European Journal of Public Health Studies
ISSN: 2668 - 1056
ISSN-L:2668 - 1056
Available on-line at: www.oapub.org/hlt

DOI: 10.46827/ejphs.v5i1.112

Volume 5 | Issue 1 | 2022

PHYSICAL ACTIVITY, PHYSICAL EDUCATION, AND HEALTH BENEFITS IN CHILDREN AND ADOLESCENTS

Konstantinos D. Tambalis[i]
Department of Nutrition and Dietetics,
School of Health Science & Education,
Harokopio University,
Athens, Greece

Abstract:
Physical activity (PA) has a wide range of benefits during childhood and adolescence including maintenance of energy balance and consequently a healthy weight healthy growth, development of the cardiorespiratory and musculoskeletal system, avoidance of cardiovascular disease risk factors (e.g. hypertension, dyslipidemia, diabetes), and the opportunity for social interaction and academic achievement. Also, there is strong evidence that PA is important for children's psychological well-being. These benefits remain unchanged in children of all body mass index categories (e.g. normal, overweight, and obese), and are also independent of gender, age, and health status. Children and adolescents with lower PA levels have a higher prevalence of psychological and emotional distress. In contrast, PA provides an important medium for children and adolescents to be successful and this helps to improve self-esteem, social wellbeing, and self-perceptions of body image and competence. Moreover, children with higher PA levels are also more likely to have better cognitive functioning. The health benefits provided by PA have been observed in several health domains and can be generally placed into three categories: (a) mental, social, and PA benefits during childhood/adolescence; (b) health benefits of childhood PA that carry over to adulthood and; (c) PA 'track' from childhood to adulthood. Because of limitations in the scientific evidence data, it is not achievable to draw definitive conclusions relating to the optimal doses of PA needed to create health benefits in separate health outcomes. Nonetheless, worldwide recommendations proposed that significant health benefits can be expected to build up to most children and adolescents who participate in 60 or more minutes of moderate to vigorous PA, per day. Moreover, must be included specific types of PA in an overall PA pattern to add comprehensive health benefits.

Keywords: physical activity, physical education, health benefits, children, adolescents

[i] Correspondence: email dp425603@hua.gr

1. Introduction

PA, and PA at or near the home and PA connected with transport. Children can be physically active in a lot of different ways, at any time of day. PA, health, and quality of life are strongly interrelated. According to Hippocrates (Greek ancient doctor and philosopher), the human body was designed to move and therefore regular PA is needed to function optimally and keep away from illness and diseases. Chronic diseases (such as cardiovascular, diabetes, osteoporosis, etc.) are affecting millions of adults throughout the world and are the first cause of death in developed countries. It is now well documented that physical inactivity is a major risk factor for developing chronic diseases, including obesity, coronary heart disease, and diabetes (1). Chronic disease factors, such as a sedentary lifestyle, are present not only in adults but also in young children (2). Increasing the incidence of these diseases is directly linked to changes in lifestyle in modern societies and more in particular physical activity behaviors, eating habits, and smoking (3). However, the configuration of these behaviors seems to start already from childhood and be affected both by the attitudes and habits of the social environment (family members, friends, teachers, school, e.tc.) as well as by behaviors promoted by the Media. Children and adolescents don't usually develop chronic diseases, such as heart disease, hypertension, type-2 diabetes, or osteoporosis, but research data has revealed that less physically active children are more expected to possess risk factors for this disease such as a lower level of HDL cholesterol, higher blood pressure, increased insulin levels and excess fat (1, 4-5). Given that pathogenicity has its roots in childhood, it is done it was easy to see that the need for interventions at that time was of great importance, to change the attitudes and the best perceptions and changes in lifestyle (nutrition, PA, etc.) beneficial to their health. Regular PA makes it less likely that these risk factors will develop and more likely that children will remain healthy as adults. Therefore, it is essential to promote PA programs early in life to prevent such diseases.

Almost 25% of U.S. children and adolescents (6 to 15-y-old) meet the 2008 PA Guidelines for Americans recommendation of at least 60 minutes of moderate-to-vigorous PA (MVPA) per day (6, 7). Most recent data, from the combined 2012 NHANES and NHANES National Youth Fitness Survey confirmed that 24.8% of adolescents 12- to 15-y-old of age reported daily consumption of 60 minutes of MVPA (8). It seems that meeting the recommendations differs by age, gender, and ethnicity, with males, younger children, and non-white ethnicities being more physically active than their female, older and white ethnicity counterparts (9). Finally, on average, only 20% of children in Organization for Economic Co-operation and Development (OECD) countries participate in moderate to vigorous PA daily (10). It has been speculated that nowadays children expend almost 600 kcal/day fewer than their counterparts 50 years ago (5). There are a plethora of reasons for this and possibly include the following: (a) more sedentary recreational pursuits such as internet/computer games and television viewing which have replaced outdoor playtime; (b) decreased opportunities for active recreational pursuits; (c) less physical education (PE) hours in schools; (d) decreased active transportation to school (e.g. walking, cycling); (e) towns and cities unfamiliar to PA opportunities and not conducive to safe active transport; (f) overprotective parents with the disproportionate worry about children's outdoor protection; (g) a family (e.g. inactive parents) and social environment (school, society) that does not support PA. Are children being adequately physically active today and if there are some important reasons why they avoid it? Child research has shown that among the main limitations and the benefits reported (**Table 1**) by the schoolchildren themselves in terms of PA were (11):

The health benefits provided by PA for both children and adolescents have been observed in several health domains and can be generally placed into three categories:

1) Mental, social, and PA benefits during childhood/adolescence.
2) Health benefits of childhood PA that carry over to adulthood.
3) PA 'track' from childhood to adulthood.

Table 1: Benefits and limitations reported by children and adolescents concerning physical activity

Limitations	Benefits
Preference for in-house activities (preference for TV, video, computer, books, music, etc.)	Social benefits (fun/enjoyment, socializing with friends, enjoying teamwork)
Low levels of energy (feeling tired and inactive, lack of energy, eating fast food)	Improvement of psychological characteristics (self-confidence, discipline development, reduction of guilt)
Limited time (reading, extra-curricular)	Improving body sensation (energy, fatigue reduction, feeling of increased physical strength, endurance, fitness, improved sleep)
Social factors (influence from a social pressure group e.g. friends, lack of parental support, criticism from others)	Improving athletic performance (skill development, reflex improvement, flexibility, coordination, agility, endurance, strength)
Mobilization (non-recurring benefits from exercise	Cognitive benefits (improved concentration and brain function, good memory)
	Response strategies (stress relief, relaxation, way to aggression, frustration, anger)

PA in childhood has a wide range of benefits during childhood including maintenance of energy balance and consequently a healthy weight healthy growth, development of the cardiorespiratory and musculoskeletal system, avoidance of cardiovascular disease risk factors (e.g. hypertension, dyslipidemia, diabetes), and the opportunity for social interaction and academic achievement (**Table 2**) (13). Also, there is strong evidence that PA is important for children's psychological well-being. (13). These benefits remain unchanged in children of all weight classes (normal, overweight, and obese), and are also independent of gender, age, and health status. Children and adolescents with lower PA levels have a higher prevalence of psychological and emotional distress. In contrast, exercise provides an important medium for children and adolescents to be successful and this helps to improve self-esteem, social wellbeing, and self-perceptions of body image and competence. Moreover, children with higher PA levels are also more likely to have better cognitive functioning (**Table 2**) (14). It is of great concern that physical inactivity is contributing to the increasing appearance of obesity, increased insulin resistance, disordered lipid profile, and elevated blood pressure in children. This in turn is probably responsible for the increasing prevalence of type 2 diabetes in children and adolescents, a disease that until recently was usually only found in overweight and obese adults (15).

2. Methods

Studies for this type of review were identified mainly via a systematic search of the electronic database of Pub Med (www.pubmed.gov). In addition to computer investigation, we use previous review articles and references from original articles and related books. Major key words included physical activity, physical education, exercise, health, children, adolescents, obesity, lipids and lipoproteins, type-1 diabetes, type-2 diabetes, cardiovascular, blood pressure, mental health, psychological health. We selected studies which involve the above words by scientific field published in the English language from January 1985 to December 2017.

3. Health Benefits in Childhood/Adolescence

3.1 Obesity

The mechanism of childhood obesity is a complex multifactorial issue including genetic, lifestyle, cultural, and environmental factors. It is well-known that obesity occurs when energy intake exceeds energy expenditure, including calories burned through PA. Genetic factors influence the susceptibility of a given child to obesity promoting environment. Because of this role in energy balance, PA is a critical factor in determining whether children can maintain a healthy body mass or lose excess body fat. Changes in the nutrition habits of children undoubtedly contributed to increasing global levels of childhood overweight/obesity, but experts now believe that decreased PA levels is the main contributor (16). The International Obesity Taskforce (IOTF) included among social habits that are believed to be contributing to the childhood obesity epidemic: (a) the reduction in active transportation to school, (b) decreased opportunities for recreational PA, and (c) increased sedentary recreation and screen time (17). Consequently, lack of sufficient PA level is strongly indicated as a contributor to the problem of childhood obesity (18).

