korelacije je pokazal močno in signifikantno povezanost med gibalno aktivnostjo in oceno iz matematike (R= 0,77; p< 0,01), slovenščine (r=0,83; p< 0,01) in povprečno zaključno oceno, ki predstavlja povprečje vseh šolskih ocen (r=0,83; p<0,01). Ocena iz matematike je statistično signifikantna z motoričnimi sposobnostmi skok v daljino z mesta (r=0,75; p<0,01), predklon sede (r=0,70; p<0,01) in s tekom na 600 m (r=-0,72; p<0,01).

1.6 Subjektivno izmerjena gibalna aktivnost in učni uspeh

V študiji "Subjektivno izmerjena gibalna aktivnost in učna uspešnost" je povprečna višina osnovnošolcev 142,42 ± 16,69 cm, povprečna teža 38,91 ± 14,7 kg in indeks telesne mase 18,4 ± 3,57 kg/m^2. Povprečna gibalna aktivnost otrok med tednom je 178,66 ± 164,72 min, med vikendom 134, 03 ± 98,71 min in celokupna gibalna aktivnost je 146,78 ± 103,81. Spearmanov koeficient korelacije je pokazal majhno, ampak značilno povezanost med izobrazbo matere (r= 0,26, p< 0,05), izobrazbo očeta (r= 0,22, p< 0,05) in gibalno aktivnostjo otrok. Materina stopnja izobrazbe je tudi pozitivno povezana z gibalno aktivnosjo otrok (r=0,10, p<0,05). Kruskal-Wallisov test je pokazal, da obstajajo statistično značilne razlike med skupinami gibalne aktivnosti, motoričnimi testi ter merami antropometrije (flamingo test, stistk pesti, dvig trupa, stopnjevalni tek, teža, višina in indeks telesne mase). Mann Whitneyjev test pa je pokazal, da imajo otroci z nizko gibalno aktivnostjo značilno slabše rezultate pri stisku pesti (ES=0,10), dvigu trupa (ES=0,21), višini (ES=0,12), teži (ES=0,12) in indeksu telesne mase kot zelo gibalno aktivni otroci. Otroci, ki so bolj gibalno aktivni, imajo boljše rezultate gibalnega fitnesa, **zato smo hipotezo 1.1 potrdili**.

Spearmanov koeficient korelacije ni pokazal povezanosti med gibalno aktivnostjo in akademsko uspešnostjo, Kruskal-Wallisov test pa ni pokazal razlik med skupinami gibalne aktivnosti in akademsko uspešnostjo otrok, zato je bila **hipoteza 1.2. ovržena.**

Spearmanov koeficient korelacije je pokazal statistično značilno povezanost med gibalnimi testi in akademsko uspešnostjo. Med akademsko uspešnostjo in skokom v daljino z mesta (r=0,07; p<0,05), flamingo testom (-0,13; p<0,01), stiskom pesti (r=-0,01; p<0,01), dvigom trupa mlajši (r=0,13; p<0,01), dvigom trupa starejši (r=0,18; p<0,00), poligonom nazaj (r=-0,09; p<0,01) ter predklonom sede (r=0,09; p<0,01) obstaja statistično signifikantna korelacija. Kruskal-Wallisov test je pokazal, da so otroci z nizko akademsko uspešnostjo statistično boljši pri stisku pesti (Z = -3.096, p <0,0167) kot otroci z normalno akademsko uspešnostjo (ES=0,10). Otroci z normalno akademsko uspešnostjo so boljši pri motoričnih testih dvig trupa (Z=-2,75; p<0,05) kot otroci z nizkim učnim uspehom (ES=0,09). Otroci z visoko akademsko uspešnostjo so boljši kot otroci z nizko akademsko uspešnostjo pri motoričnih testih: flamingo test (Z=-3,29; p<0,05; ES=0,15), dvig trupa mlajši (Z=4,66; p<0,05; ES=0,16), dvig trupa starejši (Z=-6,33, p<0,05; ES=0,21) in poligon nazaj (Z=-3,064, p<0,05; ES=0,10). Otroci z nizkim učnim uspehom so bili boljši (ES=0,15) v stisku pesti (Z=-2,82, p<0,05) od otrok z visoko učno uspešnostjo. Otroci z visoko akademsko uspešnostjo so signifikantno boljši pri dvigih trupa mlajši (Z=-4,66, p<0,05; ES=0,17) in dvigu trupa starejši (Z=-6,33; p<0,05; ES=0,22) kot otroci z normalno akademsko uspešnostjo. Akademsko bolj uspešni otroci so boljši v koordinaciji (poligon nazaj), repetitivni moči (dvig trupa) in ravnotežju (flamingo test). Akademsko slabši otroci so boljši v mišični moči (stisk pesti). **Hipoteza 1.3 je bila delno potrjena.**

1.7 Objektivno izmerjena gibalna aktivnost in učni uspeh

Povprečna gibalna aktivnost šestošolcev je 141,83 $\pm$ 7,37 min. Spearmanov koeficient korelacije ni pokazal statistično značilne povezanosti med gibalnim fitnesom in gibalno aktivnostjo. Kruskal-Wallisov test ni pokazal statistično značilnih razlik med gibalnim fitnesom in gibalno aktivnostjo. **Hipteza 2.1. je bila ovržena**.

