Prevalence of Obesity and Association between Body Fatness and Aerobic Fitness in Serbian Preschool Children

Sergej M. Ostojic, Marko D, Stojanovic, Zoran Milosevic
Faculty of Sport and Physical Education,
University of Novi Sad, Serbia

Jagoda Jorga
Faculty of Medicine,
University of Belgrade, Serbia

Sladjana Grujic
Center for Health, Exercise and Sport Sciences,
Stari DIF, Belgrade, Serbia

1 Introduction

Obesity has arguably become one of the most urgent health problems in modern society for both developed and developing countries. Childhood obesity is particularly concerning because the extra pounds often start children on the path to health problems that were once confined to adults, such as diabetes, high blood pressure, and high cholesterol (Lobstein *et al.*, 2004; Tjepkema, 2006). The prevalence of obesity among children has been increasing dramatically in the past two decades, with one in four children between 6 to 14 years presently overweight (Hedley *et al.*, 2006). Although prevalence of overweight and obesity varies quite substantially across ethnic groups and gender, numerous studies have shown alarmingly high childhood levels of being fat (Ogden *et al.*, 2002; Wang *et al.*, 2002; Ostojic & Stojanovic, 2010; Ostojic *et al.*, 2011). Prevalence level varies substantially with geographical region in European children and is reported to be as high as 35% for the Eastern-region children (Krassas *et al.*, 2001; Ostojic *et al.*, 2011). While most studies reported obesity and overweight prevalence for elementary school children and adolescents, no such extensive data are present for the obesity prevalence in preschool children. The global prevalence of overweight in preschool children was estimated to about 3% (de Onis & Blossner, 2000). Some countries and regions had considerably higher rates, and overweight in preschoolers was shown to increase in 16 of 38 countries with trend data. Countries with the highest prevalence of overweight are located mainly in the Middle East, North Africa, and Latin America. ToyBox-study group (van Stralen *et al.*, 2012) reported prevalence of overweight indices in European preschoolers (4-7 years), with prevalence of overweight and obesity across the countries ranged from 8% to 30% and 1% to 13%, respectively, with highest rates in Southern European countries (i.e. Spain and Greece). Yet, to the authors best knowledge, to date there are no published data regarding overweight and obesity prevalence rates for Serbian preschool children. Lack of physical activity and/or physical fitness, and excess caloric consumption are some of the major reasons epidemiologists suggest for the increase of obesity in the past two decades in both adults and children (Brunnet *et al.*, 2007; Ortega *et al.*, 2007). Dennison *et al.* (2002) further identified association between sedentary behaviors (e.g. TV viewing) and risk of being overweight to preschool-aged children. Recent study from Bürgi and co-workers (2011) reported positive association between physical activity and aerobic fitness in preschool children, with higher physical activity was associated with less body fat in 217 healthy preschool children (age 4-6 years). It seems that low level of physical activity and/or health-related physical fitness, represented by cardiorespiratory (aerobic) endurance, contributes to the development of obesity in children (Ostojic *et al.* 2010a; 2010b). Since the habitual levels of physical activity are closely related to cardiorespiratory fitness, submaximal and maximal exercise testing have become frequently used as indirect physical activity assessment methods in children (Ara *et al.* 2007).

Several studies have shown that overweight children perform more poorly on cardiorespiratory fitness tests than their thinner counterparts, with low to moderately high inverse correlations found between cardiorespiratory fitness and adiposity (Al-Nakeeb *et al.*, 2007; Niederer *et al.*, 2012; Ostojic *et al.*, 2011). Although it would appear plausible to assume that higher level of physical fitness in children result in a more favorable body composition, data that permit examination of relationship between aerobic fitness and body fatness in youth are limited and considered controversial, particularly for preschool children (Goran *et al.*, 1999; Lee & Arslanian, 2007). Moreover, little is known about the relationship between physical fitness and different body fatness indicators besides body mass index (BMI), such as waist circumference or percentage of body fat, in preschool children.

Serbia is southeastern European country with estimated population of somewhat over 7 million people, predominantly Slavic Serbs, with overall life expectancy around 74 years. In addition, 55.7% of adult population is overweight, with 19.0% obese (Grujic *et al.*, 2010). To the best of our knowledge, there is only one study examining prevalence of overweight and obesity in Serbian preschool children (Stojanovic & Belojevic, 2009), with no data available examining association between obesity and aerobic fitness. On the other hand, it has been recognized that the preschool period corresponds to the time of the adiposity rebound, which is considered critical for obesity development and consequent health problems in later life (Rolland-Cachera *et al.*, 2006). Therefore, the objectives of present study were to investigate the prevalence of overweight and obesity among Serbian preschool children, and determine relationship between aerobic fitness and body fatness indicators in 4-6-year-old Serbian preschoolers.

2 Methods

2.1 Participants

The evaluation took place between April and May during the school year 2009-2010 with stratified (geographically) random sampling was used in this cross-sectional study. Eight kindergartens were identified from the local Department of Education and were randomly selected from Belgrade borough area of Zvezdara (150.000 inhabitants) on a proportional basis, with 15-30% of each respective kindergarten age group being sampled. Around 80% of children in Zvezdara attend preschool. Principals of the kindergartens were contacted with the aims of the study explained to both kindergarten nurses and educators, and school administrators. Once a kindergarten had agreed to participate in the study, letters to parents were distributed. All participants and parents were fully informed verbally and in writing about the nature and demands of the study. All subjects and parents gave their informed consent and volunteered to participate in the study with the approval of the University's Ethical Advisory Commission in accordance with the Helsinki Declaration. Parents completed medical history questionnaire for their children and were informed that they could withdraw a child from the study at any time, even after giving their written consent. Children with conditions that might have led to limitations in physical activity and mobility were excluded after alleged health problem stated in questionnaire has been certified by a specialized physician.