Table 2: Most important health benefits of physical activity in children and adolescents

1. Health benefits in childhood/adolescence
• Maintains energy balance and prevents overweight/obesity
• Decreases risk factors for:
❖ cardiovascular disease (e.g. obesity)
❖ type-2 diabetes
❖ hypertension
❖ dyslipidemia
• Promotes management of type-1 diabetes
• Promotes healthy growth and development of the musculoskeletal system (i.e. bones, muscles, and joints)
• Develops a healthy cardiorespiratory system (i.e. heart and lungs)

• Develops neuromuscular awareness (i.e. coordination and movement control)
• Improves mental health and psychological well-being through:
❖ Reduced anxiety, stress, and depression
❖ Promotes self-esteem
❖ Improved cognitive function and academic performance
❖ Improved sleep
❖ Improves social interaction
2. Health benefits of childhood physical activity that carry over to adulthood
• Reduced probability of overweight/obesity during adulthood
• Reduced probability of morbidity from cardiovascular disease during adulthood
• Increased bone mass/strength reduces the likelihood of osteoporosis in adulthood
3. Physical activity 'track' from childhood to adulthood
• Increased probability of becoming a physically active adult

The prevalence of obesity in children and adolescents has been recognized as a global epidemic (19). In 2012, 16.9% of 2- to 19-year-olds children and adolescents in the U.S. were obese (20). In the European Union, overweight/obese children are expected to rise by 1.3 million per year, with more than 300,000 of them becoming obese every year (21). The relation between PA with overweight/obesity in school-aged children and adolescents has been extensively studied. A review of 31 observational studies, where overweight/obesity was classified using age and gender-specific BMI criteria (e.g., BMI z-scores) incorporated weak to modest relationships between PA and overweight/obesity (22). Specifically, in the total of studies, the median odds ratio for overweight/obesity in the least physically active group relative to the most active group was 1.33. Moreover, it seems that studies that assessed MVPA alone were more strongly and consistently related to obesity compared to the studies that included low-intensity PA within the PA measure. Also, in studies of objectively measured PA, the result indicated significant relation between PA with overweight/obesity that was strong in magnitude. The association between PA with obesity was stronger in males than in females, while it is concluded that a dose-response relation between PA and obesity exists (22). Also, another review showed that children and adolescents of both sexes who participate in relatively high levels of PA had less adiposity than less active ones (1). A review of 24 intervention studies (17 RCTs), which examined several different measures of total and abdominal adiposity, ranging from 4 weeks to 2 years (mean amount 17 to 30 minutes per day) observed significant changes in measures of BMI, total fat, and/or abdominal fat in response to aerobic PA (22). However, the effect sizes, even for the studies that revealed significant improvements, tended to be small (<0.50). Another review in experimental studies of overweight boys and girls involved in systematic PA interventions of moderately intense (30 to 60 minutes in duration, 3 to 7 days per week) found a decrease in total body and visceral adiposity in overweight children and adolescents. Nevertheless, it seems that such programs do not significantly influence the percentage of body fat in normal-weight children and adolescents, while limited evidence indicated that more intensive and longer sessions (>80 minutes/day) are more successful in reducing percentage fatness in normal-weight children (1). Furthermore, a review that examined the evidence on the associations between pedometer-determined PA and adiposity showed consistent evidence of negative associations between walking and adiposity (23). Finally, a meta-analysis of 34 intervention trials (median exercise 3 times/week, 50 min/session over a 12-week period) speculated significant reductions in BMI z-score for aerobic activities and combined aerobic and strength PA, but not strength alone (M±SD, 95% CI: aerobic, -0.10, -0.15 to -0.05; aerobic and strength, -0.11, -0.19 to -0.03; strength, 0.04, -0.07 to 0.15) (24).

PA increases energy expenditure and induces lipolysis, as a result of which the fat mass is decreased, if the energy expended is not compensated for with an augment in caloric intake. The public health significance of PA on childhood obesity is that it could reverse negative consequences of obesity (physiological and psychosocial). For instance, it is of great concern that obese children and adolescents become targets of discrimination and tend to develop a negative self-image, while participation in sports improves their self-esteem. Specifically, PA could positively act in numerous health complications of childhood obesity such as disturbances in blood lipids, glucose intolerance, hypertension, sleep problems, and orthopedic complications (25, 26).

Conclusively, increased levels of PA and reduced sedentary behavior should be the foremost focus of strategies aimed at preventing and treating overweight/obesity in children and adolescents.

3.2 Type-2 Diabetes

Diabetes is a chronic metabolic disease characterized by total or partial insulin deficiency resulting in hyperglycemia. Childhood type-2 diabetes is a disease that affects a child who typically: (a) is overweight or obese (BMI ≥85th–94th and >95th percentile for age and gender, respectively); (b) has a strong family history of type 2 diabetes; (c) has substantial residual insulin secretory capacity at diagnosis; (d) has the insidious onset of disease; (e) demonstrates insulin resistance; and (f) lacks evidence for diabetic autoimmunity (27). The current scientific view (American Diabetes Association criteria) is that diabetes defined as: (a) HbA1c ≥6.5%; or (b) fasting plasma glucose ≥126 mg/dL (7.0 mmol/L); or (c) 2-hour plasma glucose ≥200 mg/dL (11.1 mmol/L) during an oral glucose tolerance test; or (d) a random plasma glucose ≥200 mg/dL (11.1 mmol/L) with symptoms of hyperglycemia. The history of fluctuation in serum glucose levels can be measured with glycosylated hemoglobin. People with diabetes have an increased risk of developing complications in microcirculation such as retinopathy, nephropathy as well as major vascular diseases of the nervous system. The pathophysiology of type-2 diabetes remains unresolved and is multifactorial. It is common to believe that the emergence and increasing prevalence of type-2 diabetes in children and adolescents is linked with the increased prevalence of obesity in these age groups. Epidemiological evidence among patients aged 18 years and younger, showing that the admission rate for obesity in English hospitals increased 63.5% from 1996-7 to 2003-4, and the admission rate for type 2 diabetes rose 44.4% during the same period (28). Presently, in the U.S., up to 1 in 3 new cases of type-2 diabetes are diagnosed in youth younger than 18 years and most commonly among children and adolescents between 10 and 19-y-old (27). This increasing trend occurring internationally and it is estimated that by the year 2030, an expected 366 million people worldwide will have type 2 diabetes (29, 30).

A review study of Berman LJ et al., (2012), concluded that PA and cardiorespiratory fitness in youth are both correlated with insulin sensitivity independent of adiposity, especially when PA is at higher intensities (31). In a more recent meta-analysis of Fedewa et al., (2015) that determined the effect of exercise training on predictors of type-2 diabetes in children and adolescents, the researchers incorporated small to moderate effect sizes for PA on fasting insulin providing support for the inclusion of PA targets in lifestyle management programs to prevent type-2 diabetes in youth (32). Although PA is a fundamental issue of weight management for the prevention and treatment of type-2 diabetes, there is a scarcity of available data from children and adolescents with the disease. However, PA is inversely related to insulin resistance and positively associated with insulin sensitivity in young people (33, 34). A review of 8 experimental studies, examined the effect of exercise (ranging from 6 to 40 weeks and including 10-30 min/day) on changes in fasting insulin and insulin resistance, all of the interventions with aerobic exercise had significant improvements in at least one of the insulin variables examined. On the contrary, only one of the four interventions that engaged in resistance exercise incorporated any meaningful improvements. The total effect size measures (95% CI) for fasting insulin in the aerobic and resistance exercise studies were -0.60 (-0.71, 0.50) and -0.31 (-0.82, 0.19), respectively (22).

Exercise improves insulin sensitivity in the trained muscle and muscle contraction-induced glucose uptake in the muscle via increased post-receptor insulin signaling, improved glucose transporter (GLUT4) mRNA and protein, higher glucose synthesis activity, and hexokinase, lower release and higher clearance of free fatty acids, and augmented transport of glucose to the muscles (35). Also, PA increases blood flow and thus induces smooth muscle cell relaxation and vasodilation (35).

In conclusion, the prevention of type-2 diabetes in children and adolescents is possible through sustained lifestyle changes. PA should be recommended to children and adolescents as one component of a healthy lifestyle package designed at preventing and managing type-2 diabetes.

3.3 Type-1 Diabetes

Type-1 diabetes, previously called insulin-dependent diabetes mellitus, develops when the body's immune system destroys pancreatic beta cells, the only cells in the body that make the hormone insulin that regulates blood glucose. This form of diabetes usually strikes children and young adults, although disease onset can occur at any age. Risk factors for type-1 diabetes may be genetic, autoimmune, or environmental. There is no known way to prevent type-1 diabetes (36).

Type-1 diabetes is the most frequent type of diabetes in children and adolescents with a prevalence of 20 to 25 per 100,000 in the United States (37). An epidemiological study in children and adolescents with type 1 diabetes concluded that 90% had poor glycemic control and 80% had low PA levels. Also, fasting blood glucose was significantly correlated with PA levels and sedentary time, while among the three groups of PA levels (insufficient × moderate × active) there were differences in HbA1c, fasting blood glucose, duration of disease, and insulin dose (38). A review study examined the relationship between PA and glycemic control in type-1 diabetes subjects revealed that there were positive influences of PA on long-term glycemic control in type-1 diabetes. Nevertheless, results were contradictory concerning insulin sensitivity and fasting glucose (39). Meta-analysis of 26 PA interventions studies in children and adolescents with type-1 diabetes reported at least one favorable health outcome at follow-up. Specifically, results showed potential benefits of PA on HbA1c (standardized mean difference -0.52, 95% CI -0.97 to -0.07; corresponds to a reduction of 8.5 mmol/mol), BMI (standardized mean difference -0.41, 95% CI -0.70 to -0.12) and triglycerides (mean difference -0.70, 95% CI -1.25 to -0.14). The largest effect size was for total cholesterol (standardized mean difference -0.91, 95% CI -1.66 to -0.17). Moreover, the authors referred that PA interventions improve cardiovascular fitness and increase PA levels (40).

