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The Early Prevention of Metabolic Syndrome by Physical Exercise

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A B S T R A C T

The article deals with physical exercise in the early prevention of metabolic syndrome, which is one of the most frequent diseases today. Sedentary life style of modern man, surrounded by sophisticated technological achievements, supersedes the time spent in motion in all age groups, from the earliest childhood. The growing number of well substantiated studies has yielded results connecting such kind of life with greater incidence of many chronic diseases and low functional capability of an organism. Metabolic syndrome (MS) is a complex process and one of the most important groups of diseases, presenting a major health problem in developing countries. MS is an increasing risk for coronary heart disease, stroke and peripheral angiopathy. MS comprises overweight and abdominal (intraperitoneal) apple shape obesity, insulin resistance or glucose intolerance (type 2 diabetes mellitus – some persons are genetically predisposed to insulin resistance), hypertriglyceridemia with low HDL and high LDL cholesterol, accompanied by arterial hypertension. The prevention of metabolic syndrome should start as early as possible. Regarding physical activity, the period of childhood and adolescence is very important from the aspects of public health. However, intervention exercise programs should not be limited to younger age groups, but must encompass all age groups within population.

Key words: *physical exercise, prevention, metabolic syndrome, coronary heart disease*

Introduction

Physical activity is markedly reduced in professional work, in going to and returning from job, as well as in performing home chores for the majority of adults today. Heavy physical work in developed countries recedes in front of mechanization and robotics. The time spent sitting in front of a TV or video becomes longer, as well as the time spent playing video games, sitting in a car, surfing on the Internet, while going shopping, to banks or elsewhere becomes rarer. The number of persons whose life can be described as sedentary has never been so large. A growing number of well substantiated studies have yielded results connecting such kind of life with greater incidence of many chronic diseases and low functional capability of an organism[1–8]. Having in mind the generally accepted fact that chronic metabolic and cardiovascular diseases have their source early, in childhood and adolescence, particularly concerning is the increasing prevalence of inactivity during adolescence.

Physical Activity

The level of everyday activity varies according to gender, age and a series of other factors[9]. The level is higher in boys than in girls of the same chronological age 10. Boys spend more time in moderate and intense activities than their female peers. Factors associated with the everyday activity level of preschool children are gender, history of preterm birth, childcare centers and the father's body mass index (BMI)[10]. The investigations of the European and North American school children and adolescents have shown that the activity of a school child rises till the early adolescent period, when it starts to decrease. The children's activity significantly decreases during adolescence, what is attributed to biological, environmental and social impacts[11,12]. The decrease is especially pronounced in the late adolescent phase, particularly in young men who are otherwise more active than girls throughout the whole period of growth and development[13]. The Dutch study by Kemper et al.[14] showed that during adolescence

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the decrease is quite observable in the time spent in moderate and high intensity activities, with observably more time devoted to mild intensity activities. Sedentary life style of modern man, surrounded by sophisticated technological achievements, supersedes the time spent in physical activity from the earliest childhood[15].

Metabolic Syndrome

Metabolic syndrome (MS) or syndromes such as syndrome X plus, insulin resistance syndrome, obesity syndrome, diabesity, metabolic three-syndrome, big four, quartet of death, plurimetabolic syndrome, or Reaven's syndrome (GM Reaven described ot in 1988)[16,17] is a complex process and in our time one of the most important group of diseases and a major health problem in developing countries. MS is an increasing risk for coronary heart disease, stroke and peripheral arteriopathy[18–20]. MS consists of overweight and abdominal (intraperitoneal) apple shape obesity, insulin resistance or glucose intolerance (type 2 diabetes mellitus – some persons are genetically predisposed to insulin resistance), hypertriglyceridemia with low HDL and high LDL cholesterol accompanied by arterial hypertension. It is associated with prothrombotic state with high serum fibrinogen or plasminogen activator inhibitor-1 level, endothelial dysfunction and a pro-inflammatory state with the high level of C-reactive protein in the serum[21]. An assemblage of risk factors for MS includes age, obesity, history of diabetes mellitus and other similar diseases such as polycistic ovarian syndrome with metabolic consequences in women, hormones and reproductive system etc[22].