Spearmanov korelacijski koeficient je pokazal signifikantno povezanost med akademsko uspešnostjo in gibalno aktivnostjo (r=0,24; p<0,046). Obstaja značilna (p< 0,05) in velika razlika (ES= 0,39) v učnem uspehu med normalno in zelo gibalno aktivnimi otroci, zato je bila **hipoteza 2.2 ovržena.**

Otroci iz predstolnice so na dan gibalno aktivni 162,07 ± 157,7 min, otroci iz ostalih mest pa 137,7 ± 75,6 min. Mann Whitneyjev U test ni pokazal značilnih razlik med gibalno aktivnostjo otrok iz Ljubljane in ostalih mest. **Hipoteza 2.3 je bila ovržena**.

Otroci iz predstolnice imajo povprečno oceno iz matematike 4,25 + 0,85; otroci iz ostalh mest pa 3,56 + 1,16. Mann-Whitneyjev test je pokazal statistično značilne razlike v gibalni aktivnosti (ES= 0,29) med otroki iz prestolnice in otroki iz drugih mest (-2,38; p< 0,05). Otroci iz Ljubljane so boljši pri matematiki v primerjavi z otroki iz drugih slovenskih mest, zato smo **hipotezo 2.4 sprejeli.**

1.8 Longitudinalna študija

V 6. razredu osnovne šole so otroci aktivni 138,89 ± 73,19 min in v 9. razredu osnovne šole 61,97 ± 144,04 min v 9. razredu osnovne šole. Povprečna ocena iz matematike za vzorec n=123 otrok znaša 4,14 + 0,99 v 6. razredu osnovne šole in 3,64 ± 1,01 v 9. razredu osnovne šole. Wilcoxon Signed Rank test je pokazal, da obstajajo značilne razlike med gibalno aktivnostjo otrok v 6. in 9. razredu osnovne šole (Z=-7,343, p<0,05). 104 otroci so bili manj gibalno aktivni v 9. razredu, le 19 pa jih je bilo bolj gibalno aktivnih v 9. razredu. **Hipoteza 3.1 je bila sprejeta.**

Spearmanov koeficient korelacije ni pokazal značilne povezanosti med gibalno aktivnostjo in akademsko uspešnostjo otrok, zato je bila **hipoteza 3.2 ovržena**.

Mann Whitneyjev test je pokazal, da so otroci iz ruralnih področij Slovenije v 6. (U= 1518,5; p< 0,00; ES= 0,27) in 9. (U= 1042,5; p< 0,02; ES= 0,23) razredu osnovne šole bolj gibalno aktivni kot otroci iz urbanih območij Slovenije. Ker so otroci iz ruralnih območij Slovenije bolj gibalno aktivni v 6. razredu ($U=1518,5$; $p<0,00$) in v 9. razredu ($U=1042,5$; $p<0,02$), smo **hipotezo 3.3 sprejeli.**

3 ZAKLJUČEK

Doktorska disertacija predstavlja prvi niz študij, izvedenih v Sloveniji, ki temeljito iščejo povezave med gibalno aktivnostjo, akademsko uspešnostjo in gibalnim fitnesom pri slovenskih osnovnošolcih. Gibalna aktivnost je bila izmerjena s štirimi merskimi instrumenti; subjektivno z vprašalnikoma SHAPES in CLASS ter objektivno z dvema merilnikoma. Rezultati poročajo, da Ministrstvo za šolstvo in šport nameni dovolj pozornosti ruralnim in revnejšim področjem Slovenije, premalo pa starejšim otrokom, ki zaključujejo osnovno šolo. Gibalna aktivnost ob koncu osnovne šole je skoraj za polovico nižja v primerjavi z gibalno aktivnostjo pred vstopom v obdobje adolescence. Slovenija je poročala navišjo oceno za gibalno aktivnost otrok in mladostnikov v primerjavi z 38-imi državami (Tremblay idr. 2016; Sember idr. 2016). Večina slovenskih šolarjev izpolnjuje priporočilo o uri gibalne aktivnosti dnevno. V primerjavi z drugimi državami ima Slovenija zelo dober šolski sistem, v katerem je povprečen petošolec deležen vsaj 41 min gibalne aktivnosti dnevno. Kot je to razvidno iz rezultatov, so gibalna aktivnost, akademska uspešnost in gibalne sposobnosti med sebojno pozitivno povezane, ne smemo pa zanemariti dejstva, da tudi določeni kofaktorji vplivajo na medsebojne povezave, kot so izobrazba staršev, stopnja zrelosti in kraj bivanja.

Na podlagi izpeljanih raziskav in temeljitega pregleda literature sklepamo, da gibalna aktivnost pozitivno vpliva na intelektualni razvoj otroka. Gibalna aktivnost zvišuje aerobno kapaciteto otrok in njihove motorične sposobnosti, kar pa je pozitivno povezano z učenjem, akademsko uspešnostjo in gibalnim fitnesom.