PA improves glucose uptake in the muscle, which is induced by muscle contraction. Total cholesterol in the blood appears to be considered in the development of atherosclerosis, also in patients with type-1 diabetes. PA affects the lipid composition of the blood in an advantageous way (41).

Children with type-1 diabetes have twice the risk of developing cardiovascular disease in comparison with those without the disease. In people with diabetes, cardiovascular disease risk factors (i.e. endothelial dysfunction), can present as early as preadolescence (42). Meta-analyses incorporated significant effects of PA on reductions in BMI, HbA1c, triglycerides, and total cholesterol (43). Therefore, children and adolescents with type 1 diabetes are advised to engage in regular PA with appropriate insulin and dietary control, and the promotion of life-long PA in this population is a priority.

To sum up, PA is essential for type 1 diabetes management in children and adolescents and has the potential to holdup cardiovascular disease.

3.4 Dyslipidemia

Lipids are fats that are either synthesized by the liver or absorbed from food. Although all lipids are physiologically important, triglycerides (TG) and cholesterol (C) contribute most to disease. Several environmental, genetic, and pathological factors can alter cholesterol and triglyceride transfer. Some of these factors are gender, age, fat distribution, diet, inheritance, and PA. When the previous factors are associated with high lipid and lipoproteins levels in the blood is referred to as dyslipidemia. Specifically, dyslipidemia involves elevated total cholesterol (TC) and TG or low-density lipoprotein cholesterol (LDL-C) that are not familial hypercholesterolemia. Normal values for lipids for children and adolescents are defined according to population levels. Gender, age, racial differences, and temporal trends may change these statistical cut points (44).

Data extracted from the National Health and Nutrition Examination Survey in the U.S. has publicized favorable trends in lipoprotein and lipid levels among children and adolescents between 1988-1994 and 2007-2010. Mean values of TC decreased from 165 to 160 mg/dl, and the prevalence of elevated TC decreased from 11.3 to 8.1%. Nevertheless, between 2007 and 2010, roughly 20% of children had either low HDL-C or high non-HDL-C (45). A systematic review suggested that relationships between PA and TC, HDL-C, LDL-C, and TG levels are generally weak in observational studies. Specifically, its results revealed a beneficial effect of PA on HDL-C and TG levels, but no consistent effect on TC or LDL-C levels (1). Results of studies relating lipid and lipoprotein levels to aerobic fitness are contradictory and do not point out a significant association. However, a study on a representative sample of 12 to 19-y-old American adolescents measuring aerobic fitness indicated that unfit girls and boys, were 1.89 and 3.68 times more possible to have high TC compared to moderately and high fit boys and girls, respectively (46). A review of studies examined the effectiveness of lifestyle interventions (including PA) on blood lipids in overweight or/and obese children, found that lifestyle interventions resulted in a significant reduction in TC (−3.5 mg/dL), LDL-C (−11.6 mg/dL), and TG (−13.3 mg/dL), but a non-significant improvement in HDL-C (3.9 mg/dL) (47). Another review that assessed the effectiveness of different PA interventions in obese children incorporated that aerobic PA had a significant effect on LDL-C (−0.49 mg/dL) and TG (− 0.55 mg/dL) (48). Moreover, a review of randomized control trials to children and adolescents with high cholesterol levels or obesity; shows a beneficial effect for aerobic PA on HDL-C and TG levels, but not on total cholesterol or LDL-C levels (22). Finally, a meta-analysis of interventions studies shows that 70% of studies had a beneficial effect on blood lipids. In detail, compared with control, intervention with PA alone or with diet improved lipid measures in children, with a mean reduction of −6.06 mg/dL in LDL-C, an increase of 1.87 mg/dL in HDL-C, and non-significant reductions in TC and TG (49).

PA improves the ability of skeletal muscles to better utilize fat instead of glycogen. This is achieved by the activation of several enzymes in the muscle needed for lipid turnover (50). Dyslipidemia is a significant modifiable risk factor for cardiovascular diseases. Serum lipid concentrations in childhood and adolescence (e.g. TC, and LDL-C) are linked with serum lipid concentrations in adulthood. There is agreement that PA protects against the development of cardiovascular diseases and it has been recommended that one of many possible mechanisms could be a positive effect of PA on the lipid profile of the blood.

In summary, PA influences positively lipid profile in children and adolescents. The dose-response relation between PA/exercise and blood lipids remains unclear. The studies that concluded favorable effects on blood lipids did not tend to prescribe higher volumes or intensities of exercise compared to those that did not produce significant changes. Favorable interventions based on 'high risk' participants (e.g. obese) imply that low volumes of MVPA may be beneficial for adolescents at the greatest risk.

3.5 High Blood Pressure

Hypertension in children and adolescents consist a crucial health problem in the developed world. Even though is believed to be usually secondary to vascular, renal, or endocrine causes, primary hypertension is becoming the most common form seen in childhood. The obesity epidemic is strongly associated with increasing prevalence rates of elevated blood pressure. The assessment of high blood pressure in children and adolescents is more involved than in adults and is aimed both at identifying secondary causes and to identify other co-morbidities of cardiovascular risk. Treatment of High blood pressure in childhood and adolescence is aimed at reducing cardiovascular risk (51).

In the U.S. the prevalence of elevated blood pressure (DBP≥ 90th percentile or SBP/DBP≥ 120/80 mmHg) increased considerably from NHANES III (1988-1994) to NHANES 1998-2008 (Boys: 15.8% to 19.2%; Girls: 8.2% to 12.6%) (52).

Review in 3 observational studies found that the associations between PA and hypertension were weak in magnitude (e.g., odds ratios<1.5). Moreover, in one of these studies, children within the least fit quartile were more probable to have hypertension compared to children in the fittest quartile, in boys and girls (22). In another review, findings proposed a dose-response association (stronger in overweight children) between aerobic fitness and blood pressure, but no association between self-reported sports participation and blood pressure (4). The evidence supports the efficacy of PA/exercise to decrease blood pressure in normotensive youth is weak. Specifically, meta-analysis and comprehensive review incorporated no clear association between PA and decrease of blood pressure in normotensive youth (1, 53). Experimental studies in children and adolescents with high blood pressure or obesity reported significant decreases in systolic blood pressure in response to aerobic PA, with large effect sizes (>0.80), and significant reductions (~6% to 11%) in diastolic blood pressure. Moreover, studies that employed resistance exercise, also reported a significant effect on blood pressure, with small to modest effect sizes being observed (22). Furthermore, 8 months of aerobic PA in both hypertensive and normotensive overweight children showed a decrease in systolic and diastolic blood pressures in the exercising subgroups of 6.5- and 4.1-mm Hg, respectively, in the normotensive, and 4.9- and 3.8-mm Hg, respectively, in the hypertensive ones (54). On the whole, data suggest that a PA intervention lasting at least 30 minutes, 3 times per week, and sufficient to improve aerobic fitness could reduce blood pressure in youth with mild essential hypertension, while, continued PA is needed to maintain the beneficial effect (1).

The beneficial effect of PA on children's blood pressure is considered to be multifactorial (not yet well known) and independent of weight loss. The mechanisms of blood pressure-lowering include vascular, neuro-hormonal, and structural adaptations. It is hypothesized that structured PA acts on several mechanisms involved in the onset of hypertension, determining a decrease in insulin resistance and hyperinsulinemia and beneficial adaptation of the cardiovascular system (reduction in sympathetic tone, reduction in arterial stiffness, and reduction in endothelial dysfunction). Moreover, it seems that a decrease in body weight, due to an increase in PA expenditure, can cause a reduction in blood pressure of 8–12 mmHg (55).

The prevention and treatment of primary hypertension in children and adolescents is based on an intervention strategy on modifiable risk factors. Among these included: overweight, diet, salt intake, sedentary behavior, and bad sleep quality. PA may exert a potential effect on overweight, sodium balance, and bad quality of sleep, in consequence acting indirectly on the metabolic mechanisms involved in the development and maintenance of blood pressure, such as deposition and distribution of the fat mass, insulin resistance, activation of the sympathetic nervous system, renin-angiotensin system, sodium homeostasis, regulation of vascular function (55).

In brief, data suggest that PA with duration of at least 30 min, a frequency of 3 times a week, and intensity sufficient to improve aerobic fitness can be effective in reducing blood pressure in children with hypertension.

3.6 Musculoskeletal System

Bone and muscle are two intricately-related tissue types; however, factors such as sex, maturation, PA/exercise acting and level can modify this relationship. Bone mass is a major contributor in determining the risk for osteoporosis later in life. PA helps to maximize bone childhood and adolescence. It also helps children and adolescents promote muscle mass and maintain a healthy weight, which can postpone into adulthood and reduce weight-related wear to joints.

Many factors influence the accumulation of bone minerals during childhood and adolescence, including PA, gender, heredity, diet, endocrine status, and several risk factors (e.g. cigarette smoking). Epidemiological studies have demonstrated a relationship between birth weight, weight in infancy, PA, and adult bone mass. Maternal smoking, diet (particularly vitamin D deficiency), and PA also seem to modulate bone mineral acquisition during intrauterine life; furthermore, both low birth size and poor childhood growth are directly linked to the later risk of hip fracture (56).

