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Physical activity levels and energy expenditure in urban Serbian adolescents - a preliminary study

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Abstract

Introduction: **The aim of this study was to evaluate the level of PA and EE in Serbian urban adolescents, using an objective measure. In particular, we explored gender and weight status related differences in PA level and EE among Serbian adolescents. In addition, their PA and EE obtained during schooldays and weekends were compared.**

Methods: **From the representative sample of elementary schools in Belgrade, one school was selected by random sampling for the purpose of the objective PA assessment. The sample included 115 students (53 boys and 62 girls) of the average age 14.0 (0.6) years. EE and the duration of PA levels were assessed by the Sense Wear PRO_3 Armband device (Body Media Inc., Pittsburgh, PA, USA). IOTF cut-off points were used to define subjects as non-overweight, overweight or obese. Analysis of variance was applied to examine the impacts of gender and weight status on EE and PA duration.**

Results: **Adolescents spent most of the time in sedentary regime 241.7 ± 62.8 min/day, on average and they were totally physically active for 196.0 ± 73.5 min/day. Boys accumulated more PA than girls and during schooldays, the PA of all adolescents was higher than during weekend days. OW girls spent less time in total PA, MPA, and VVPA. On the other hand, NW and OW boys differed only in VVPA. Consequently, OW girls had lower energy expenditure compared with their NW peers, but no such differences in boys were found.**

Discussion: **The results of this study indicate that low PA activity might be a more important factor in propagation of overweight in girls than boys, at least in early adolescent period. PA in girls should be strongly encouraged, with a special focus on vigorous PA during weekends.**

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Key words: *Physical activity. Energy expenditure. Adolescents.*

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NIVELES DE ACTIVIDAD FÍSICA Y DESGASTE ENERGÉTICO EN ADOLESCENTES URBANOS SERBIOS - ESTUDIO PRELIMINAR

Resumen

Introducción: **El objetivo de este estudio era evaluar el nivel de AF (actividad física) y DE (desgaste energético) en adolescentes urbanos serbios, usando una medida objetiva. En particular, exploramos las diferencias relacionadas con género y peso en el nivel de AF y DE entre los adolescentes serbios. Además, se comparó la AF y DE obtenidos durante los días de colegio y durante los fines de semana.**

Métodos: **A partir de la muestra representativa de los colegios de primaria de Belgrado, se seleccionó un colegio aleatoriamente para la evaluación de la AF objetivo. La muestra incluyó a 115 estudiantes (53 niños y 62 niñas) con una edad media de 14,0 (0,6) años. Los niveles de DE y la duración de la AF fueron evaluados mediante el dispositivo de detección en el brazo Sense Wear PRO3 Armband device (Body Media Inc., Pittsburgh, AF, USA). Se emplearon puntos de selección IOTF para definir a los sujetos como sin sobrepeso, con sobrepeso u obesos. Se aplicó el análisis de la varianza para examinar los impactos de género y peso sobre el DE y la duración de la AF.**

Resultados: **Los adolescentes pasan la mayor parte del tiempo en un régimen sedentario 241,7 ± 62,8 min/día como media, y su actividad física total fue de 196,0 ± 73,5 min/día. Los niños acumularon más AF que las niñas durante los días de colegio, y la AF de todos los adolescentes fue superior que en los días del fin de semana. Las niñas con sobrepeso pasaron menos tiempo en AF total, MAF, y VVAF. Por su parte, los niños con peso normal y sobrepeso difirieron solo en VVAF. Consecuentemente, las niñas con sobrepeso presentaron un menor desgaste energético en comparación con aquellas con peso normal, pero no se encontró tanta diferencia en niños.**

Debate: **Los resultados de este estudio indican que una baja AF podría ser un factor más importante en la propagación del sobrepeso en niñas que en niños, por lo menos en el periodo preadolescente. Se debería fomentar la AF entre las niñas, con especial atención a una AF vigorosa durante los fines de semana.**

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Introduction

Physical activity (PA) is a term commonly used to define any bodily movement produced by skeletal muscles that results in energy expenditure (EE)[1]. Total daily energy expenditure (TEE) represents all of the types of EE in 24 hours, whereas EE associated with PA is the most variable TEE component generated by the daily activity levels, which include employment, sport, and any other activities. PA and physical activity energy expenditure (PAEE) are highly variable among individuals and need to be accurately measured to establish their relationship with health outcomes[2]. TEE has declined in children and adolescents, which is a direct result of a decline in PA among children and adolescents, and an accompanying increase in sedentary behavior[3].