Definitions of the metabolic syndrome

The World Health Organization (WHO) definition[23,24] requires that individual with MS have: 1) hyperglycaemia/ insulin resistance or fasting glucose level ≥6.1 mmol/L and at least two of the following criteria: 2) abdominal or central obesity and WHR (waist to hip ratio) >0.90 in men and >0.85 in women and/or BMI >30 kg/m^2; 3) serum triglyceride level ≥1.69 mmol/L and/or HDL cholesterol <0.9 mmol/L in males and <1.00 mmol/L in females; 4) high blood pressure ≥140/90 mmHg or treatment with drugs; 5) microalbuminuria: urinary albumin excretion rate 20 μg/min or urinary albumin/creatinine ratio >3.5 mg/mmol.

The criteria of *the National Institute of Health (Third Report of the National Cholesterol Education Program or NECP, Evaluation, and Treatment of High Blood Cholesterol in Adults, Adult Treatment Panel III or ATP III)*[25] does not explicitly include insulin resistence of glucose intolerance as required criteria, rather defines the MS as the co-occurence of three or more of the following five criteria: 1) abdominal obesity-waist circumference >102 cm in men, >88 cm in women; 2) hyperglycaemia: fasting plasma glucose ≥6.1 mmol/L or treatment with antidiabetics; 3) serum triglyceride level >1.69 mmol/L or drug treatment; 4) HDL cholesterol <1.04 mmol/L in men, <1.29 mmol/L in women or drug treatment; 5) high blood pressure ≥130 mmHg systolic and ≥85 mmHg diastolic or drug(s) treatment.

The criteria of *the American Heart Association (AHA) and The National Heart, Lung and Blood Institute*[26,27] *(NHLBI)* include: 1) waist circumference the same as ATP III (does not include BMI) and at least two of the following criteria: 2) fasting glucose ≥5.6 mmol/L; 3) serum triglycerides the same as WHO; 4) serum HDL cholesterol the same as NCEP/ATP III; 5) blood pressure the same as NCEP/ATP III.

The criteria of *the European group for the study of the insulin resistance*[28] *(EGIR)* includes insulin resistance with 2 of the following: fasting plasma glucose level ≥6.1 mmol/L without diabetes mellitus; increased waist circumference ≥94 cm for males and ≥80 cm for females; triglyceride levels ≥2.0 mmol/L or treatment for elevated triglycerides level, and/or HDL cholesterol levels <1.0 mmol/L or treatment for reduced HDL cholesterol levels; blood pressure ≥140/90 mmHg or treatment for arterial hypertension.

The criteria of *the International Diabetes Federation (IDF)*[29–31] include: 1) central obesity, i.e. waist circumference in Mediterraneans: ≥94 cm in males, ≥80 cm in females, and at least two of the following criteria: 2) fasting plasma glucose level the same as in ATP III or therapy for type 2 diabetes mellitus; 3) serum triglycerides ≥1.7 mmol/L or therapy for triglyceridemia; and/or 4) HDL-cholesterol level <1.00 mmol/L in males and <1.30 in females; 5) blood pressure as in ATP III and AHA/NHLBI or therapy with antihypertensives.

The criteria of *the International Diabetes Federation (IDF) in adolescents (10-16 years)*[32,33] requires the following: 1) central obesity measured by waist circumference ≥90 percentile for child,s age, and at least two of the following criteria: 2) glucose level ≥5.6 mmol/L, glucose intolerance; 3) serum triglyceride level ≥1.7 mmol/L; 4) HDL-cholesterol level <1.03 mmol/L; 5) blood pressure ≥130 or ≥85 mmHg (Table 1). According to IDF[31], it is not possible to diagnose metabolic syndrome in children <10 years. However, in children with abdominal obesity and risk factors: positive family history of MS, type 2 diabetes mellitus, obesity, hyperlipoproteinemia, cardiovascular diseases including arterial hypertension, further observations and preventive measures have do be done, primarily for weight reduction.