The forces associated with muscular contractions during weight-bearing PA and exercises such as strength/resistance training have a favorable influence on skeletal tissue (1). Review research examining factors that influence bone mineral density and content in children and adolescents revealed the positive influence of PA on bone development (57). Prospective studies of children with varying levels of current or past PA indicated a significant influence of PA on skeletal health (1). Moreover, correlation studies relating PA to indicators of muscular strength and endurance in children and adolescents presented a favorable effect, while longitudinal studies of adolescents indicate a positive influence of habitual PA on upper body muscular endurance (1).

Aerobic PA has a small effect on enhancing muscle mass; in contrast, various studies have shown that high-intensity resistance PA induces muscle hypertrophy, which is associated with improvements in muscle strength. In children and adolescents, strength training can increase muscle strength, power, and endurance is now recommended as safe and proper for enhancing physical health and function (58, 59). A review study in interventions trials indicated those 10 minutes of moderate-to-high intensity weight-bearing PA performed on 2 or 3 days of the week can produce a beneficial effect on bone mineral density (22). Moreover, experimental studies involving programs of 10 to 60 minutes duration of moderate to high-strain weight-bearing PA for 2 to 3 or more days per week give similar results in boys and girls (1). Also, the National Osteoporosis Foundation's position statement referred that 83% of 36 randomized control trials for the effects of PA on bone mineral content reported statistically significant differences between exercise and control groups after the intervention (60).

A functional association between bone and muscle is observed throughout growth, development, and aging. Muscle has long been recognized as the main source of anabolic mechanical stimuli for bone tissue, though the accurate nature of the stimuli (e.g., strain magnitude and frequency) that stimulate bone formation is not clarified. Muscle-derived changes in intramedullary pressure, muscle-derived growth factors, and muscle-derived stem cells are all possible to contribute to bone formation (61). Adaptations of resistance exercise training are due to muscle fiber hypertrophy and neural adaptations, with muscle hypertrophy playing a more significant role in adolescents, especially in males.

PA may decrease osteoporosis-related fracture risk by improving muscle strength, flexibility, coordination, and balance, by enhancing bone mineral accrual during development; by enhancing bone strength; and by decreasing the risk of falls (62). Early puberty is a key developmental period. Approximately 26% of the mineral content in the adult skeleton is accrued during the 2 years around the time of peak height velocity. This amount of mineral accrual represents approximately the same amount of bone mineral that most people will lose in their entire adult lives (60).

Conclusively, bone is most responsive to PA that is dynamic, moderate to high in load magnitude, short in load duration, and applied quick (63). The load magnitude is produced by impact with the ground (e.g., jumping), impact with an object or muscle power moves such as the lift phase in jumping and vaulting. Although PA is a modifiable factor that contributes to peak bone mass and strength, our understanding of how to quantify the dimensions of PA that are osteogenic (including frequency, intensity, time, and type) is incomplete (60).

3.7 Mental Health (Anxiety, Stress, and Depression)

Indicators of mental health in children and adolescents were delimited to anxiety, depression, and self-concept, but there are several studies of PA and other important aspects of mental health, such as emotional distress, perceived stress, and perceived vigor or exhaustion. Self-concept comprises several domains academic and non-academic, social and emotional, and physical (sport competence, strength or endurance, appearance).

Mental disorders are a serious public health issue and affect approximately 15% of the global burden of disease. Young people are excessively affected by depression, anxiety, and other mental health disorders (64). According to U.S. Public Health Service, (2000), almost 20% of school-age children have a diagnosable mental health disorder, and overweight/obese children are at increased risk (65).

A review of studies on depression and related symptoms used self-reported measures of PA reported small or modest relations between PA and depression (22). Several observational studies have recognized the relationship between PA and mental health but are inadequate to clarify the direction of that association (1). It could be that PA improves mental health, or it could be that people are more physically active when they are mentally healthy. Most possible the relationship is bidirectional. Experimental studies that examined changes in depression, based on aerobic PA, observed significant improvements in at least one depressive symptom measure in response to 8 to 12-week exercise programs, although the effect sizes were small to modest (22). Cross-sectional studies suggest a weak to the moderate positive influence of PA on anxiety and depression symptoms, while this influence varies with the mode of activity (1). Moreover, cross-sectional studies suggest a moderately positive association between PA and physical (sport competence) self-concept. The influence of PA on self-concept may be mediated by mode of activity, with beneficial effects associated with aerobics, aerobics combined with strength/flexibility activities, dance, perceptual-motor, and cognitive-behavioral modifications to augment PA (1). PA has most often been shown to improve mood (64). In addition to reducing symptoms of depression and anxiety, researchers point out that regular PA may help prevent the onset of these conditions (66). The favorable effect of PA on sleep may contribute to mental health (67). The impact of PA on these measures of mental health is moderate, with effect sizes generally ranging from 0.4 to 0.7 (64).

Both physiological and psychological mechanisms clarify the associations of PA with mental health. Physiologically, PA is recognized to elevate the synaptic transmission of monoamines and stimulates the release of endorphins, which have an inhibitory effect on the central nervous system, creating a sense of calm and improved mood (65). Potential psychological mechanisms include (a) distraction from unfavorable stimuli; (b) an increase in self-efficacy; and (c) positive social interactions that can result from quality physical activity programming (68).

To sum up, PA can improve mental health by lessening and preventing conditions such as anxiety, stress, and depression, as well as improving mood and other aspects of well-being. The mental health benefits of physical activity can be experienced by all age groups and genders. Moderate effect sizes have been documented among children and adolescents, however, children with the highest risk of mental illness may experience the most benefit. Poor physical health can impair mood and mental function. Health-related quality of life improves with PA enhancing the sense of well-being (69).

3.8 Cognitive Performance and Academic Achievement

Scientific research in neuroscience has resulted in considerable progress in linking PA to cognitive performance in addition to brain structure and function. Cognitive performance refers to the set of mental processes that contribute to perception, memory, intellect, and action. Academic achievement refers to the extent to which a child/student has achieved his educational goals, commonly measured by examinations or other assessments (i.e., grades) (70).

In the last decades, academic achievement has resulted in a consequence of decreasing opportunities for children and adolescents to be physically active during the school day and beyond. Additionally, there is a general shifting of time in school away from PE to allow for more time on academic subjects, although little evidence supports the idea that more time allocated to the subject matter will translate into improved academic scores (71). On the other side, PA experts have long argued, especially for the necessity of school PA, suggesting that the time spent in PA not only would benefit health but also might contribute to academic performance (72).

A growing body of research suggests that time spent engaged in PA is related not only to a healthier body but also to a healthier mind (73). A review, of 14 correlation studies of PA during the school day, confirmed a positive relationship to academic performance (74). In another review of cross-sectional studies, results showed a positive association between academic performance and PA and physical fitness (1) Moreover, prospective studies examined the changes in cognitive performance observed over time, revealed a positive relationship between PA and cognitive function in children (70). Several studies proposed that the addition of PE to the curriculum results in positive gains in academic performance, while other results also advocate a relative improvement in academic performance per unit of time spent in PA (1). Several data incorporated a positive influence of PA on concentration and memory, while mechanistic studies of cognitive function also suggest a positive effect of PA on intellectual performance (1). A recent meta-analysis concluded that the relations among PA, cognition, brain structure and brain function have generally established promising results with no evidence of deleterious effects. In addition, the same meta-analysis incorporated favorable results derived from cross-sectional and longitudinal studies of PA on academic performance, but the results obtained from controlled experiments were mixed (70).

Animal research stated the neurogenic-reserve hypothesis, which proposes that PA in early life optimizes brain networks concerned in memory and also creates a reserve of precursor cells that influence individuals' learning capabilities throughout the life span (75).

Health is a crucial moderating factor in a child’s ability to learn. It is well accepted that healthy children learn better, and numerous studies have confirmed that health benefits are associated with PA, including psychosocial factors, and cognitive and brain health (1). Given that the brain is responsible for both physical actions and mental processes of the human body, brain health is imperative across the life span. The potential benefits of PA and PE on learning, cognitive performance, and brain function for children and adolescents are essential to understand because these effects may possess a key role in improvements of academic achievement.

In total, a wide range of beneficial psychosocial health outcomes has been associated with PA. The scientific literature suggests that PA has a positive influence on cognitive function as well as brain structure and function (70). Even though results tend to be positive for a relationship between PA and academic achievement, not all outcomes were positive and those that were positive frequently varied among studies (70).

4. Health Benefits of Childhood Physical Activity that Carry Over to Adulthood

Regarding the direct effect of childhood PA on adult health status, the scientific evidence appears to be dependent on the health outcome. PA in childhood can influence adult health status indirectly through encouraging changes in health outcomes in children (76).

Several studies have publicized that childhood obesity tracks into adulthood and it is concerned that obese children have twice the risk of being obese as adults compared to non-obese children (77). Adults who were obese as children carry a risk of poorer health and increased mortality compared with adults who were not obese as children. Moreover, overweight and obesity in youth are also connected to metabolic syndrome in adulthood. Therefore, it seems logical that PA during childhood could be somewhat protective against obesity later in life, as being active as a child/adolescent may contribute to attenuate gains in body mass later in life. Cardiovascular disease has its roots in childhood. Adequate PA level in childhood is likely to carry favorable behavioral and biological effects into later life (78). It has been proposed that maintaining adequate levels of aerobic fitness and PA during childhood reduces the adult risk of cardiovascular disease (79). During the growing years, boys and girls rapidly gain bone mineral density. Peak bone mass is achieved by the age of 20-30 and so attempts to enhance it must concentrate on childhood and adolescence. It has been stated that weight-bearing PA during the growing years, stresses the bones to a greater extent, resulting in the attainment of greater bone mass which is protective against osteoporosis in old age (80).