2.2 Experimental Design

Each child underwent a one-day testing session. During this session, anthropometric assessment and physical fitness test were carried out. Height was measured using a mobile stadiometer (Model 202, Seca, Birmingham, UK) to the nearest 0.1 cm, while body mass was obtained to the nearest 0.1 kg using a calibrated electronic scale (Model 877, Seca, Birmingham, UK). The subjects were measured in privacy by the respective genders in underwear only, and in the same state of hydration and nourishment after voiding. All anthropometric measurements were taken between 9 and 11 a.m. after a overnight fast of between 10 and 12 h. BMI was calculated as weight (kg)/height $(m)^2$. Children were considered overweight or obese based on BMI age-specific reference guidelines (Table 1) (Kiess *et al.*, 2001; Kain *et* al., 2002; Flodmark*et al.*, 2004).

Class	Percentile range
Underweight	Less than the 5th percentile
Healthy weight	5th percentile to less than the 85th percentile
Overweight	85th to less than the 95th percentile
Obese	Equal to or greater than the 95th percentile

Table 1: Reference guidelines for detection of overweight and obesity according to BMI-for-age weight status categories in children.

Waist circumference was measured using a Gulick anthropometric tape (Creative Health Products, Plymouth, MI, USA) at the level of the narrowest point between the lower costal border and the illiac crest. Skinfold thickness at two sites (triceps and medium calf) was obtained using a Harpenden caliper (British Indicators Ltd., St. Albans, UK). The landmarks are identified and measured according to Wilmore & Behnke (1969), with the median of three measurements used to represent skinfold thickness. Percentage of body fat was determined according to age and gender-specific equations (girls, percentage of body fat = 0.610 ·(triceps skinfold [mm] + calf skinfold [mm]) + 5.1; boys, percentage of body fat = 0.735 ·(triceps skinfold [mm] + calf skinfold [mm]) + 1.0) (Slaughter *et al.*, 1988). The same trained technician performed tests on each subject for anthropometric measurements according to the International Society for the Advancement of Kinanthropometry (Marfell-Jones *et al.*, 2006). Aerobic fitness was determined using maximal multi-stage shuttle-run test (Leger & Lambert, 1982). Subjects were required to run back and forth between two lines 20 m apart, while keeping pace with audio signals emitted from a pre-recorded CD. The frequency of sound signals increases in such a way that running speed starts at 8.5 km/h and is increased by 0.5 km/h each minute. The test ended when the participant stopped or failed to maintain the prescribed pace for two consecutive signals, with the final stage reached recorded and used to calculate maximal oxygen uptake (VO_{2max}). This test has shown to be valid and reliable for the prediction of the VO_{2max} in children (van Mechelen *et al.*, 1986), and with some minor adaptations (e.g. adult running with the children to provide the adequate pace) is regularly used lately for testing preschool children (Niederer *et al.*,2009). Familiarization session for shuttle run testing was performed one week before testing commencement for each kindergarten.

2.3 Statistical Analyses

Descriptive statistics were run on all variables. Statistical significance between continuous variables were assessed using Student's *t* test with *p* values of less than 0.05 considered statistically significant. Categorical data were evaluated using chi-square (X^2) analysis. Relationship between body fat, BMI, and waist circumference, and VO_{2max} were examined using Pearson's product-moment correlation coefficient. The data were analyzed using the statistical package *SPSS*, PC program, version 17.0 (SPSS Inc., USA).

3 Results

This study used 318 healthy preschool children (191 boys, 127 girls; age 4 to 6 years) of the kindergarten preschool program. All participants were in good health, free from musculoskeletal dysfunctions, and metabolic and heart diseases. None of the subjects was on the medication at the time of the study, nor using supplements for health and vitamin capsules. The prevalence of overweight was 27.3% for total sample, and did not vary among the girls and boys, 27.8% and 26.9% respectively (Figure 1). Significant differences were found between male and female preschoolers regarding the prevalence of obesity (4.1% in boys *vs.*6.3% in girls, $p < 0.05$; Chi-square test).

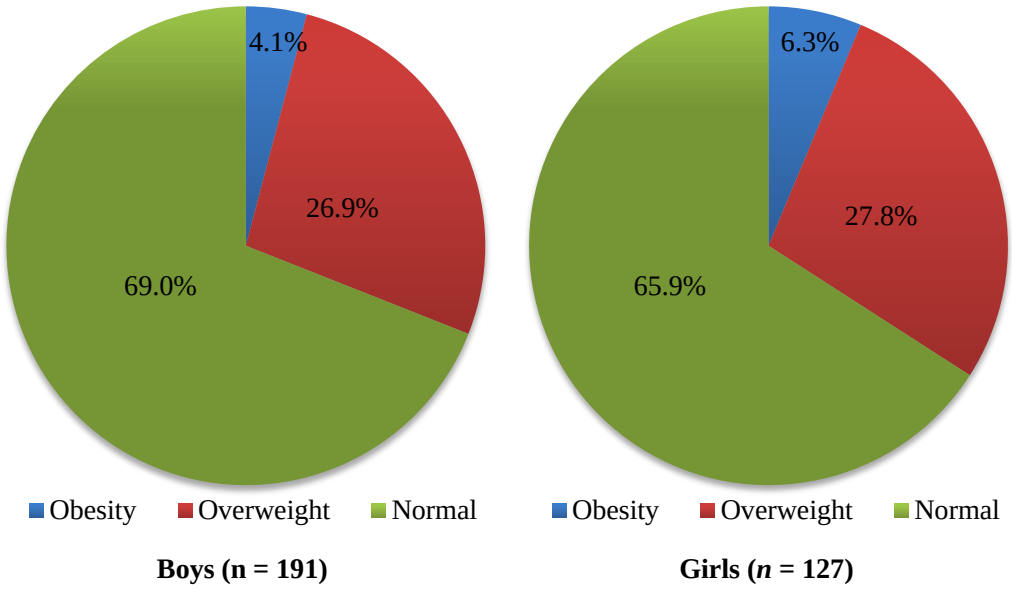

Figure 1: Percentage of overweight and obese preschool children by gender

Anthropometric and physiological data are shown in Table 2. Both boys and girls had comparable age, weight, height and BMI. Boys showed significantly lower waist circumference and body fat as compared to their female counterparts ($p < 0.05$). Moreover, boys attained better performance in multi-stage fitness test, and therefore had higher maximal oxygen uptake ($p < 0.05$).