In the study of Hirschler[33] out of 167 children, 11.3% had the metabolic syndrome and 21.9% among overweight children. Ford and co-workers[34] have reported the prevalence of 24% in adult U.S. population aged ≥20 yrs, increasing from 6.7% among the participants aged 20 through 29 years to 43.5% and 42.0% for the participants aged 60 through 69 years and aged at least 70 years, respectively. In 2004, Ford et al.[35] reported an increase in MS prevalence in U.S. adults aged ≥20 yrs from 24% in NHANES III25 to 27% in NHANES 1990–2000[24]. Similar prevalence is reported for some European populations[18,36,37]. Bokor et al.[38] have revealed the high prevalence of MS among obese European children and adolescents. Recently, a modification of the metabolic syndrome

TABLE 1
CRITERIA OF METABOLIC SYNDROME

	Adults					Adolescents
Clinical and biochemical parameters	WHO[23,24]	NCEP ATP III[25]	AHA/ NHLBI[26,27]	EGIR[28]	IDF[29-31]	IDF[32,33]
Waist circumference (cm)	–	≥102 m ≥88 f	≥102 m ≥88 f	≥94 m ≥80 f	≥94 m ≥80 f	≥90th percentile
Waist to hip ratio (WHR)	>0.90 m >0.85 f	– –	– –	– –	– –	– –
Glucose (mmol/L)	≥6.1	≥6.1	≥5.6	≥6.1	≥5.6	≥5.6
Insulin resistance	yes	no	no	yes	no	no
Body mass index (BMI kg/m^2)	>30	–	–	–	–	–
Triglycerides (mmol/L)	≥1.69	≥1.69	≥1.69	≥2.0	≥1.7	≥1.7
HDL-cholesterol (mmol/L)	<0.90 m <1.00 f	<1.04 m <1.29 f	<1.04 m <1.29 f	<1.0 <1.0	<1.03 m <1.30 f	<1.03
Blood pressure (mmHg)	≥140/90	≥130/85	≥130/85	≥140/90	≥130/85	≥130/85

criteria designed for children and adolescents shows that 50 percent of U.S. children who are severely overweight have MS[39].

Physical Exercise in the Prevention of Metabolic Syndrome

The group of known risk factors for the development of chronic metabolic and cardiovascular diseases with high incidence in modern populations (e.g. atherosclerosis, metabolic syndrome, coronary heart disease, diabetes mellitus, arterial hypertension) comprises obesity, increased fats in blood, elevated arterial blood pressure, low sensitivity to insulin, physical inactivity, cigarette smoking, and in the last two decades the identified group of risk factors for the development of coronary heart disease (CHD), including factors as fibrinogen, homocysteine, C-reactive protein, plasminogen activator inhibitor 1 and endothelial dysfunction. In the prevention of chronic diseases, we are particularly interested in factors which can be already treated in the early age. A significant number of young people present at least one risk factor for the development of coronary heart diseases. With the increase of risk factors rises also the individual risk for chronic diseases of the heart and blood vessels[40,41]. Here we must ask ourselves whether an early start of physical exercise prevents the occurrence of some cited risk factors for certain diseases. Parizkova[42] in her lecture in 1996, at the annual meeting of the just established European Association of Sport Sciences stated, that »…a genotype characterized by a high level of spontaneous body activity has a significantly higher HDL-C, with the trend of larger body dimensions, less fat reserve, higher energy input by food, higher cardiorespiratory and motor abilities, what is observable already in the pre-school age«[41]**.** The effect of physical exercise in childhood and adolescence upon health in adult age can be viewed through: directly observable benefit, the influence on the child's health and the impact upon the level of physical activity in adulthood[43] – or, more precisely, according to Blair et al.[44], through possible connection between physical activity during childhood and adolescence and health in adult age: 1) the connection of physical activity and health in young age; 2) the connection of physical activity during young age and physical activity in adulthood; and 3) the connection of physical activity during young age and health in adult age.