4.1 Obesity

A longitudinal study that examined changes in self-reported habitual PA concerning changes in fatness from ages 9 to 19 years, found that those classified as physically active during adolescence had smaller gains in BMI and skinfolds than those classified as inactive (81). Moreover, a study in 1,319 boys and girls aged 9-18 years who were followed up for 21 years revealed an indirect effect for adolescent PA acting throughout youth obesity (82). A systematic review concerning childhood predictors of adult obesity suggested that there was suggestive evidence for a protective role of PA in childhood on adult fatness (83). Another review by Wareham et al., (2007), incorporated almost similar results (84).

4.2 Type-2 Diabetes

Risk factors for type-2 diabetes retained from childhood to adulthood predict type-2 diabetes in young adulthood (85). Many of the lifestyle behaviors that accompany these risk factors in adults, such as physical inactivity and poor eating habits have their roots in childhood and adolescence (86). Hence, it could be hypothesized that there is an association between PA in childhood and type-2 diabetes in adulthood, mediated by obesity. An extensive review speculated that type-2 diabetes can be eliminated through moderate diet and lifestyle modifications such as increasing PA and reducing sedentary behaviors (87). In conclusion, there are no convincing data concerning the direct relationship between PA in childhood and type-2 diabetes in adulthood.

4.3 Cardiovascular Disease

In a longitudinal study, Ferreira et al. (2005) examined adolescents aged 13 years and followed up at age 36 years those participants who developed metabolic syndrome had lower levels of fitness and vigorous PA. A review by Hallal et al., (2006), it was incorporated a little relationship between PA in childhood and cardiovascular disease risk factors in adulthood (88). Finally, a previous review demonstrated that participation in sports during childhood is not connected with cardiovascular disease during adulthood (89). In summary, no sufficient data are supporting the direct relationship between PA in childhood and cardiovascular disease in later life.

4.4 Musculoskeletal System

Although, the prevailing aspect is to recognize the importance of childhood exercise as a crucial component of osteoporosis prevention; a review study by MacKelvie et al., (2002) observed that whether improvements in bone mineral and bone strength from exercise in childhood decrease fracture risk in later life is a controversial issue (90, 91). Several retrospective studies proposed a constant effect of exercise on bone mineral density in previously athletes (92, 93). A 14-y follow-up study of 581 children revealed a significant positive association between PA during adolescence and bone mineral density in women (94). Therefore, despite the encouraging findings it remains to be strongly determined if PA effects on the skeletal system carry over from childhood to adulthood.

Detecting relationships between childhood PA and adult health is quite difficult and the evidence base deteriorates. Decreasing a range of sedentary behaviors and increasing PA levels may be an efficient strategy in the management of overweight/obesity in children and adolescents and their health consequences as an adult. Furthermore, PA should be encouraged among children and adolescents as one factor of lifestyle habits aimed at preventing type 2 diabetes, later in life. Also, the presented positive effects of PA on skeletal health, especially in the early pubertal stage, maybe represent an advantageous opportunity for improved bone development. Finally, a quality PA experience could be promoting psychological well-being in adulthood in many ways.

In conclusion, there is deteriorated evidence that childhood PA straightforwardly influences health in adulthood. However, specific health indicators such as obesity and bone mineral density do track from childhood to adulthood; consequently, childhood PA may have an indirect effect on adult health.

5. Physical Activity 'Track' from Childhood to Adulthood

Several public health interventions focused on children and adolescents are based on the principle that healthy behaviors established in childhood will persist later in life (76). There is a growing body of scientific evidence that suggests that the PA habits established during childhood and adolescence tend to track into later life (95-97). It is of great concern that children who emerge from their first years of life feeling confident about their physical skills and have had encouraging experiences of PA, are more possible to be physically active through adulthood. Negative attitudes gained as a child may persist into adulthood and affect people's willingness to participate in PA. Undoubtedly, the way PA and exercise are experienced in childhood and adolescence impacts subsequent participation as an adult (98). It seems that the association between childhood PA and adult health becomes more apparent as numerous of the health outcomes (e.g., BMI) linked with PA track from childhood into adulthood (99).

A study that examined the tracking of PA between adolescence and adulthood in a cohort who were followed at 3-year intervals for 9–12 years to 21, 24, 27, and 30 years, showed moderate correlations, with the highest correlations for 3-year intervals and declining as the interval increased (96). Several reviews examined tracking of PA incorporated that tracking through childhood, appears relatively good, but small to moderate relationships between childhood and adolescent PA and health and adult PA and health (76, 100, 101). Another systematic review of adolescent PA and health speculated a consistent effect of PA during adolescence on adult PA; however, the extent of this association is moderate (88). Moreover, several studies reported stronger associations between PA in childhood and PA in adulthood when the quality of the PA in childhood, rather than the quantity, is taken into consideration (96, 98, 102). The above finding supports the importance of the nature of the PA; as if tracking does exist it is probably due to the quality of PA in childhood rather than involvement per se.

It is strongly suggested that regular PA during childhood and adolescence may be of increased importance in the prevention of chronic disease later in life. In particular, the promotion of more PA and PE, especially in the school setting, is estimated to result in psychosocially healthier children who are more possible to engage in PA in adulthood (99).

In brief, the literature on tracking shows that PA does ‘track’ from childhood to adulthood, but at relatively low levels. However, it is essential to consider the significant methodological limitations of the tracking literature. Overall: (a) PA tracks within childhood at moderate levels; (b) tracking from childhood/adolescence into adulthood is small. It is difficult to determine whether this is due to a true effect or is attributable to measurement problems; (c) tracking is likely to be strengthened by increasing the quality of the PA experience.

6. Recommendations

The referred guidelines have been adopted by governmental public health bodies in several countries including the United States (Centers for Disease Control and Prevention, American Center of Sports Medicine), United Kingdom (Department of Health), and Australia (Department of Health and Ageing) (103-106). The current recommendations are:

a) Children and adolescents should be accumulating at least 60 minutes of moderate-to-vigorous intensity PA, daily;
b) At least three days a week, as part of children’s daily sixty (60) minutes of PA, it should include activities to improve bone health and muscle strength;
c) In children’s PA, most of the sixty (60) or more minutes per day should be either moderate- or vigorous-intensity aerobic PA;
d) To achieve additional health benefits, children should engage in more activity – up to several hours per day;

e) Children's daily PA does not have to be done all in one go. The sixty (60) minutes can be accumulated with shorter bouts throughout the day.

It is important to encourage children to participate in PAs that are appropriate for their age, that is enjoyable, and that offer variety. Moreover, it is of great concern to understand that this PA guideline refers to the minimum levels recommended for children and adolescents for health. As considered above, increases in PA above those recommended will result in further health benefits for the majority of children and adolescents. Children can meet the 60-minute target through the accumulation of bouts of activity of varying duration and types all day. This can include short intermittent bouts of PA or longer bouts as play during breaks at school, walking to and from school, and programmed activity such as PE, sport, or games. It is well-known that PA involving moderate to vigorous intensity improves cardiorespiratory fitness, while, all movement that involves carrying body weight (e.g. walking) help children and adolescents to maintain energy balance. Targeting bone health, children must engage in bouts of bone-strengthening activities that create high physical forces on the bones and joints (e.g. running, jumping, skipping, ball games, and gymnastics). To develop and maintain muscular fitness and flexibility it should participate in active play involving carrying, climbing, or in sports. It concluded that a wide range of different modes and intensities of physical activity can provide a total of health benefits across all body systems. Adolescents are probable to meet the recommended PA levels through a quite different range of activities such as walking to and from school, organized sports and games, exercise classes in school, and recreational activities. To make lifetime PA an attractive view to children and adolescents, it is significant that the PE program facilitates them to experience enjoyment in an extensive range of activities, to feel confident about their bodies, and to appreciate the benefits of PA for health. Specifically, PE is globally recommended as crucial as it provides cognitive content and instruction designed to develop behaviors, motor skills and knowledge to enhance PA and exercise (107). Regular participation in PE acts as an aim intended to make possible the establishment of engagement in PA. Several studies planned to quantify the health benefits of PE during the school day concluded that among health benefits incorporated elevated levels of physical fitness, decreased adiposity, and reduced risk for cardiovascular disease (108, 109). Also, a study investigating the effects of daily PE in elementary school on PA during adulthood showed that PE was associated with PA in later life (97), while several longitudinal studies concluded that PE experiences may be correlated to adult engagement in PA (72, 96, 97, 99, 101).

7. Conclusion

The current review of the scientific literature supports the notion that PA provides significant health benefits for children and adolescents. The most recognized health benefits include healthy growth and development of the musculoskeletal and cardiorespiratory systems, decreased body fatness, favorable cardiovascular and metabolic disease risk profiles (type 2 diabetes, blood pressure, lipid), better bone health, reduced symptoms of anxiety, depression, and stress and increased opportunity for social interaction, and academic achievement. Moreover, it seems that adequate PA level in childhood is probable to carry favorable behavioral and biological effects into later life, while PA does 'track' from childhood to adulthood, although at relatively low levels. The amounts and types of PA required creating health benefits vary across the health outcomes in children and adolescents. Accordingly, because of limitations in the scientific evidence data, it is not achievable to draw definitive conclusions relating to the optimal doses of PA needed to create health benefits in separate health outcomes. Nonetheless, worldwide recommendations proposed that significant health benefits can be expected to build up to most children and adolescents who participate in 60 or more minutes of moderate to vigorous physical activity, per day. Moreover, must be included specific types of physical activity in an overall physical activity pattern for children and adolescents to add comprehensive health benefits. Specifically, participation in muscle-strengthening physical activity to improve muscular strength, vigorous aerobic physical activity to promote cardiorespiratory fitness and cardiovascular and metabolic disease risk factors, and bone-strengthening physical activity to enhance bone health, 3 or more days per week for 60 minutes or more per day. It is of great concern that children should encourage physical activity patterns that allow them to attain health benefits long-lasting as well as support them to continue a physically active lifestyle later in life. In this final section, the main find outs are concisely reiterated. Only conclusions supported by the study findings should be included.