The knowledge about the health benefits of regular PA has contributed to the establishment of public health recommendations for children and adolescents on an adequate level of PA[4]. Despite these recommendations, epidemiological studies indicate that the level of PA is declining with age[5], and adolescence is recognized as a period when this decline is most pronounced[6]. It has been shown that low PA in adolescence independently predicts obesity in adulthood[7] and that PA levels in youth track into adulthood[8,9]. The time spent in sedentary behavior is inversely associated with the PA level in adolescents[10-12], and this is more common in girls[13]. The results of research in different countries also indicate that male adolescents are more active than female adolescents[13-16]. Therefore, the period of adolescence seems to be a critical time (especially for girls) when the risk for obesity increases and the amount of activity drops greatly[17]. In addition, the question is whether boys and girls are more active during schooldays or during weekends and to what extent it contributes to their total PA. Previous researches have shown that adolescents are more active on schooldays than during weekends and others report no difference or higher levels of activity during weekends[18-21].

Another insufficiently explained question is the question about the relations between PA and obesity during adolescence. There is evidence suggesting that overweight and obese children and adolescents are less active than their normal weight peers[17,22], but it is unclear which aspects of PA such as frequency, intensity and volume are related to overweight and obesity. Previous studies that used objective methods to investigate the relationship between PA and obesity have shown conflicting results. While some studies show overweight status or obesity to be inversely related to PA measures[23], other report no association[24]. One reason for this uncertainty is a discrepancy of different methodology used to assess PA. Thus, to better understand the contribution of PA to TEE in adolescents, and to understand how this contributes to overweight and related chronic disease risk factors, it is important to implement techniques to accurately assess EE. In an attempt to increase the accuracy of predicting EE, the SenseWear Pro$_3$ Armband (SWA) utilizes a combination of measurement systems: accelerometry, galvanic skin response, near-body ambient temperature, skin temperature, and heat flux. The SWA detects and measures PA of the lower and upper body and is able to detect the change in EE associated with load carrying, change of grade and non-ambulatory PA, thus eliminating the drawbacks of PA assessment based only on accelerometer data[25].

As far as we are aware, there have been no studies in Serbia that used objective measures for measuring PA in adolescents so far. Studies that used self-report to assess the PA of adolescents in Serbia have shown that there is no difference in PA level between normalweight and overweight/obese adolescents[26]. Furthermore, in Serbia, as in most European countries[11,12], a change in diet and lifestyle (sedentary) has been noted, which is reflected in an increase of the number of overweight/obese children and adolescents in the past 15 years. According to the data from 2011, the prevalence of overweight and obesity in a representative sample of Belgrade children and adolescents, aged 9 to 14, was 24.2%, with 19.2% being overweight and 5% being obese[27]. Having in mind that PA can be important in the regulation of body weight, fatness, and the structural and functional integrity of bone and skeletal muscle tissues[28], and also that it can be an important factor in maintaining health and well-being of children and youth, there is an interest to explore the associations of PA and overweight in adolescents in Serbia. Also, PA monitoring and promotion must be two basic objectives in public health across the world, so the results of this study should contribute to better understanding of the general behavior of adolescents in terms of their PA and EE, as well as to contribute to the direction in which it should be moving some future research on this problem.

Therefore, the aim of this study was to evaluate the level of PA and EE in Serbian urban adolescents, using an objective measure (SWA). In particular, we explored gender and weight status related differences in PA level and EE among Serbian adolescents. In addition, their PA and EE obtained during schooldays and weekends were compared. We expect that the obtained findings would provide more insight in the activity level of Serbian urban adolescents.

Methods

Participants

As a part of a wider national project, aimed to follow up schoolchildren's physical fitness and PA during the elementary school time in the territory of Serbia, a study has been designed aimed to assess the self-reported level of PA among schoolchildren in the capital of Serbia (Belgrade, 1,232,731 inhabitants). Moreover, in a subsample the level of PA was examined using an objective method (i.e. a multi-sensor activity monitor). The limiting factor to conduct that research on the representati-

ve sample was the number of available SWA devices. Therefore, one school from Belgrade was selected by random sampling for the purpose of the objective PA assessment whereas after surveying, 157 (62%) out of 254 available students of the seventh and the eighth grade of elementary school, aged 13-14 years, agreed to participate in the study. Based on body mass and height measurement performed prior the study, children who agreed to participate in the study were compared in terms of BMI with those who didn't. T - test revealed no difference in BMI between those boys (p=0.56) and girls (p= 0.59) who participated in the study and those who did not. In addition, there were no differences in the sum of skinfolds between the boys (p=0.22) and girls (p= 0.08) who participated in the study and those who did not. Out of the total number of students in the study, the results of 42 students were not included in the analysis because they did not fulfill the measurement requirements, so that at the end of measurement the sample included 115 students (53 boys and 62 girls) of the average age 14.0 (0.6) years (Table I). Students were further classified relative to gender and weight status[29], into NW students [83 students (boys – 33, girls – 50)] and overweight and obese (OW) [the total of 32 students (boys – 20, girls – 12)]. Overweight included both, overweight (10 girls and 16 boys) and obese adolescents (2 girls and 4 boys).