	Boys (n = 191)	Girls (n = 127)	Total (n = 318)
Age (years)	5.1 ±0.6	5.2 ±0.6	5.1 ±0.6
Height (cm)	111.4±5.1	110.6±4.8	111.1 ± 5.0
Weight (kg)	18.9 ±3.2	18.9 ±2.9	18.9 ±3.0
Body mass index (kg/m^2)	15.2 ±1.7	15.5 ±2.1	15.3 ±2.0
Waist circumference (cm)	52.6 ±4.0	54.9 ±5.3[a]	53.5 ±4.5
Body fat (%)	22.8±6.8	25.9 ±8.7[a]	24.0 ±7.6
Maximal oxygen uptake (ml/kg/min)	30.5±8.2	26.1±7.0[a]	28.7 ±7.7

Table 2: Characteristics (means ±SD) of the study subjects by gender. [a]p< 0.05 boys *vs.* girls

The highest level of weight, BMI, body fat and waist circumference encountered in the study in a 5-year old girl (35.5 kg, 29.3 kg/m^2, 44.2%, and72.3 cm, respectively) implies potential existence of extreme obesity in Serbian preschoolers, although no clinical syndromes were stated by her parents The relationship between indicators of body fatness and $VO_{2max}$are illustrated in Figure 2.The correlation coefficient was moderately high for body fat *vs.* VO_{2max}(r = -0.58; p < 0.05). There was significant inverse correlation between waist circumference and VO_{2max} (r = -0.46; p < 0.05), with insignificant correlation between BMI and VO_{2max} (r = -0.10; p > 0.05).

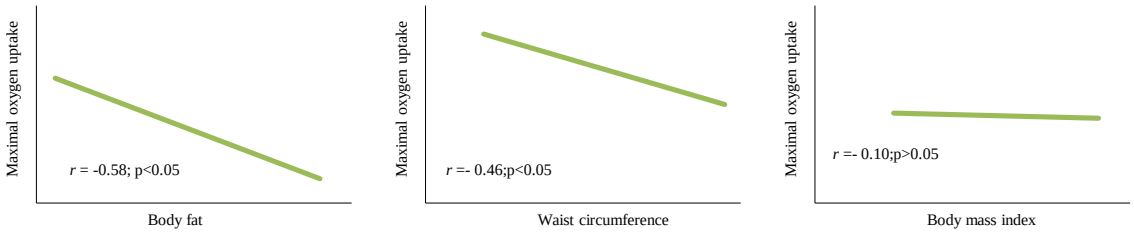

Figure 2: Relationship between body fatness indicators and maximal oxygen uptake (n = 318).

4 Discussion

The present study displayed high prevalence of overweight (27.3%) and obesity (5.0%) in whole sample of preschoolers, with the prevalence of obesity more frequent in girls (6.3% *vs.* 4.1%, girls and boys, respectively). The data also demonstrated moderately high negative correlation between aerobic endurance and body fatness in Serbian preschool children, suggesting that children who have high cardiorespiratory fitness during early childhood have less overall adiposity than their unfit counterparts. The results from the present study emphasize the necessity to identify the children with weight problems and to develop early interventions to improve health-related fitness in preschoolers, and prevent the increase of childhood obesity.

4.1 Prevalence of obesity in preschool children

Obesity among children is increasing worldwide, impacting research on ubiquity and etiology on both national and international level. It seems that obesity rise particularly sharply among preschoolers, with the bulk of prevalence studies published in the past decade reporting rates of overweight and/or obesity wide-ranging. The prevalence of obesity found among the preschool children of the present study was comparable to the single study done with Serbian preschoolers (Stojanovic & Belojevic, 2009) as well as to data presented earlier from other national studies in similar age group, using the same method for classification. Southeast Serbian urban preschoolers were reported to have a prevalence of obesity of 6.3% and 3.8% for girls and boys, respectively. Martorell and co-workers (2000) reported relatively low level of obesity and overweight in preschool children from developing countries, with 32 of 50 countries had a prevalence of obesity below 2.3%, the value in the reference population. Manios and co-workers (2007) reported notable prevalence of obesity in preschool Greek children, with the rate was 16.0% in boys and 15.5% in girls, respectively. More than one third of the provincial population of Canadian preschool children were overweight and obese, with the rates did not differ significantly by sex or age group (Canning *et al.*, 2004). Same group reported relatively rapid rise in overweight and obesity in children as young as 4 years in little more than a decade, with almost 10% increase of combined rates of overweight and obesity from 1984 (25.1%) to 1997 (36.0%) (Canning *et al.*, 2007). Similar results were found in 2009 for low-income Oklahoma preschool children; with 30.7%children were overweight, including 13.7% obese (Weedn *et al.*, 2012). Seminal overview study by de Onis *et al.* (2010) reported global prevalence and trends of overweight and obesity among preschool children. Fourthy-three million children in the world, of which 35 million in developing countries, were estimated overweight and obese in 2010, with another 92 million being at risk of overweight. In addition, the 2.5% incensement in worldwide prevalence of childhood overweight and obesity between 1990 and 2010 has been reported, with trend expected to reach 9.1% (60 million) youngest children in 2020. The prevalence is lower in Asia (4.9% in 2010), but the number of affected children is noteworthy (18 million). It seems that obesity was more common in urban areas, in children of mothers with higher education, and in girls; these relationships did not differ by gross national product (GNP), but GNP was related negatively to stunting and positively to overweight (de Onis *et al*., 2010). Obesity does not appear to be a major public health problem among preschool children in Asia and Sub-Saharan Africa. Yet, in a number of countries in Latin America and the Caribbean, the Middle

East and North Africa, and the region of Eastern Europe/Commonwealth of Independent States, levels are as high as in the United States (Martorell *et al.*, 2000; de Onis *et al*., 2010).