Conflict of Interest Statement

The author declares no conflicts of interests.

About the Author

Konstantinos D. Tambalis, (MSc, MSc, PhD) is a Research and Teaching Associate at the Department of Nutrition and Dietetics of the Harokopio University in Greece. His research interests are in the areas of Physical Education, epidemiology of exercise, and athletic nutrition.

References

1. Strong WB, Malina RM, Blimkie CJ, Daniels SR, Dishman RK, Gutin B, et al., 2005 Evidence based physical activity for school-age youth. Journal of Pediatrics 146(6): 732-737. doi: 10.1016/j.jpeds.2005.01.055.
2. Blair NJ, Thompson JM, Black PN, Becroft DM, Clark PM, Han DY, et al., 2007. Risk factors for obesity in 7-year-old European children: the Auckland Birthweight Collaborative Study. Archives of Disease in Childhood 92(10): 866-871. doi: 10.1136/adc.2007.116855.
3. Seppala T, Hankonen N, Korkiakangas E, Ruusuvuori J, Laitinen J, 2017. National policies for the promotion of physical activity and healthy nutrition in the

workplace context: a behaviour change wheel guided content analysis of policy papers in Finland. BMC Public Health 18(1): 87. doi: 10.1186/s12889-017-4574-3.
4. Andersen LB, Wedderkopp N, Hansen HS, Cooper AR, Froberg K, 2003. Biological cardiovascular risk factors cluster in Danish children and adolescents: the European Youth Heart Study. Preventive Medicine 37(4): 363-367. doi: 10.1016/s0091-7435(03)00145-2.
5. Boreham C, Riddoch C, 2001. The physical activity, fitness and health of children. Journal of Sports Sciences 19(12): 915-929. doi: 10.1080/026404101317108426.
6. Song M, Carroll DD, Fulton JE, 2013. Meeting the 2008 physical activity guidelines for Americans among U.S. youth. American Journal of Preventive Medicine 44(3): 216-222. doi: 10.1016/j.amepre.2012.11.016.
7. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M, 2008. Physical activity in the United States measured by accelerometer. Medicine and Science in Sports and Exercise 40(1): 181-188. doi: 10.1249/mss.0b013e31815a51b3.
8. Fakhouri TH, Hughes JP, Burt VL, Song M, Fulton JE, Ogden CL, 2014. Physical activity in U.S. youth aged 12-15 years, 2012. NCHS Data Brief 2014(141): 1-8.
9. Belcher BR, Berrigan D, Dodd KW, Emken BA, Chou CP, Spruijt-Metz D, 2010. Physical activity in US youth: effect of race/ethnicity, age, gender, and weight status. Medicine and Science in Sports and Exercise 42(12): 2211-2221. doi: 10.1249/MSS.0b013e3181e1fba9.
10. System YRBS. Centers for Disease Control and Prevention, National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention (CDC/NCHHSTP). 2014. Accessed 24 December 2021
11. O'Dea JA, 2003. Why do kids eat healthful food? Perceived benefits of and barriers to healthful eating and physical activity among children and adolescents. Journal of the American Dietetic Association 103(4): 497-501. doi: 10.1053/jada.2003.50064.
12. Riddoch CJ, Boreham CAG, 1995. The Health-Related Physical Activity of Children. Sports Medicine 19: 86–102. https://doi.org/10.2165/00007256-199519020-00002.
13. Loprinzi PD, Cardinal BJ, Loprinzi KL, Lee H, 2012. Benefits and environmental determinants of physical activity in children and adolescents. Obesity Facts 5(4): 597-610. doi: 10.1159/000342684.
14. Khan NA, Hillman CH, 2014. The relation of childhood physical activity and aerobic fitness to brain function and cognition: a review. Pediatric Exercise Science 26(2): 138-146. doi: 10.1123/pes.2013-0125.
15. American Diabetes Association, 2000. Type 2 diabetes in children and adolescents. American Diabetes Association. Diabetes Care 23(3): 381-389. doi: 10.2337/diacare.23.3.381.
16. Brown CL, Halvorson EE, Cohen GM, Lazorick S, Skelton JA, 2015. Addressing Childhood Obesity: Opportunities for Prevention. Pediatric Clinics of North America 62(5):1241-1261. doi: 10.1016/j.pcl.2015.05.013.

17. Lobstein T, Baur L, Uauy R, IASO International Obesity Task Force. Obesity in children and young people: a crisis in public health. Obesity Reviews 5(Suppl 1): 4-104. doi: 10.1111/j.1467-789X.2004.00133.x.
18. Janssen I, Katzmarzyk PT, Boyce WF, Vereecken C, Mulvihill C, Roberts C, et al., 2005. Comparison of overweight and obesity prevalence in school-aged youth from 34 countries and their relationships with physical activity and dietary patterns. Obesity Reviews 6(2):123-132. doi: 10.1111/j.1467-789X.2005.00176.x.
19. James WP, 2008. The epidemiology of obesity: the size of the problem. Journal of Internal Medicine 263(4): 336-352. doi: 10.1111/j.1365-2796.2008.01922.x.
20. Ogden CL, Carroll MD, Kit BK, Flegal KM, 2014. Prevalence of childhood and adult obesity in the United States, 2011-2012. JAMA 311(8): 806-814. doi: 10.1001/jama.2014.732.
21. Kosti RI, Panagiotakos DB, 2006. The epidemic of obesity in children and adolescents in the world. Central European Journal of Public Health 14(4):151-159. doi: 10.21101/cejph.a3398.
22. Janssen I, Leblanc AG, 2010. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. The International Journal of Behavioral Nutrition and Physical Activity 7: 40. doi: 10.1186/1479-5868-7-40.
23. Miguel-Berges ML, Reilly JJ, Moreno Aznar LA, Jimenez-Pavon D, 2017. Associations Between Pedometer-Determined Physical Activity and Adiposity in Children and Adolescents: Systematic Review. Clinical Journal of Sports Medicine 28(1): 64-75. doi: 10.1097/JSM.0000000000000419.
24. Kelley GA, Kelley KS, Pate RR, 2017. Exercise and BMI z-score in Overweight and Obese Children and Adolescents: A Systematic Review and Network Meta-Analysis of Randomized Trials. Journal of Evidence-Based Medicine 10(2): 108-128. doi: 10.1111/jebm.12228.
25. Dietz WH, 1998. Health consequences of obesity in youth: childhood predictors of adult disease. Pediatrics 101(3 Pt 2): 518-25. PMID: 12224658
26. Rosenbaum M, Leibel RL, 1988. Pathophysiology of childhood obesity. Advances in Pediatrics 35: 73-137. PMID: 3055868
27. Copeland KC, Silverstein J, Moore KR, Prazar GE, Raymer T, Shiffman RN, et al., 2013. Management of newly diagnosed type 2 Diabetes Mellitus (T2DM) in children and adolescents. Pediatrics 131(2): 364-382. doi: 10.1542/peds.2012-3494.
28. Aylin P, Williams S, Bottle A, 2005. Obesity and type 2 diabetes in children, 1996-7 to 2003-4. BMJ 331(7526): 1167. doi: 10.1136/bmj.331.7526.1167.
29. Narayan KM, Williams R, 2009. Diabetes--a global problem needing global solutions. Primary Care Diabetes 3(1): 3-4. doi: 10.1016/j.pcd.2008.12.001.
30. Wild S, Roglic G, Green A, Sicree R, King H, 2004. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diabetes Care 27(5): 1047-1053. doi: 10.2337/diacare.27.5.1047.
31. Berman LJ, Weigensberg MJ, Spruijt-Metz D, 2012. Physical activity is related to insulin sensitivity in children and adolescents, independent of adiposity: a review

of the literature. Diabetes Metabolism Research and Reviews 28(5): 395-408. doi: 10.1002/dmrr.2292