Measures

Apparatus

EE and the duration of PA levels were assessed by the Sense Wear PRO_3 Armband device (Body Media Inc., Pittsburgh, PA, USA). The SWA is a wireless, noninvasive, multiple-sensor activity monitor that is worn over the triceps muscle. The SWA PRO_3 monitor integrates data from five sensors including a two-axis accelerometer, heat flux sensor, galvanic skin response (GSR) sensor, skin temperature sensor, and a near-body ambient temperature sensor to estimate EE under free-living conditions. The accelerometer measures the distinct patterns created by walking and/or running. A heat flux sensor measures the amount of heat dissipating from the body. A GSR sensor is used as an indicator of evaporative heat loss and is measured by means of two hypoallergenic stainless steel electrodes. This measures the electrical conductivity of the skin, which changes in response to sweat and emotional stimuli. Skin temperature is used as an estimate of the body's core temperature during PA and is measured by a sensitive electronic thermometer. A body temperature sensor measures the temperature of the cover on the armband side. The SWA has been validated in free-living adults, children and adolesecents in several studies[25,30].The information from the sensors, together with gender, age, height, weight and handedness is incorporated into proprietary algorithms (Sense Wear Professional software version 6.1; Body Media Inc.) to estimate EE and PA duration. These algorithms are age and activity specific and are automatically applied on the basis of an analysis of the pattern of signals from the sensors. Data from all the sensors are averaged over 1-min periods, and these data were stored in memory and subsequently downloaded to a computer.

Outcomes variables were further relativized as total daily energy expenditure (TEE), physical activity energy expenditure (PAEE energy expended for PA requiring > 3 METs) and the duration of PA performed at various intensities. The intensity was described as metabolic equivalents (METs). Time spent in 1.5-2.9 METs was classified as light physical activity (LPA) time spent in 3-5.9 METs was classified as moderate physical activity (MPA), time spent in 6-8.9 METs was classified as vigorous physical activity (VPA) and time spent in > 9 METs was classified as very vigorous physical activity (VVPA). Total PA variable implies total PA, i.e. all the PAs above 3 METs, regardless of their level. The thresholds of 3.0, 6.0 and 9.0 METs were selected as they estimate a walking pace of 4 km/h, a running pace of 7 and 10 km/h respectively[31], and have been frequently used in defining PA in children[14,32,33].

The proportion of adolescents achieving current health-related PA recommendations established by the United Kingdom Expert Consensus Group[34] was calculated separately for schooldays and weekend days. These recommendations suggest a minimum daily accumulation of at least 60 min of moderate-intensity activity. In addition, the proportion of adolescents achieving a minimum daily accumulation of at least 20 min of vigorous PA ≥ 3 days, suggested by the Healthy people 2010 (US Department of Health and Human Services), was also estimated in this study[35].

Procedures

All the measurements were performed during the spring (March till June) in 2011. The consent was solicited from the participating school boards, and student participation was voluntary. Written, informed consent containing a full explanation of the aims of the study, its protocol and the possible hazards, discomfort, and inconvenience related to the procedures used was obtained from the student's parent or legal guardian. In addition, all the procedures have been verbally explained to students, together with any possible discomfort they might encounter. Also, the students were explained that they were free to withdraw from the study at any time.

Data related to gender, age, height, body weight, lateralization and non/smoking status of a respondent were programmed in SWA prior to its activation and they represent proprietary algorithm for EE assessment. In order to provide reliable data on PA in children and adolescents, it takes at least 3 days of monitoring, according to previous research[31]. Within the protocol, the respondents were instructed to wear de-

vices over the triceps muscle of their right arm, during entire four consecutive days (including two schooldays and both weekend days), except during bathtime and other water activities. The requirement for further data analysis, i.e. participation in the study, was that students wear devices on their arms for a minimum of 21 hour a day. The study protocols were approved by the Ethics Committee of the Faculty of Sport and Physical Education of the University of Belgrade.

Anthropometrics

Measurement of Body Mass and Its Classification

Subjects were barefoot in their shorts and T-shirts. Height was measured with Seca stadiometers (Seca Instruments Ltd., Hamburg, Germany) to the nearest 0.1 cm and weight with pre-calibrated portable weighting scales Tanita Inner Scan Model BC-587 (Tanita Europe GmbH., Sindelfingen, Germany) to the nearest 0.1 kg. The body mass index (BMI) was calculated as body mass weight / height^2 (kg / m^2). The international age- and gender-specific child BMI cut-off points for children developed by the Childhood Obesity Working Group of the International Obesity Task Force were used to define subjects as non-overweight, overweight or obese[29]. Participants were evaluated during school physical education classes by physical education teachers specially trained for this data collection.

The sum of five skinfolds, /S5SF = sum of five skinfolds (biceps, triceps, subscapular, suprailiac and calf)/ was used as a control variable of BMI index. Skinfold thickness was measured on the left side of the body to the nearest 0.1 mm with a skinfold caliper (Caliper Holtain; Holtain Ltd., Walles, UK) at the following sites: (1) triceps, halfway between the acromion process and the olecranon process; (2) biceps, at the same level as the triceps skinfold, directly above the centre of the cubital fossa; (3) subscapular, about 20 mm below the tip of the scapula, at an angle of 45º to the lateral side of the body; (4) suprailiac, about 20 mm above the iliac crest and 20 mm towards the medial line; (5) calf, at the level of maximum calf circumference, on the medial aspect of the calf.