It seems that childhood obesity become a global epidemic and is threatening to have reached epidemic proportions in Serbia as well (Ostojic *et al.*, 2011). In accordance with the previous research from our group in elementary school children and adolescents (Ostojic & Stojanovic, 2010; Ostojic *et al.*, 2010a; Ostojic *et al.*, 2010b; Ostojic *et al.*, 2011), data in the present study indicates that the prevalence of overweight is similar among boys and girls. Girls tend to have higher prevalence of obesity then boys (6.3% *vs.*4.1%, respectively). Furthermore, girls have significantly higher total body fat percentage as compared to boys (25.9% *vs.* 22.8%), and higher waist circumference (54.9 cm *vs.* 52.6 cm), both relevant indicators of obesity. The sex difference in both obesity prevalence and body fatness indicators may be related to several factors such as maturation, growth history, and behavioral and environmental factors, which requires more investigation (Ostojic *et al.*, 2011). An interesting gender difference was suggested considering sexual maturation, with early sexual maturation was positively associated with overweight and obesity in girls, but the associations were reverse for boys (Wang, 2002). In addition, Sugimori *et al.* (1997) identified influence of several behavioral and environmental factors on the development of obesity in preschool children, such as food consumption patterns (e.g. eating snacks irregularly), physical inactivity, short sleep duration (9 hours or less), socioeconomic status and micro and macro environment (e.g. person other than the mother responsible for taking care of the child, father's or mother's BMI above 24 kg/m^2). The gradual increase in body weight that leads to obesity is the consequence of a prolonged positive energy balance (Hill, 2006). Several factors can influence energy balance and therefore be identified as contributors to the current obesity epidemic in children, with biological, behavioral, environmental, and social being most cited (Rowlands *et al*., 1999). Although relative contribution of energy intake *vs.* energy expenditure to the obesity epidemic is a source of continuing debate, the available data clearly indicate that physical activity play integral role in the obesity prevention (Roberts *et al*., 2000). Obese children are at increased risk of acute medical illnesses and chronic diseases such as osteoarthritis, diabetes mellitus, and cardiovascular disease, which can lead to poor quality of life; increased personal and financial burden to individuals, families, and society; and shortened lifespan (Dugan, 2008).

4. 2 Aerobic fitness in preschoolers

Cardiorespiratory (aerobic) fitness seems to be an important indicator of health in both preschool and school children (Andersen *et al*., 2008). High aerobic fitness during childhood has been associated with healthier cardiovascular and metabolic profiles during these years and also later in life (Hager *et al.*, 1995; Ruiz *et al.*, 2006; Ruiz *et al.*, 2007). Moreover, it has been recognized that aerobic fitness in children predicts future physical activity level, contributing to overall health profile of adults (Lopes *et al*., 2010). Although aerobic fitness has a large genetic component (up to 40%) (Wolfarth *et al.*, 2005), it is mainly determined by a person's activity level (Ignico & Mahon, 1995). Therefore, evaluating aerobic fitness through estimation of maximal oxygen uptake (VO_{2max}) identifies children with an aerobic fitness level below required, with those children may be able to reach the desirable VO_{2max} with adequate aerobic physical activity. Data from large cohorts of 6-19 years children demonstrated a decline in aerobic fitness of 0,4% per year between 1970 and 2003 (Tomkinson & Olds, 2007), with the paucity of data regarding aerobic fitness levels of preschool children.

The average aerobic fitness for children assessed in the present study (28,7 ml/kg/min) was lower then previously reported, with boys had higher $VO_{2max}$for about 14% as compared to girls. Yoshizawa *et al.* (1977) determined VO_{2max} in 85 healthy kindergarten children by track running; with VO_{2max} per unit of body weight was 49.5 ml/kg/min for boys, and 46.3 ml/kg/min for girls. Similar results were found for Danish children 6-7 years of age (Eiberg *et al.*, 2005), with boys had higher VO_{2max} (48.5 *vs.* 44.8 ml/kg/min) than girls. However, it should be recognized that all mentioned studies used "gold standard" method for VO_{2max} determination measuring gas exchange during test, while in our study VO_{2max} was estimated with shuttle run test. Indeed, shuttle run test has been frequently shown to under predict data obtained with "gold standard" testing procedures (Stickland *et al*., 2003).

Aerobic capacity is found to be consistently greater in boys throughout childhood, with the observed difference have been ascribed to a combination of factors including body composition and cardiac size and function (Rowland *et al.*, 2000). Studies using procedures for direct determination of VO_{2max} have recorded average values of about 45 ml/kg/min for preschool children (Cooper *et* al., 1984; Washington *et al.* 1988; Duncan *et al*. 1996), with boys have higher value of VO_{2max} than girls. Lower maximal oxygen uptake in Serbian preschoolers allusively indicates less desirable fitness profile, with aerobic capacity needs to be improved by physical activity. Dencker *et al.* (2011) recently indicated that main contributing factors for VO_{2max} were total body fat, maximal heart rate, sex, age and physical activity. We could hypothesized that both genetic factors and inadequate physical activity history contributes to inadequate aerobic fitness

in Serbian preschool children which requires further investigation. Gender differences in VO_{2max} found in our study are in accordance with previous studies.