32. Fedewa MV, Gist NH, Evans EM, Dishman RK, 2014. Exercise and insulin resistance in youth: a meta-analysis. Pediatrics 133(1): e163-174. doi: 10.1542/peds.2013-2718.
33. Imperatore G, Cheng YJ, Williams DE, Fulton J, Gregg EW, 2006. Physical activity, cardiovascular fitness, and insulin sensitivity among U.S. adolescents: the National Health and Nutrition Examination Survey, 1999-2002. Diabetes Care 29(7):1567-1572. doi: 10.2337/dc06-0426.
34. Kasa-Vubu JZ, Lee CC, Rosenthal A, Singer K, Halter JB, 2005. Cardiovascular fitness and exercise as determinants of insulin resistance in postpubertal adolescent females. Journal of Clinical Endocrinology and Metabolism 90(2): 849-854. doi: 10.1210/jc.2004-0455.
35. Pedersen BK, Saltin B, 2015. Exercise as medicine - evidence for prescribing exercise as therapy in 26 different chronic diseases. Scandinavian Journal of Medicine and Science in Sports 25 (Suppl 3): 1-72. doi: 10.1111/sms.12581.
36. Prevention, CfDCa, 2011. National diabetes fact sheet, 2011. Fast facts on diabetes. Atlanta, GA: U.S. Department of Health and Human Services. Accessed 29 December 2021
37. Sperling MA, 2014. Pediatric Endocrinology. 4th ed. Philadelphia: Elsevier Saunders. Accessed 24 December 2021
38. Miculis CP, De Campos W, da Silva Boguszweski MC, 2015. Correlation between glycemic control and physical activity level in adolescents and children with type 1 diabetes. Journal of Physical Activity & Health 12(2): 232-237. doi: 10.1123/jpah.2013-0024
39. Lopes Souto D, Paes de Miranda M, 2011. Physical excercises on glycemic control in type 1 diabetes mellitus. Nutricion Hospitalaria 26(3): 425-429. doi: 10.1590/S0212-16112011000300001.
40. Quirk H, Blake H, Tennyson R, Randell TL, Glazebrook C, 2014. Physical activity interventions in children and young people with Type 1 diabetes mellitus: a systematic review with meta-analysis. Diabetic Medicine 31(10): 1163-1173. doi: 10.1111/dme.12531.
41. Kraus WE, Houmard JA, Duscha BD, Knetzger KJ, Wharton MB, McCartney JS, et al., 2002. Effects of the amount and intensity of exercise on plasma lipoproteins. The New England Journal of Medicine 347(19): 1483-1492. doi: 10.1056/NEJMoa020194.
42. Babar GS, Zidan H, Widlansky ME, Das E, Hoffmann RG, Daoud M, Alemzadeh R, 2011. Impaired endothelial function in preadolescent children with type 1 diabetes. Diabetes Care 34(3):681-685. doi: 10.2337/dc10-2134.
43. Kriska AM, LaPorte RE, Patrick SL, Kuller LH, Orchard TJ, 1991. The association of physical activity and diabetic complications in individuals with insulin-dependent diabetes mellitus: the Epidemiology of Diabetes Complications Study-

-VII. Journal of Clinical Epidemiology 44(11): 1207-1214. doi: 10.1016/0895-4356(91)90153-z.
44. Haney EM, Huffman LH, Bougatsos C, Freeman M, Steiner RD, Nelson HD, 2007. Screening and treatment for lipid disorders in children and adolescents: systematic evidence review for the US Preventive Services Task Force. Pediatrics 120(1): e189-214. doi: 10.1542/peds.2006-1801.
45. Chauhan A, Paunikar P, 2014. Update on pediatric hyperlipidemia. Current Opinion in Pediatrics 26(2):252-258. doi: 10.1097/MOP.0000000000000078.
46. Carnethon MR, Gulati M, Greenland P, 2005. Prevalence and cardiovascular disease correlates of low cardiorespiratory fitness in adolescents and adults. JAMA 294(23): 2981-2988. doi: 10.1001/jama.294.23.2981.
47. Ho M, Garnett SP, Baur L, Burrows T, Stewart L, Neve M, Collins C, 2012. Effectiveness of lifestyle interventions in child obesity: systematic review with meta-analysis. Pediatrics 130(6): e1647-1671. doi: 10.1542/peds.2012-1176.
48. Escalante Y, Saavedra JM, Garcia-Hermoso A, Dominguez AM, 2012. Improvement of the lipid profile with exercise in obese children: a systematic review. Preventive Medicine 54(5):293-301. doi: 10.1016/j.ypmed.2012.02.006.
49. Cai L, Wu Y, Cheskin LJ, Wilson RF, Wang Y, 2014. Effect of childhood obesity prevention programmes on blood lipids: a systematic review and meta-analysis. Obesity Reviews 15(12): 933-944. doi: 10.1111/obr.12227.
50. Saltin B, Helge JW, 2000. [Skeletal muscles, physical activity and health]. Der Orthopade 29(11):941-947. doi: 10.1007/s001320050546.
51. Samuels J, Bell C, Samuel J, Swinford R, 2015. Management of Hypertension in Children and Adolescents. Current Cardiology Reports 17(12): 107. doi: 10.1007/s11886-015-0661-1.
52. Rosner B, Cook NR, Daniels S, Falkner B, 2013. Childhood Blood Pressure Trends and Risk Factors for High Blood Pressure: The NHANES Experience 1988-2008. Hypertension 62(2): 247-254. doi: 10.1161/HYPERTENSIONAHA.111.00831.
53. Kelley GA, Kelley KS, Tran ZV, 2003. The effects of exercise on resting blood pressure in children and adolescents: a meta-analysis of randomized controlled trials. Preventive Cardiology 6(1): 8-16. doi: 10.1111/j.1520-037x.2003.01224.x.
54. Hansen HS, Froberg K, Hyldebrandt N, Nielsen JR, 1991. A controlled study of eight months of physical training and reduction of blood pressure in children: the Odense schoolchild study. BMJ 303(6804): 682-685. doi: 10.1136/bmj.303.6804.682.
55. Strambi M, Giussani M, Ambruzzi MA, Brambilla P, Corrado C, Giordano U, et al., 2016. Novelty in hypertension in children and adolescents: focus on hypertension during the first year of life, use and interpretation of ambulatory blood pressure monitoring, role of physical activity in prevention and treatment, simple carbohydrates and uric acid as risk factors. Italian Journal of Pediatrics 42(1): 69. doi: 10.1186/s13052-016-0277-0.
56. Cooper C, Harvey N, Javaid K, Hanson M, Dennison E, 2008. Growth and bone development. Nestle Nutrition Workshop Series Pediatric Program 61: 53-68. doi: 10.1159/000113170.

57. Ondrak KS, Morgan DW, 2007. Physical activity, calcium intake and bone health in children and adolescents. Sports Medicine 37(7): 587-600. doi: 10.2165/00007256-200737070-00003.
58. Behringer M, Vom Heede A, Yue Z, Mester J, 2010. Effects of resistance training in children and adolescents: a meta-analysis. Pediatrics 126(5): e1199-1210. doi: 10.1542/peds.2010-0445.
59. Bernhardt DT, Gomez J, Johnson MD, Martin TJ, Rowland TW, Small E, et al., 2001. Strength training by children and adolescents. Pediatrics 107(6): 1470-1472. doi: 10.1542/peds.107.6.1470.
60. Weaver CM, Gordon CM, Janz KF, Kalkwarf HJ, Lappe JM, Lewis R, et al., 2016. The National Osteoporosis Foundation's position statement on peak bone mass development and lifestyle factors: a systematic review and implementation recommendations. Osteoporos International 27(4): 1281-1386. doi: 10.1007/s00198-015-3440-3.
61. Hamrick M, 2010. JMNI special issue: basic science and mechanisms of muscle-bone interactions. J Musculoskelet Neuronal Interact 10(1): 1-2. PMID: 20190374
62. Kohrt WM, Bloomfield SA, Little KD, Nelson ME, Yingling VR, American College of Sports M. American College of Sports Medicine Position Stand: physical activity and bone health. Medicine and Science in Sports and Exercise 36(11): 1985-1996. doi: 10.1249/01.mss.0000142662.21767.58.
63. Turner CH, Robling AG, 2003. Designing exercise regimens to increase bone strength. Exercise and Sport Sciences Reviews 31(1): 45-50. doi: 10.1097/00003677-200301000-00009.
64. Biddle SJ, Asare M, 2011. Physical activity and mental health in children and adolescents: a review of reviews. British Journal of Sports Medicine 45(11): 886-895. doi: 10.1136/bjsports-2011-090185.
65. Ahn S, Fedewa AL, 2011. A meta-analysis of the relationship between children's physical activity and mental health. Journal of Pediatric Psychology 36(4): 385-397. doi: 10.1093/jpepsy/jsq107.
66. Penedo FJ, Dahn JR, 2005. Exercise and well-being: a review of mental and physical health benefits associated with physical activity. Current Opinion in Psychiatry 18(2): 189-193. doi: 10.1097/00001504-200503000-00013.
67. Dishman RK, Hales DP, Pfeiffer KA, Felton GA, Saunders R, Ward DS, et al., 2006 Physical self-concept and self-esteem mediate cross-sectional relations of physical activity and sport participation with depression symptoms among adolescent girls. Health Psychology 25(3): 396-407. doi: 10.1037/0278-6133.25.3.396.
68. Peluso MA, Guerra de Andrade LH, 2005. Physical activity and mental health: the association between exercise and mood. Clinics (Sao Paulo) 60(1): 61-70. doi: 10.1590/s1807-59322005000100012.
69. McAuley E, Shaffer SM, Rudolph D, 1995. Affective responses to acute exercise in elderly impaired males: the moderating effects of self-efficacy and age. International Journal of Aging & Human Development 41(1):13-27. doi: 10.2190/KAK1-01XJ-CLBL-T1EJ.