Variables

The group of independent variables included gender, weight status - based on BMI[29], schooldays and weekend days, while the group of dependent variables consisted of those from the field of SWA analysis– TEE (kJ/kg/day), PAEE (kJ/kg/day), LPA (min / day), TPA (min / day), MPA (min / day),VPA (min / day), VVPA (min / day). A control variable was the sum of five skinfolds, S5SF = sum of five skinfolds (biceps, triceps, subscapular, suprailiac and calf).

Statistical analysis

Kolmogorov-Smirnov test indicated a normal distribution of results except in VVPA variables in boys and girls during weekend days. Analysis of variance (ANOVA) was applied to examine the impacts of gender (male/female) and weight status (NW/OW) on EE and PA duration. T–test was used to examine possible differences in BMI and the sum of skinfolds (S5SF) between the boys and girls who participated in the study and the students (boys and girls) of the same age from the school who did not participate in the study. Differences in EE and PA duration between schooldays (mean of two schooldays) and weekend days (mean of Saturday and Sunday) were assessed using repeated measures ANOVA with one between-subjects factor (boys vs. girls and overweight vs. normal-weight children). Frequency distribution was used to determine how many respondents achieved the recommended PA standards (60 min of MPA and 20 min of VPA during ≥ 3 days), and chi –square test was used to examine possible differences between the groups of adolescents in achieving these standards. Statistical significance was at the level of $p < 0.05$. All data were analyzed using SPSS 17.0 (SPSS INC, Chicago, IL).

Table I
Age, physical characteristics and body composition of all, OW and NW children stratified by gender

	Boys				*Girls*				*Boys/Girls*
	All (n = 53)	*Overweight (n = 20)*	*Non-overweight (n = 33)*	*PES*	*All (n = 62)*	*Overweight (n = 12)*	*Non-overweight (n = 50)*	*PES*	*PES*
Age (years)	13.9±0.5	13.9±0.5	13.9±0.5	0.01	14.0±0.6	14.0±0.6	14.0±0.6	0.01	0.01
Height (m)	1.68±0.11^c	1.71±0.11	1.66±0.98	0.06	1.64±0.06	1.63±0.45	1.64±0.62	0.01	0.06
Weight (kg)	61.2±16.9^a	75.5±16.5	52.5±9.8^c	0.44	55.8±12.1	71.1±17.8	52.1±6.4^c	0.39	0.03
BMI (kg/m^2)	21.4±4.0	25.5±3.1	18.9±2.0^c	0.63	20.8±4.0	26.4±5.5	19.4±1.8^c	0.49	0.01
S5SF (mm)	57.5±30.5	85.7±30.4	40.4±12.9^c	0.53	61.6±24.9	94.6±32.4	53.7±14.4^c	0.43	0.01

Values are mean ± SD. BMI = body mass index; S5SF = sum of five skinfolds (biceps, triceps, subscapular, suprailiac and calf); PES = Partial Eta Squared. Significant difference within gender, overweight and non-overweight group group $^a p < 0.05$; $^b p < 0.01$; $^c p < 0.001$;

Results

Out of 157 students, 115 students (73%) managed to wear SWA monitors over 4 entire days or a minimum of 21 hour a day. Boys wore SWA 22.4 h/day on average, whereas girls wore it 22.5 h/day on average. Physical characteristics of the respondents are shown in Table I. Adolescent boys were taller and heavier than the girls of the same age, whereas there were no differences in BMI and the sum of skinfolds. According to BMI[29], 72.2% of adolescents were non-overweight, 22.6% were overweight and 5.2% were obese. The observed relativized EE in all adolescents during four days was approximately 185.3 ± 25.0 kJ/kg/day, whereas EE during PA was 69.4 ± 29.2 kJ/kg/day. Adolescents spent most of the time in sedentary regime 241.7 ± 62.8 min/day, on average and they were totally physically active 196.0 ± 73.5 min/day (Table II). During schooldays, the PA of all adolescents was higher than during weekend days. Within different levels of PA, they spent 76% of the time in MPA, 21% in VPA and 3% in VVPA.

ANOVA showed that there were gender differences in favor of boys in all the observed variables, during the entire period, both schooldays and weekend days, except in MPA during weekend days. Physical characteristics of adolescents stratified according to gender and weight status are given in Table I. There was a significant difference between non-overweight (NW) adolescents (boys and girls) and overweight adolescents (OW) in weight, BMI and S5SF (Table I).