4. 3 Correlation between aerobic fitness and adiposity

Regular physical activity plays an important role in maintenance of weight and body composition, and in the regulation of skeletal muscle and adipose tissue metabolism (Warburton *et al.*, 2006). Several investigators have reported an interrelationship between physical activity and body composition in young children (DuRant *et al.*, 1994: Hussey *et al.*, 2007; Ostojic & Stojanovic, 2010). Precise assessment of habitual physical activity is critical for accurate descriptive epidemiology of the physical activity-obesity relationship, for designing appropriate interventions aimed at modifying body composition and related risk factors, and for promoting lifestyle change (Dugan, 2008). However, because physical activity is complex, multidimensional behavior, precise measurement remains a challenge for practitioners, researchers, and health care providers, especially among young children. Self reported physical activity questionnaires, physiological measures of fitness (direct and indirect VO_{2max} assessment), with several objective techniques, such as heart rate monitors, pedometers and accelerometers, have been used extensively for the measurement of physical activity in children (Sirard & Russell, 2001). Although objective techniques are proved to be superior tool for physical activity assessment, they are often impractical and time consuming, thus implying that indirect assessment of physical activity could be more appropriate in large sample studies. Moreover, it seems that study of aerobic fitness and body fat is probably a more valid approach than measurement of self-reported physical activity and body weight, particularly in children (Hager *et al*., 1995; Jansen *et al*., 2005; Ostojic & Stojanovic, 2010).

It has been reported that overweight and obese children showed a lower cardiorespiratory (aerobic) fitness than normal children (Klasson-Heggebo *et al.*, 2006; Hussey *et al*., 2007). However, studies analyzing an association between aerobic fitness and different measures of body composition (e.g. body fat, waist circumference) in population of preschool children are scarce. Johnson and co-workers (2000) reported significant negative relationship between aerobic fitness and the rate of increasing adiposity in one hundred fifteen black and white US children ($F = 3.92$). Authors claimed that aerobic fitness might be more important than absolute energy expenditure in the development of obesity in white or black children. Hansen *et al.* (2005) reported significant correlation between VO_{2max} and fatness independent of body weight ($r = 0.41$; $p< 0.001$) in 369 boys and 327 girls from preschool classes in Copenhagen. Recently, Niederer at al (2012) found significantly better aerobic fitness among normal weight than overweight 4-6 year old children, with the differences more pronounced in older preschool-age children. Authors concluded that relationship between aerobic fitness and body fat is already noticeable in preschool-age children and that targeted programs to increase aerobic fitness and decrease overweight should start in kindergarten.

Our results show a significant inverse relationship ($r = -0.58$) between aerobic fitness and percentage body fat in both boys and girls. The results in terms of the other anthropometrical variables show both a significant (with waist circumference) and insignificant (with BMI) relation with cardiorespiratory fitness, which has also been reported earlier in children and adolescents (Winsley *et al.*, 2006; Ekelund *et al*., 2001; Ostojic *et al*., 2011). Since the present study was cross-sectional, cause-and-effect conclusions are not warranted. However it appears that the goal of favorably altering adiposity in children should begin with increasing physical activity and fitness, which in turn will lead to reductions in body fat (Ostojic *et al.*, 2011). Moreover, children who improve their cardiorespiratory fitness during childhood have less overall adiposity and less abdominal adiposity than their counterparts during adolescence and adulthood (Tjepkema, 2006). Due to fact that BMI poorly correlate with aerobic fitness, other indicators of adiposity rather than weight has been shown to be associated with cardiorespiratory fitness in school children (Rowlands *et al.*, 1999). We found insignificant correlation between VO_{2max} and BMI ($r = 0.10$; $p > 0.05$) suggesting that a combination of body fat from simple measures such as triceps and calf skinfolds, waist circumference and perhaps fitness, should be used in the clinical settings to identify the children with high risk of obesity.

Our results suggest that low aerobic fitness, as valid indicator of physical activity, is closely linked to increased level of adiposity in preschool children. Physical inactivity seems to be one of the factors interconnected with obesity; however it is perhaps one of the easiest to modify, although may authors identified barriers to childhood physical activity (e.g. influence of young family members to play video games, parental time constraints, street safety, low access to sports facilities, and insufficient communication with child care centers) (Rodr ǵuez-Oliveros *et al*.; 2011). Considering the fact that for many Serbian kindergartens curriculum physical activity classes are voluntary, introduction of mandatory physical education to preschool program may be prudent. The main aim of such classes should be children engagement in health-providing physical activities in contrast to the typical movement skills-development curriculum design. Moreover, it has been proved that physical education can have an important role in promoting children's participation in extra-curricular health-enhancing physical activity (McKenzie *et al.*, 2003). In the lights of the present

results and due to the fact that Serbian kindergarten curriculum do not include obligatory physical activity, while guidelines for physical activity in youth recommend involvement in moderate to vigorous physical activities for at least 60 min a day for health promotion a well as from a weight control perspective (Twisk, 2001), initiatives should be put forward to promote physical activity in Serbian preschool children, in both kindergarten and out-of-school environment.

5 Conclusion

The present study shows apposite association between aerobic fitness and both body fatness and waist circumference in Serbian preschool children, suggesting that preschoolers with high VO_{2max} during kindergarten years have less total and abdominal adiposity than their unfit counterparts. It seems that the rate of overweight and obesity in Serbian preschool children is high, particularly for girls, with girls had higher obesity rates than boys. Although there are many factors that can contribute to obesity among the children, this study emphasizes the necessity to develop interventions to improve physical fitness in children and to prevent the increase of childhood obesity.