The investigations of Wilmore[40] long ago have confirmed that from the early school age we find in children the factors for the development of CHD. The prevalence of obesity increases with school age. Obesity, along with reduced physical activity, will develop in the case of inadequately high energy intake through food in relation to actual energy expenditure[45]. A significant link between obesity and hours spent in front of a TV has been confirmed in the sample of American children[46,47]. Sedentary habits are also related to increased intake of additional snacks[47]. The majority of studies base the estimation of overweight and obesity only upon the measures of body mass and height, mostly by using body mass index. In children, for the definition of overweight and obesity are used respective cutoff points of the 85. and 95. percentile of referent BMI values for a particular

age[48,49]. Nowadays, the estimations are more and more based on the body composition analysis, the portion of body fat and its distribution[50–57]. In a five-year period we have registered the trend of changes in the body composition in Croatian preschool children with the increase of body fat portion, without changes in BMI, along with the substantial reduction of non-fat mass portion in girls, particularly on the account of muscle mass in upper extremities[58]. The causes of such changes we have sought in nutritional habits and physical exercise. In population of Croatian school children, overweight is present in about 11% of children aged 7–14 yrs, and among them 5.2% are obese[59].

It need not be particularly stressed that obesity jeopardizes health and is connected with the early onset of a series of diseases, as coronary heart disease, arterial hypertension, diabetes mellitus, hyperlipoproteinemia, liver diseases and some malignant diseases more frequently occurring in obese people. Obesity endangers health and negatively impacts the ability of mastering motor tasks. According to Vanhala et al.[60], obesity in adult age is more harmful for health if it lasts since childhood. Fat tissue (particularly its visceral component) is not only »ballast« mass but hormonally extremely active tissue[61]. Many factors secreted in adipose tissue participate in the pathogenesis of metabolic diseases. Thus, the excessive accumulation of fat tissue is regarded as an independent metabolic risk[60]. The body fat accumulation of the central abdominal type (android or apple-like type) is a substantially greater metabolic risk than other types of body fat accumulation (gynoid or pear-like, and intermediary type). Thus, today the measures of waist circumference and the ratio of waist and hip circumference are considered to be important predictors of metabolic risk and risk for some chronic diseases, independent from overweight estimated by the body mass index. Visceral fat is a strong predictor of insulin resistance and glucose intolerance. It is related to the increased level of triglycerides and decreased level of high-density lipoproteins (HDL-cholesterol)[61].

Physical exercise plays an important role in the body mass regulation and in the prevention of obesity in children and adults[4,5,7,8,42,62–64]. It influences both sides of energy balance. Physical exercise is considered as one of the key links between hormonal modulators of energy metabolism[5]. Sympathetic nervous system and catecholamine affecting adipose metabolism directly and through the impact on hormones influencing the fat metabolism play the major role in enhancing the lipolysis during exercise[5]. The amount of fat oxidized during exercise and post-exercise period depends on a number of factors. The type of exercise, its intensity and duration, energy expenditure during exercise, gender and individual fitness level are some of the factors influencing the amount of oxidized fat[8].

A number of studies show lower levels of arterial blood pressure and other cardiovascular risk factors in children with better functional capacities[65–68]. The study by Boreham et al.[67] has showed that in 15-yr-old boys physical activity was beneficially associated with systolic blood pressure, lipid profile, and cardiorespiratory fitness. In 15-yr-old girls, sport participation was beneficially associated with fatness and cardiorespiratory fitness. Obese children often have higher levels of blood pressure. Examining the independence of the relationship between the cardiovascular risk factors and both body fatness and cardiorespiratory fitness in adolescents, Boreham et al.[67] have revealed that the relationships between fitness and cardiovascular risk status in adolescents are mediated by fatness. Similar results have been recently shown by Tomas et al.[69]. The results stress the importance of early prevention of overweight and obesity.