Estimated relativized TEE, PAEE and daily PA of NW and OW adolescents were stratified according to gender. The following results have been obtained. Estimating relativized TEE in NW and OW adolescents, the difference was found in girls, whereas no differen-

Table II
Relativized overall energy consumption during PA and overall PA during working days and weekend days stratified by gender and body status of the respondents

		Boys				*Girls*			*Boys/Girls*	
		All (n = 53)	*Overweight (n = 20)*	*Non-overweight (n = 33)*	*PES*	*All (n = 62)*	*Overweight (n = 12)*	*Non-overweight (n = 50)*	*PES*	*PES*
TEE (kJ/kg/day)	All days	197.1±25.1[c]	191.8±23.7	200.3±26.0	0.03	175.3±20.5	157.3±16.2	179.6±19.3[c]	0.19	0.19
	Schooldays	207.1±27.1[c]	203.1±26.6	209.6±27.6	0.01	180.7±20.9	163.5±20.1	185.1±19.3[c]	0.16	0.23
	Weekend days	182.1±35.9[c]	175.0±26.0	186.6±40.5	0.02	167.0±25.5	147.2±19.2	171.5±24.6[c]	0.14	0.06
PAEE (kJ/kg/day)	All days	84.3±30.1[c]	82.4±28.5	85.4±31.6	0.01	56.6±21.1	46.5±13.7	59.0±21.8	0.06	0.23
	Schooldays	94.6±32.6[c]	92.8±30.1	95.5±34.6	0.01	62.6±22.4	54.0±19.7	64.9±22.4	0.04	0.25
	Weekend days	69.1±41.0[c]	66.6±33.1	70.2±45.6	0.01	47.3±25.0	34.8±13.6	50.6±26.3[c]	0.06	0.09
Light PA (min/day)	All days	210.2±54.1	223.1±52.5	202.4±54.4	0.03	286.6±57.2[b]	234.8±48.6	276.7±56.6[a]	0.08	0.22
	Schooldays	227.4±69.5	242.5±70.4	218.3±68.4	0.03	293.9±65.3[b]	256.1±66.8	302.9±62.3[a]	0.08	0.20
	Weekend days	192.9±50.6	203.6±50.0	186.5±50.7	0.03	243.3±64.6[b]	213.5±35.2	250.5±68.2[b]	0.05	0.16
Total PA (min/day)	All days	229.0±73.1[c]	229.2±71.2	228.9±75.3	0.01	167.8±62.5	134.0±37.0	175.9±63.7[c]	0.07	0.17
	Schooldays	257.2±76.1[c]	255.1±68.5	258.5±81.3	0.01	185.5±63.4	154.2±51.9	193.0±64.0	0.06	0.21
	Weekend days	186.7±98.1[c]	190.4±93.4	184.4±102.1	0.01	141.2±73.9	103.6±39.4	150.2±77.7[c]	0.06	0.07
MPA (min/day)	All days	161.7±51.1[b]	171.0±59.3	156.0±45.4	0.02	138.4±48.6	115.8±41.3	143.8±49.0	0.05	0.05
	Schooldays	182.3±51.7[c]	188.7±57.2	178.4±48.6	0.01	150.2±48.5	124.1±36.6	156.5±49.2[a]	0.07	0.09
	Weekend days	130.7±68.1	144.6±69.9	122.3±66.7	0.03	120.7±62.7	103.4±72.5	124.9±60.2	0.02	0.01
VPA (min/day)	All days	61.3±36.2[c]	56.3±27.4	64.3±40.8	0.01	26.4±17.6	23.6±17.2	27.1±17.8	0.01	0.28
	Schooldays	66.1±39.2[c]	64.1±31.2	67.3±43.7	0.01	29.3±21.4	28.7±24.6	29.5±20.8	0.01	0.26
	Weekend days	54.1±57.2[c]	44.7±36.2	59.8±66.6	002	22.1±19.1	16.0±17.0	23.5±19.5	0.02	0.13
VVPA (min/day)	All days	7.1±7.6[c]	3.6±4.0	9.3±8.4[b]	0.13	2.4±2.7	0.7±0.8	2.8±2.9[c]	0.10	0.16
	Schooldays	8.6±10.8[c]	4.9±5.9	10.8±12.4[a]	0.07	2.6±3.8	1.0±1.4	3.0±4.0[c]	0.05	0.13
	Weekend days	4.9±8.8[a]	1.6±2.8	6.9±10.4[b]	0.09	2.1±3.9	0.2±0.4	2.6±4.2[c]	0.06	0.04

Values are mean ± SD. TEE = total energy expenditure; PAEE = physical activity energy expenditure; Light PA = light physical activity (1.5-2.9 METs); Total PA = total amount of physical activity (>3 METs); MPA = moderate physical activity (3-5.9 METs); VPA = vigorous physical activity (6-8.9 METs); VVPA = very vigorous physical activity (>9 METs); PES = Partial Eta Squared. Significant difference within gender, overweight and non-overweight group group [a]$p < 0.05$; [b]$p < 0.01$; [c]$p < 0.001$;

ces were found in boys (Table II). OW girls had lower relativized TEE value over all four measurement days but also separately during two schooldays and two weekend days. When analyzing relativized values of TEE during PA, no differences were found in boys, while in NW and OW girls, there difference occurred only during weekend. OW girls had lower PAEE value during weekend in relation to NW girls (Table II).