References

Al-Nakeeb, Y., Duncan, M.J., Lyons, M., & Woodfield, L. (2007). Body fatness and physical activity levels of young children. *Annals of Human Biology*, 34, 1-12.

Andersen, L.B., Sardinha, L.B., Froberg, K., Riddoch, C.J., Page, A.S., & Anderssen, S.A. (2008). Fitness fatness and clustering of cardiovascular risk factors in children from Denmark, Estonia and Portugal: the European Youth Heart Study. *International Journal of Pediatric Obesity*, 3, 58-66.

Ara, I., Moreno, L.A., Leiva, M.T., Gutin, B., & Casajús, A. (2007). Adiposity, physical activity, and physical fitness among children from Aragon, Spain. *Obesity*, 15, 1918-1924.

Brunnet, M., Chaput, J-P., & Tremblay, A. (2007). The association between low physical fitness and high body mass index or waist circumference is increasing with age in children: the 'Quebec en Forme' Project. *International Journal of Obesity*, 31, 637-643.

Bürgi, F., Meyer, U., Granacher, U., Schindler, C., Marques-Vidal, P., Kriemler, S, *et al.* (2011). Relationship of physical activity with motor skills, aerobic fitness and body fat in preschool children: a cross-sectional and longitudinal study (Ballabeina). *International Journal of Obesity*, 2011, 35, 937-944.

Canning, P.M., Courage, M.L., & Frizzell, L.M. (2004). Prevalence of overweight and obesity in a provincial population of Canadian preschool children. *CMAJ*, 171, 240-242.

Canning, P., Courage, M.L., Frizzell, L.M., & Seifert, T. (2007). Obesity in a provincial population of Canadian preschool children: differences between 1984 and 1997 birth cohorts. *International Journal of Pediatric Obesity*, 2, 51-57.

Cooper, D.M., Weiler-Ravell, D., Whipp, B.J., & Wasserman, K. (1984). Aerobic parameters of exercise as a function of body size during growth in children. *Journal of Applied Physiology*, 561, 628-634.

de Onis, M., & Blössner, M. (2000). Prevalence and trends of overweight among preschool children in developing countries. *American Journal of Clinical Nutrition*, 72, 1032-1039.

de Onis, M., Blössner, M., & Borghi, E. (2010). Global prevalence and trends of overweight and obesity among preschool children. *American Journal of Clinical Nutrition*, 92, 1257-1264.

Dencker, M., Hermansen, B., Bugge, A., Froberg, K., &Andersen, L.B. (2011). Predictors of VO_{2peak} in children age 6- to 7-years-old. *Pediatric Exercise Science*, 23, 87-96.

Dennison, B.A., Erb, T.A., & Jenkins, P.L. (2002). Television viewing and television in bedroom associated with overweight risk among low-income preschool children. *Pediatrics*, 109, 1028-1035.

Dugan, S.A. (2008) Exercise for preventing childhood obesity. *Physical Medicine and Rehabilitation Clinics of North America*, 19, 205-216.

Duncan, G.E., Mahon, A.D., Howe, C.A., & Corral, P.D. (1996). Plateau in oxygen uptake at maximal exercise in male children. *Pediatric Exercise Science*, 8, 77-86.

DuRant, R.H., Baranowski, T., Johnson, M., & Thompson, W.O. (1994). The relationship among television watching, physical activity, and body composition of young children. *Pediatrics*, 94, 449-455.

Eiberg, S., Hasselstrom, H., Grønfeldt, V., Froberg, K., Svensson, J., & Andersen, L.B. (2005). Maximum oxygen uptake and objectively measured physical activity in Danish children 6-7 years of age: the Copenhagen school child intervention study. *British Journal of Sports Medicine*, 39, 725-730.

Ekelund, U., Poortvliet, E., Nilsson, A., Yngve, A., Michael, A.,& Sjöström, M. (2001).Physical activity in relation to aerobic fitness and body fat in 14- to 15-year-old boys and girls. *European Journal of Applied Physiology*, 85, 195–201.

Flodmark, C.E., Lissau, I., Moreno, L.A., Pietrobelli, A., & Widhalm, K. (2004). New insights into the field of children and adolescents' obesity: the European perspective. *International Journal of Obesity and Related Metabolic Disorders*, 28, 1189-1196.

Goran, M.I., Reynolds, K.D., & Lindquist, C.H. (1999). Role of physical activity in the prevention of obesity in children. *International Journal of Obesity and Related Metabolic Disorders*, 23, S18–33.

Grujic, V, Dragnic, N., Radic., I., Harhaji., S., & Susnjevic, S. (2010). Overweight and obesity among adults in Serbia: results from the National Health Survey. *Eating and Weight Disorder*, 15, e34-42.

Hager, R.L., Tucker, L.A., & Seljaas, G.T. (1995). Aerobic fitness, blood lipids, and body fat in children. *American Journal of Public Health*, 85, 1702–1706.

Hansen, S.E., Hasselstrøm, H., Grønfeldt, V., Froberg, K., &Andersen, L.B. (2005). Cardiovascular disease risk factors in 6-7-year-old Danish children: the Copenhagen School Child Intervention Study. *Preventive Medicine*, 40, 740-746.

Hedley, A.A., Ogden, C.L., Johnson, C.L., Carroll, M.D., Curtin, L.R., & Flegal, K.M. (2004). Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002. *Journal of American Medical Association*, 291, 2847-2850.

Hill, J.O. (2006). Understanding and addressing the epidemic of obesity: an energy balance perspective. *Endocrine Reviews*, 27, 750-761.