Many studies of the correlation of activity levels or cardiovascular fitness and risk factors for the development of coronary heart disease in the young have confirmed significant positive correlation between HDL-C level and aerobic endurance, as well as higher HDL-C level and lower triglyceride level in active children[70–72]. A certain number of studies have investigated the possible correlation of cardiovascular disease risk factors, such as homocysteine, fibrinogen, C-reactive protein, plasminogen activator inhibitor I, thrombin-antithrombin complex and endothelial function with the level of physical activity in children and adolescents[73–75]. More thorough research of this phenomenon is still expected.

In children, the type of relationship and levels of minimal daily physical activity indispensable for the prevention of risk factors for chronic metabolic and cardiovascular diseases are less known than in adults. Speaking about adults, there is a consensus on general recommendations for minimal duration, frequency and intensity of physical activity aimed at health protection and prevention of chronic diseases[76,77], as well as special recommendations for the prevention and treatment of obesity[62,63]. For school children, the attitudes are not homogenous. For the purpose of health protection, the majority argue for the minimum of 60 minutes of moderate to intense activity daily, adjusted to age. It develops cardiovascular endurance and muscle strength, simultaneously includes »carrying one's own body mass« (what contributes to bone density)[78], and diminishes the time of sedentary daily activities in front of the TV, PC, video games, telephone etc. Canadian authors recommend increase in the daily amount of physical activity for another 30 minutes[79]. Anderson et al.[80] consider the recommended minimum of 60 minutes insufficient and suggest more activities, but varied according to age. Approach based on recommendations for restricting time spent in sedentary activities is not simple and requires change in numerous environmental factors which will facilitate more safe and free motion of children and adolescents[62].

Thus, health protection and primary prevention of obesity and metabolic syndrome, the syndrome of growing prevalence, should be started as early as possible with special attention paid to adoption of correct nutritional habits and physical activities from preschool to school age. It is important to include parents in encour-

aging and directing a child to activities, along with the crucial role of school through physical education, which is needed daily, and further promotion of school sports, restriction of time the children spend sitting at school daily and weekly, as well as by prolonging breaks during which children may practice physical activities. Ensuring safe moving of children in everyday comings to and goings from school on foot or on bikes, as well as availability of equipped and safe playgrounds, will enable increased level of physical activity during free time.

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TJELESNO VJEŽBANJE U RANOJ PREVENCIJI METABOLIČKOG SINDROMA

S A Ž E T A K

Metabolički sindrom jedna je od najčešćih bolesti danas. Sjedeći način življenja moderna čovjeka okruženog sofisticiranim tehnološkim pomagalima već u ranoj dječjoj dobi pretpostavlja se kretanju. Način življenja, prema mnogim istraživanjima, povezan je s povećanom incidencijom kroničnih bolesti i smanjenju funkcijske sposobnosti. Metabolički sindrom (MS) najčešća je skupina bolesti, napose u zemljama u razvoju**.** To je usloženo zbivanje u kojem je povećana opasnost za razvoj koronarne bolesti srca, moždane kapi i periferne angiopatije. MS uključuje povećanu tjelesnu masu, abdominalni ili jabukoliki (intraperitonealni) tip pretilosti, rezistenciju na inzulin ili netoleranciju glukoze (tip 2 šećerne bolesti – neke su osobe genetski predodređene za rezistenciju prema inzulinu), hipertrigliceridemiju, s niskom koncentracijom serumskog lipoproteina visoke gustoće (HDL), povišenom koncentracijom lipoproteina niske gustoće (LDL) i povišenim arterijskim krvnim tlakom. U članku su izneseni postupci tjelesnog vježbanja u ranoj prevenciji tog sindroma. Njegova prevencija treba početi što je ranije moguće. Glede tjelovježbe, period ranog djetinjstva i adolescentne dobi vrlo su važni sa stanovišta javnog zdravstva. Međutim, postupci intervencijskog tjelovježbenog programa ne trebaju biti vezani samo za skupinu mlađe dobi, već trebaju obuhvaćati sve dobne skupine stanovništva.