Observing LPA of the adolescents from these groups, there were no differences between OW and NW in boys, while there were significant differences between NW and OW groups in girls. NW girls spent significantly more time in LPA than OW girls, and that was the case during all four days of measurement, but also separately observing, during schooldays and weekend days. NW girls in our sample spent most of the time in LPA, and particularly during weekend days (302.9 ± 62.3 min / day).

When it comes to the variables related to PA: total PA, MPA, VPA and VVPA, the results obtained in boys show that they only differed in VVPA variable. OW boys spent significantly less time in VVPA in total, but also separately during schooldays and weekend days.

The following results have been obtained in girls: OW girls spent less time in total PA during all days of measurement, as well as during weekend in relation to NW girls. Observing MPA, the differences occurred during schooldays since OW girls spent less time in MPA than NW girls. There were no differences observed in VPA in girls, and in the case of VVPA variable, NW girls spent significantly more time in activities of that intensity in relation to OW girls both over the entire time period and during schooldays and weekend days respectively.

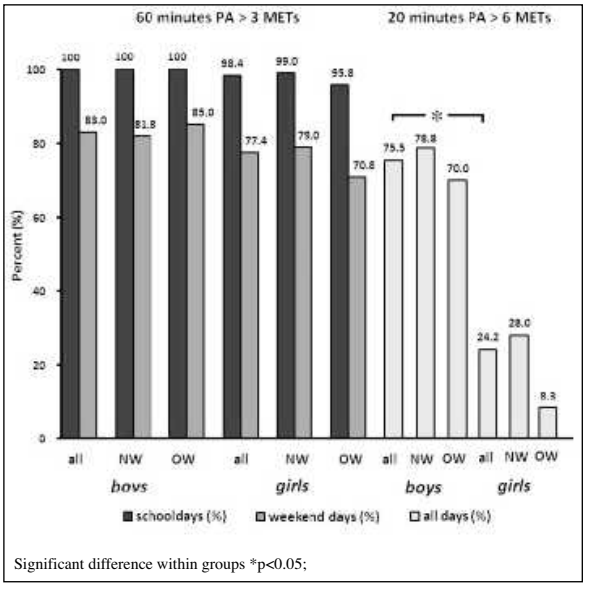

Fig. 1.—Proportion of children accumulating at least 60 min of PA > 3 METs and 20 minutes vigorous PA ≥ 3 days per week (> 6 METs) during either schooldays and weekend days or all days stratified by gender and weight group.

Figure 1 shows the percentage of adolescents (boys and girls), as well as the adolescents (OW and NW) who achieved at least 60 min of MPA and at least 20 min of VPA during ≥ 3 days. There were no differences between the observed groups in achieved recommended standard of 60 min during schooldays and weekend days. While in the recommended standard of 20 min of VPA during ≥ 3 days, and based on the chi-square test of independence, the relation between gender and the percentage of those who were 20 and more minutes in VPA ≥ 3 days was found, c2 (1, n = 115) = 28.090, p = 0.001, there was a difference in favor of boys. As to the percentage showing groups based on weight status there were no differences in boys and girls.

Discussion

This is the first study in Serbia which objectively reports on the daily assessment of PA and EE levels in Serbian adolescents. Introduction of objective measurements of daily PA represents a new era in comparison to previous studies which mainly used the methods of self-reporting to assess activity in children and adolescents[16,26]. Improving the methodology of PA measurement, such as the application of SWA devices, is of utmost importance if we want to use the results of such studies as references when establishing the health policy of a country.

One of the findings obtained in this pilot study, that male and female adolescents spent most of their time in LPA, indicates the necessity of further researches of this type in a representative sample of the population of this age, as well as necessary actions of health policy of our country in preventing the consequences of insufficient PA in youth. As in the case of similar researches of this type[21,24,36,37], and in this study as well, female adolescents, regardless of weight status, spent most of the time during day in LPA. When it comes to PA level, the activity mostly practiced by both male and female adolescents in this study was MPA. Comparing the obtained results to EYHS study which analyzed MPA in adolescents of similar age from Europe, the boys and girls in our study spent more time in MPA in relation to their peers from Portugal, Denmark, Estonia and Norway[14]. Considering the time spent in PA of adolescents during schooldays as well as during weekend days the differences were noticed in favor of schooldays, as well as in similar studies[18,20,24]. Boys and girls were more active during schooldays in comparison to weekend days. In a longitudinal study which dealt with the assessment of different levels of PA in children from the USA from 9 to 15 years of age[19], it was found that the critical age for achieving the standard of 60 min of MPA during schooldays is 13.1 years in girls, and 14.7 years in boys. During weekend, that critical age was 12.6 years in girls and 13.4 years in boys. Taking into account the results of this study[19], as well as the results of our and

some previous studies[18,24], in the following period, it is necessary to promote PA during weekend days, i.e. to organize interesting events dedicated to adolescents of both gender, which would contribute to the improvement of their PA.