Hussey, J., Bell, C., Bennett, K., O'Dwyer, J.,& Gormley, J. (2007).Relationship between the intensity of physical activity, inactivity, cardiorespiratory fitness and body composition in 7-10-year-old Dublin children. *British Journal of Sports Medicine*, 41, 311-316.

Ignico, A.A., & Mahon, A.D. (1995). The effects of a physical fitness program on low-fit children. *Research Quarterly in Exercise and Sport*, 66, 85–90.

Janssen, I., Katzmarzyk, P.T., Srinivasan, S.R., Chen, W., Malina, R., Bouchard, C., *et al*. (2005). Combined influence of body mass index and waist circumference on coronary artery disease risk factors among children and adolescents. *Pediatrics*, 115, 1623-1630.

Johnson, M.S., Figueroa-Colon, R., Herd, S.L., Fields, D.A., Sun, M., Hunter, G.R., *et al.* (2000). Aerobic fitness, not energy expenditure, influences subsequent increase in adiposity in black and white children. *Pediatrics*, 106, E50.

Kain, J., Uauy, R., Vio, F., & Albala, C. (2002). Trends in overweight and obesity prevalence in Chilean children: comparison of three definitions. *European Journal Clinical Nutrition*, 56, 200-204.

Kiess, W., Galler, A., Reich, A., Müller, G., Kapellen, T., Deutscher, J. *et al*. (2001). Clinical aspects of obesity in childhood and adolescence. *Obesity Reviews*, 2, 29-36.

Klasson-Heggebo, L., Andersen, L.B., Wennlof, A.H., Sardinha, L.B., Harro, M., Froberg, K. *et al*. (2006). Graded associations between cardiorespiratory fitness, fatness, and blood pressure in children and adolescents. *British Journal of Sports Medicine*,40, 25–29.

Krassas, G.E., Tzotzas, T., Tsametis, C., & Konstantinidis, T. (2001). Prevalence and trends in overweight and obesity among children and adolescents in Thessaloniki, Greece. *Journal of Pediatric Endocrinology and Metabolism*, 14, S1319–1326.

Lee, S.J., & Arslanian, S.A. (2007). Cardiorespiratory fitness and abdominal adiposity in Youth. *European Journal of Clinical Nutrition*, 61, 561–565.

Leger, L.A., & Lambert, J. (1982). A maximal multistage 20-m shuttle run test to predict VO_2max. *European Journal of Applied Physiology*, 49, 1-12.

Lobstein, T., Baur, L., & Uauy, R. (2004). Obesity in children and young people: a crisis in public health. *Obesity Reviews*, 5, S4-85.

Lopes, V.P, Rodrigues, L.P., Maia J.A., Malina, R.M. (2010). Motor coordination as predictor of physical activity in childhood. *Scandinavian Journal of Medicine and Science in Sports*, 21, 663-669.

Manios, Y., Costarelli, V., Kolotourou, M., Kondakis, K., Tzavara, C, & Moschonis, G. (2007). Prevalence of obesity in preschool Greek children, in relation to parental characteristics and region of residence. *BMC Public Health*, 7, 178.

Marfell-Jones, M., Olds, T., Stewart, A., & Carter, L. (2006). *International Standards for Anthropometric Assessment*. Potchefstroom, South Africa: ISAK.

Martorell, R., Kettel Khan, L., Hughes, M.L., & Grummer-Strawn, L.M. (2000). Overweight and obesity in preschool children from developing countries. *International Journal of Obesity and Related Metabolic Disorders*, 24, 959-967.

McKenzie, T.L., Li, D., Derby, C., Webber, L.S., Luepker, R.V., & Cribb, P. (2003). Maintenance of effects of the CATCH physical education program: Results from the CATCH-ON study. *Health Education and Behavior*, 30, 447-462.

Niederer, I., Kriemler, S., Zahner, L., Bürgi, F., Ebenegger, V., Marques, P., & Puder, J.J. (2012). BMI-group-related differe*nces in physical fitness and p*hysical activity in preschool age-children: A cross-sectional analysis. *Research Quarterly for Exercise and Sport*, 83, 12-19.

Niederer, I., Kriemler, S., Zahner, L., Bürgi, F., Ebenegger, V., Hartmann, T., *et al*. (2009). Influence of a lifestyle intervention in preschool children on physiological and psychological parameters (Ballabeina): study design of a cluster randomized controlled trial. *BMC Public Health*, 9, 94-103.

Ogden, C.L., Flegal, K.M., Carroll, M.D., & Johnson, C.L. (2002). Prevalence and trends in overweight among US children and adolescents, 1999-2000. *Journal of American Medical Association*, 288, 1728-1732.

Ortega, F.B., Tresaco, B., Ruiz, J.R., Moreno, L.A., Martin-Matillas, M., Mesa, J.L., *et al.* (2007). Cardiorespiratory fitness and sedentary activities are associated with adiposity in adolescents. *Obesity*, 15, 1589-1599.

Ostojic, S.M., & Stojanovic, M.D. (2010). High aerobic fitness is associated with lower total and regional adiposity in 12-yr-old overweight boys. *Journal of Sports Medicine and Physical Fitness*,50, 443-449.

Ostojic, S.M., O'Neil, M., Calleja, J., Terrados, N., & Stojanovic, M. (2010a).Cardiorespiratory fitness and adiposity in overweight and non-overweight 8-year-old school children. *Minerva Pediatrica*, 62, 537-543.

Ostojic, S.M., Stojanovic, M., Stojanovic,V., & Maric, J. (2010b).Adiposity, physical activity and blood lipid profile in 13-year-old adolescents. *Journal of Pediatric Endocrinology and Metabolism*, 23, 333-344.

Ostojic, S.M., Stojanovic, M.D., Stojanovic, V., Maric, J., & Njaradi, N. (2011). Correlation between fitness and fatness in 6-14-year-old Serbian school children. *Journal of Health, Population and Nutrition*, 29, 53-60.