70. Donnelly JE, Hillman CH, Castelli D, Etnier JL, Lee S, Tomporowski P, et al., 2016 Physical Activity, Fitness, Cognitive Function, and Academic Achievement in Children: A Systematic Review. Med Sci Sports Exerc 48(6): 1223-1224. doi: 10.1249/MSS.0000000000000966.
71. Pellegrini AD, Smith PK, 1998. Physical activity play: the nature and function of a neglected aspect of playing. Child Development 69(3): 577-598. PMID: 9680672
72. Trudeau F, Shephard RJ, 2008. Physical education, school physical activity, school sports and academic performance. International Journal of Behavioral Nutrition and Physical Activity 5: 10. doi: 10.1186/1479-5868-5-10.
73. Hillman CH, Erickson KI, Kramer AF, 2008. Be smart, exercise your heart: exercise effects on brain and cognition. Nature Reviews Neuroscience 9(1): 58-65. doi: 10.1038/nrn2298.
74. Rasberry CN, Lee SM, Robin L, Laris BA, Russell LA, Coyle KK, et al., 2011. The association between school-based physical activity, including physical education, and academic performance: a systematic review of the literature. Preventive Medicine 52(Suppl 1): S10-20. doi: 10.1016/j.ypmed.2011.01.027.
75. Kempermann G, 2008. The neurogenic reserve hypothesis: what is adult hippocampal neurogenesis good for? Trends in Neuroscience 31(4): 163-169. doi: 10.1016/j.tins.2008.01.002.
76. Malina RM, 2001. Physical activity and fitness: pathways from childhood to adulthood. American Journal of Human Biology 13(2): 162-172. doi: 10.1002/1520-6300(200102/03).
77. Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, Byers T, 1993. Do obese children become obese adults? A review of the literature. Preventive Medicine 22(2): 167-177. doi: 10.1006/pmed.1993.1014.
78. Ortega FB, Ruiz JR, Castillo MJ, Sjostrom M, 2008. Physical fitness in childhood and adolescence: a powerful marker of health. International Journal of Obesity (Lond) 32(1): 1-11. doi: 10.1038/sj.ijo.0803774.
79. Boreham C, Twisk J, Neville C, Savage M, Murray L, Gallagher A, 2002. Associations between physical fitness and activity patterns during adolescence and cardiovascular risk factors in young adulthood: the Northern Ireland Young Hearts Project. International Journal of Sports Medicine 23(Suppl 1): S22-26. doi: 10.1055/s-2002-28457.
80. Bass SL, 2000. The prepubertal years: a uniquely opportune stage of growth when the skeleton is most responsive to exercise? Sports Medicine 30(2): 73-78. doi: 10.2165/00007256-200030020-00001.
81. Kimm SY, Glynn NW, Obarzanek E, Kriska AM, Daniels SR, Barton BA, et al., 2005 Relation between the changes in physical activity and body-mass index during adolescence: a multicentre longitudinal study. Lancet 366(9482): 301-307. doi: 10.1016/S0140-6736(05)66837-7.
82. Yang X, Telama R, Viikari J, Raitakari OT, 2006. Risk of obesity in relation to physical activity tracking from youth to adulthood. Medicine and Science in Sports and Exercise 38(5): 919-925. doi: 10.1249/01.mss.0000218121.19703.f7.

83. Parsons TJ, Power C, Logan S, Summerbell CD, 1999. Childhood predictors of adult obesity: a systematic review. International Journal of Obesity and Related Metabolic Disorders 23(Suppl 8): S1-107. PMID: 10641588.
84. Wareham N, 2007. Physical activity and obesity prevention. Obesity Reviews 8(Suppl 1): 109-114. doi: 10.1111/j.1467-789X.2007.00328.x.
85. Morrison JA, Glueck CJ, Woo JG, Wang P, 2012. Risk factors for cardiovascular disease and type 2 diabetes retained from childhood to adulthood predict adult outcomes: the Princeton LRC Follow-up Study. International Journal of Pediatric Endocrinology 2012(1): 6. doi: 10.1186/1687-9856-2012-6.
86. King A, Fuster V, 2010. Children are key to CVD prevention. Nature Reviews Cardiology 7(6): 297. doi: 10.1038/nrcardio.2010.66.
87. Schulze MB, Hu FB, 2005. Primary prevention of diabetes: what can be done and how much can be prevented? Annual Review of Public Health 26: 445-467. doi: 10.1146/annurev.publhealth.26.021304.144532.
88. Hallal PC, Victora CG, Azevedo MR, Wells JC, 2006. Adolescent physical activity and health: a systematic review. Sports Medicine 36(12): 1019-1030. doi: 10.2165/00007256-200636120-00003.
89. Brill PA, Burkhalter HE, Kohl HW, Blair SN, Goodyear NN, 1989. The impact of previous athleticism on exercise habits, physical fitness, and coronary heart disease risk factors in middle-aged men. Research Quarterly for Exercise and Sport 60(3): 209-215. doi: 10.1080/02701367.1989.10607442.
90. Bachrach LK, 2000. Making an impact on pediatric bone health. Journal of Pediatrics 136(2): 137-139. doi: 10.1016/s0022-3476(00)70088-6.
91. MacKelvie KJ, Khan KM, McKay HA, 2002. Is there a critical period for bone response to weight-bearing exercise in children and adolescents? a systematic review. British Journal of Sports Medicine 36(4):250-257; discussion 7. doi: 10.1136/bjsm.36.4.250.
92. Bass S, Pearce G, Bradney M, Hendrich E, Delmas PD, Harding A, Seeman E, 1998. Exercise before puberty may confer residual benefits in bone density in adulthood: studies in active prepubertal and retired female gymnasts. Journal of Bone and Mineral Research 13(3): 500-507. doi: 10.1359/jbmr.1998.13.3.500.
93. Khan KM, Bennell KL, Hopper JL, Flicker L, Nowson CA, Sherwin AJ, et al., 1998. Self-reported ballet classes undertaken at age 10-12 years and hip bone mineral density in later life. Osteoporosis International 8(2): 165-173. doi: 10.1007/BF02672514.
94. Fehily AM, Coles RJ, Evans WD, Elwood PC, 1992. Factors affecting bone density in young adults. American Journal of Clinical Nutrition 56(3): 579-586. doi: 10.1093/ajcn/56.3.579.
95. Janz KF, Dawson JD, Mahoney LT, 2000. Tracking physical fitness and physical activity from childhood to adolescence: the muscatine study. Medicine and Science in Sports and Exercise 32(7): 1250-1257. doi: 10.1097/00005768-200007000-00011.

96. Telama R, Yang X, Viikari J, Valimaki I, Wanne O, Raitakari O, 2005. Physical activity from childhood to adulthood: a 21-year tracking study. American Journal of Preventive Medicine 28(3): 267-273. doi: 10.1016/j.amepre.2004.12.003.
97. Trudeau F, Laurencelle L, Shephard RJ, 2004. Tracking of physical activity from childhood to adulthood. Medicine and Science in Sports and Exercise 36(11): 1937-1943. doi: 10.1249/01.mss.0000145525.29140.3b.
98. Taylor WC, Blair SN, Cummings SS, Wun CC, Malina RM, 1999. Childhood and adolescent physical activity patterns and adult physical activity. Medicine and Science in Sports and Exercise 31(1): 118-123. doi: 10.1097/00005768-199901000-00019.
99. Telama R, Yang X, Laakso L, Viikari J, 1997. Physical activity in childhood and adolescence as predictor of physical activity in young adulthood. American Journal of Preventive Medicine 13(4): 317-323. PMID: 9236971
100. Jones RA, Hinkley T, Okely AD, Salmon J, 2013. Tracking physical activity and sedentary behavior in childhood: a systematic review. American Journal of Preventive Medicine 44(6): 651-658. doi: 10.1016/j.amepre.2013.03.001.
101. Telama R, 2009. Tracking of physical activity from childhood to adulthood: a review. Obesity Facts 2(3): 187-195. doi: 10.1159/000222244.
102. Engstrom H, Briand A, 1991. [Puerperium. Health is an overview over one's own life. Interview by Jens Rossen]. Sygeplejersken 91(10): 8-9. PMID: 1853291
103. Baquet G, van Praagh E, Berthoin S, 2003. Endurance training and aerobic fitness in young people. Sports Medicine 33(15): 1127-1143. doi: 10.2165/00007256-200333150-00004.
104. American College of Sports Medicine, 2015. Physical Activity in Children and Adolescents. https://www.acsm.org/docs/default-source/files-for-resource-library/physical-activity-in-children-and-adolescents.pdf?sfvrsn=be7978a7_2. Accessed 14 January 2021
105. Department of Health Physical Activity HIaP, 2004. At Least Five a Week: Evidence on the Impact of Physical Activity and its Relationship with Health. A Report from the Chief Medical Officer. London: England.
106. Physical activity and exercise guidelines for all Australians, 2014. Australia's Physical Activity and Sedentary Behaviour Guidelines. https://www.health.gov.au/health-topics/physical-activity-and-exercise/physical-activity-and-exercise-guidelines-for-all-australians. Accessed 14 January 2021.
107. US Department of Health and Human Services, US Department of Education 2020. Promoting Better Health for Young People Through Physical Activity and Sports. U.S Department of Health and Human Services. 2008. Guidelines for Physical Activity for Americans. http://www.health.gov/PAGuidelines. Accessed 24 December 2021.
108. Dwyer T, Coonan W, Worsley A, Leitch D, 2010. An assessment of the effects of two physical activity programmes on coronary heart disease risk factors in primary school children. Australian and New Zealand Journal of Public Health 3(3): 196-202. doi.org/10.1111/j.1753-6405.1979.tb00254.x

109. Dwyer T, Coonan WE, Leitch DR, Hetzel BS, Baghurst RA, 1983. An investigation of the effects of daily physical activity on the health of primary school students in South Australia. International journal of epidemiology 12(3): 308–313. doi.org/10.1093/ije/12.3.308