Gender differences in the volume of daily PA, as well as in EE were confirmed in this study. The total average PA was 27% higher in boys than in girls, which is similar to the findings of the EYHS study in European adolescents[14]. In the overall sample the average TEE was 11% higher, as well as the average PAEE, which was 38% higher in boys than in girls, and these findings are similar to the studies in English and Dutch adolescents[13,15]. Moreover, observing PAEE during schooldays and weekend days, the results of our study as well as of the study in Dutch adolescents have shown that PAEE in adolescents was higher during schooldays[15]. Although there are socio-cultural and economic differences between countries in Europe, the obtained results suggest that adolescents have higher PAEE during schooldays because they are, presumably, more active within their school and extracurricular activities during those days.

When it comes to different PA levels, there were gender differences in all the observed variables over the entire time period, schooldays and weekend days, except in MPA during weekend days, in favor of boys. The results of this study are similar to the results of other studies of this type, and they have confirmed that the boys of this age were physically more active than girls[13,14,18,19,24,31,36,38]. Previous studies have already determined a decline in the volume of PA in girls from childhood to adolescence[19,24,33], and others assume that differences in the levels of PA between boys and girls may be partially explained by establishing different gender roles in children during growing up[36]. Observations that boys participated in total PA in a much larger scale than girls indicate the need for developing and introducing some new PA programs tailored to the interests of girls of this age. As recommended in other studies dealing with this issue[19,33], we should find a way, within the framework of a national strategy, to motivate and encourage girls to participate in PA.

Major findings of this study observing relativized values of TEE and relativized values of total EE during PA, in NW and OW adolescents are that in boys there were no differences in these values, while OW girls had lower relativized TEE value over all four days of measurement as well as during two schooldays and weekend days. When it comes to PAEE, OW girls had lower PAEE value during weekend compared to NW girls. Comparisons between studies are very difficult due to the differences in design, methodology, and the interpretation of results. However, comparing the obtained results with a study in which the respondents, a little younger, aged 10-11, were measured by the same methodology[20], it may be noticed that the results differ because in that study significant difference in TEE and PAEE was obtained in both boys and girls, whereas in our study, the differences occurred only in girls. What should be noted in relation to the Croatian study[20] is that the data, in one part, were not relativized in relation to body weight, so that a group of OW children had an absolutely increased energy consumption compared to NW group. After EE and PAEE relativization, the data were similar to the results of our study.

Also, major findings of this study show that the time spent in total PA was the same in both NW boys and OW boys, but the distribution according to the intensity of PA was different. Observing different PA levels there was no difference between NW and OW boys in LPA, MPA, and VPA, while NW boys spent significantly more time in VVPA, both over the entire time period and during schooldays and weekend days. Students from OW group spent less time in VVPA, but they compensated it within MPA (Table II). Analyzing the results obtained in the studies that measured PA by accelerometers, it may be noticed that the results are inconsistent. In the studies[20,22,23,36] NW boys both of the same or similar age, were physically active longer than OW boys, while in our study, as in some others[22,24,38], there was no difference in the time spent in PA. Comparing boys of different weight status but of younger age[39] no differences were found in the time spent in MPA. As for the findings in this study, it may be speculated why there was no difference in the observed variables in boys. One of the reasons may be attributed to the specificity of the sample in which OW group consisted of more overweight than obese boys (16 overweight and 4 obese boys). Overweight boys had the total PA of 160.2 min/day, whereas obese boys had the total PA of 148.3 min /day. OW boys, regardless of their weight status, did not lack any motor skills or confidence to participate actively in physical education classes. In addition, at school, they were encouraged and motivated by their physical education teachers to be active in physical education classes, and to take part in PA in their free time in accordance with their abilities, and this is one possible explanation why there were no differences between these groups.

Analyzing PA in girls of different weight status, the following results were obtained in this study. The girls from NW group spent most of the time in LPA and it was much more than the girls from OW group. This suggests that the problem of the inactivity in adolescents, especially girls, is not related only to OW population, but it is normal behavior of young people of this age[21,24]. Also, one of the possible explanations of the obtained results may be found in the results of a study showing a positive correlation between wearing the device and PA in girls, and therefore it is possible that our OW girls wearing devices were more motivated to be more active than usual[40]. OW girls spent less time in total PA during all measurement days, as well as during weekend compared to NW girls. In the study that monitored girls of younger age and of different weight status[39], there was no difference in the time spent in MPA and in VPA, while in female adolescents

in our study, the situation was different. In our study, OW girls were significantly less physically active, 42 min/day (24%) compared to NW girls. They spent less time in MPA (28 min/day, 20%), less time in VPA (4 min/day), as well as in VVPA (3 min/day) compared to NW girls, and the obtained results are similar to those of the study in female adolescents from the American continent[21].