Roberts, S.B., Lucas, A., & Hirsch, J. (2000). Low energy expenditure as a contributor to infant obesity. *American Journal of Clinical Nutrition*, 71, 154-156.

Rodríguez-Oliveros, G., Haines, J., Ortega-Altamirano, D., Power, E., Taveras, E.M., González-Unzaga, M.A., *et al.*(2011). Obesity determinants in Mexican preschool children: parental perceptions and practices related to feeding and physical activity. *Archives of Medical Research*, 42, 532-539.

Rolland-Cachera, M.F., Deheeger, M., Maillot, M., & Bellisle, F. (2006) Early adiposity rebound: causes and consequences for obesity in children and adults. *International Journal of Obesity*, 30, 11-17.

Rowland, T., Goff, D., Martel, L., & Ferrone, L. (2000). Influence of cardiac functional capacity on gender differences in maximal oxygen uptake in children. *Chest*, 117, 629–635.

Rowlands, A.V., Eston, R.G., & Ingledew, D.K. (1999). Relationship between activity level, aerobic fitness, and body fat in 8- to 10-yr-old children. *Journal of Applied Physiology*, 86, 1428-1435.

Ruiz, J.R., Rizzo, N.S., Hurtig-Wennlöf, A., Ortega, F.B., Warnberg, J., & Sjöström, M. (2006). Relations of total physical activity and intensity to fitness and fatness in children; The European Youth Heart Study. *American Journal of Clinical Nutrition*, 84, 299–303.

Ruiz, J.R., Ortega, F.B., Loit, H.M., Veidebaum, T., & Sjöström, M. (2007). Body fat is associated with blood pressure in school-aged girls with low cardiorespiratory fitness: the European Youth Heart Study. *Journal of Hypertension*, 25, 2027-2034.

Sirard, R.J., & Russell, R.P.(2001). Physical activity assessment in children and adolescents. *Sports Medicine*, 31, 439-454.

Slaughter, M.H., Lohman, T.G., Boileau, R.A., Horswill, C.A., Stillman, R.J., Van Loan, M.D., *et al*. (1988). Skinfold equations for estimation of body fatness in children and youth. *Human Biology*, 60, 709-723.

Stojanovic, D., & Belojevic, G. (2009). Prevalence of obesity among children aged 6-7 years in South-East Serbia. *Obesity Reviews*, 10, 262-264.

Stickland, M.K., Petersen, S.R., & Bouffard, M. (2003) Prediction of maximal aerobic power from the 20-m multi-stage shuttle run test. *Canadian Journal of Applied Physiology*, 28, 272-82.

Sugimori, H., Yoshida, K., Miyakawa, M., Izuno, T., Kishimoto, T., Takahashi, E., *et al.* (1997). Influence of behavioral and environmental factors on the development of obesity in three-year-old children: a case-control study based on Toyama study. *Environmental Health and Preventive Medicine*, 2, 74-78.

Tjepkema, M. (2006). Adult obesity. *Health Reports*, 17, 9-25.

Tomkinson, G., & Olds, T. (2007) Secular changes in pediatric aerobic fitness test performance: the global picture. *Medicine and Sport Science*, 50, 46-66.

Twisk, J.W. (2001). Physical activity guidelines for children and adolescents: a critical review. *Sports Medicine*, 31, 617-627.

van Mechelen, W., Hlobil, H., & Kemper, H.C. (1986). Validation of two running tests as estimates of maximal aerobic power in children. *European Journal of Applied Physiology and Occupational Physiology*, 55, 503-506.

van Stralen, M.M., te Velde, S.J., van Nassau, F., Brug, J., Grammatikaki, E., Maes, L., *et al.* (2010). Weight status of European preschool children and associations with family demographics and energy balance-related behaviors: a pooled analysis of six European studies. *Obesity Reviews*, 13, S29-41.

Wang, Y. (2002). Is obesity associated with early sexual maturation? A comparison of the association in American boys versus girls. *Pediatrics*, 110, 902-909.

Wang, Y., Monteiro, C., & Popkin, B.M. (2002).Trends of obesity and underweight in older children and adolescents in the United States, Brazil, China, and Russia. *American Journal of Clinical Nutrition*,75, 971–977.

Warburton, D.E., Nicol, C.W., & Bredin, S.S. (2006). Health benefits of physical activity: the evidence. *CMAJ*, 174, 801-809.

Washington, R.L., von Gundy, J.C., Cohen, C., Sondheimer, H.M., & Wolfe, R.R. (1988). Normal aerobic and anaerobic exercise data for North American school-age children. *Journal of Pediatrics*, 112, 223-233.

Weedn, A.E., Ang, S.C., Zeman, C., & Darden, P.M. (2012). Obesity prevalence in low-income preschool children in Oklahoma. *Clinical Pediatrics*, (in press).

Wilmore, J.H., & Behnke, A.R. (1969). An anthropometric estimation of body density and lean body weight in young men. *Journal of Applied Physiology*, 27, 25-31.

Winsley, J.R., Armstrong, N., Midlebrooke, R.A., Ramos-Ibanez, N., & Williams, C.A. (2006). Aerobic fitness and visceral adipose tissue in children. *Acta Pædiatrica*, 95, 1435-1438.

Wolfarth, B., Bray, M.S., Hagberg, J.M., Perusse, L., Rauramaa, R., Rivera, M.A., *et al*. (2005). The human gene map for performance and health-related fitness phenotypes: The 2004 update. *Medicine and Science in Sports and Exercise*, 37, 881–903.

Yoshizawa, S., Ishizaki, T., & Honda, H. (1977). Physical fitness of children aged 5 and 6 years. *Journal of Human Ergology*, 6, 41-51.