Analyzing the percentage of boys and girls who managed to achieve at least 60 min of MPA, during schooldays and weekend days, there were no differences between the observed groups in achieved recommended standards[34]. Based on previous studies[14,18,19], the percentage of those who manage to achieve the recommended minimum of 60 min of MPA decreases proportionally with age. MPA values in boys in this study ranged from 65 to 360 min / day during schooldays and from 13 to 390 min/day during weekend, while in girls these values were from 10 to 278 min/day during school days and from 12 to 483 min/day during weekend. All of our boys and almost all of our girls fulfilled this requirement during schooldays, whereas the percentage of boys (83%) and girls (77 %) who achieved this standard during weekend days was slightly lower. In a study that explored PA in adolescents of similar ages from four European countries[14], 82 % of boys and 62 % of girls fullfiled the requirement of 60 min of MPA, while in a Norwegian study[18] 61% of boys and 50% of girls achieved the recommended standard. Comparing the results of our study with the results of these studies, it may be noticed that in our study, the percentage of boys (92%) and girls (88%) who achieved the recommended standard was higher. One possible explanation of the obtained results may be the effects of seasonal variations in activity patterns, given that the results in our study were collected in spring, when days are longer and warmer than in winter, and PA activity in adolescents is expected to be higher. In addition, a question which the authors of an American study also speculate about[14], is whether current activity recommendation is appropriate, whether this is "enough" to provide health benefits, since most adolescents achieved the recommended standard, but the prevalence of overweight and obesity in adolescents further increases anyway. According to our research, as well as according to other studies[14], it is necessary to conduct further extensive researches that will address this issue and provide the answers to whether this recommended standard is optimal, minimal or insufficient to provide health benefits for adolescents nowadays.

In this study, the standard related to VPA which recommends continuing PA above 6 METs of 20 or more minutes during ≥ 3 days has also been set[35]. A much lower percentage of adolescents met this stricter criterion, and the percentage of girls who managed to meet it was especially low (Figure 1). According to some authors who have explored different levels of PA in children and adolescents[33], the majority of gender gap in overall PA was accounted for by the girls' low participation in vigorous-intensity activities. The percentage of boys who were 20 or more minutes in VPA during ≥ 3 days was different than that in girls (51.3% of boys met this criterion), and similar results were obtained in the American study that examined gender and age differences in PA[33]. Also, the results in this study[33] and the results of a Swedish study that monitored PA in children aged 8 to 11[32], suggest that VPA is inversely related to age, i.e. they support the notion that VPA declines rapidly during childhood and adolescence. It may be assumed that the activity of this type, which involves vigorous physical activity, decreases with age, and especially in girls, who in a much greater scale, in relation to boys, cease to be actively involved in sports exactly in adolescence.

As already mentioned, the strengths of this study are that this was the first study in Serbia which objectively reports daily assessment of PA and EE levels in Serbian adolescents during schooldays and weekend days, as well as PA and EE levels of non-overweight and overweight adolescent boys and girls. However, in addition to this, there were several limitations in this study. First, the design was of a transversal character, which limited the possibility to connect the results, and wearing SWA may also modify the normal activity of a child. Second, since this is a pilot study, we should be cautious in the generalization of the obtained data. Third, the data collection was limited to 4 days. Although this number of days was given as the adequate duration for an accurate and reliable assessment of the behavior during common activities in this age group[31], yet, extending data collection to seven days might give even more precise patterns of PA. Fourth, the activities of energetic intensity in children are rarely sustained for more than 10 seconds[37], it is possible that the interval of 1 min-sampling which was used in this study has led to the underestimation of VPA and VVPA values[31]. In the end, since biological age has not been estimated, we may not rule out the possibility that different PA levels both between genders and in OW and NW adolescents were caused by different time of maturity.

It has been found that there were gender differences in all variables, except in LPA, in favor of boys. Also, there were gender differences in all the observed variables over the entire time period, i.e. during schooldays and weekend days, except in MPA during weekend days, in favor of boys. Based on these indicators, which are similar to those in other studies, some new programs of PA tailored to the interests of girls of this age should be developed and introduced in the future, as well as a way to motivate and encourage girls to participate in PA should be found.

Observing the weight status of students, the time spent in total PA was equal in both NW and OW boys, but the distribution according to the intensity of PA was different. There was no difference in different PA levels (LPA, MPA, and VPA) between NW and OW

boys, except in VVPA where NW boys spent significantly more time both during the enitire time period and during schooldays and weekend days separately. Within the relativized values of TEE and the relativized values of total EE during PA, there were no differences in NW and OW adolescents. It may be assumed that such results have stemmed from certain specificity of the sample in which the group of OW boys consisted of more overweight than obese boys. It seems that the group of OW boys, regardless of their weight status, did not lack confidence in motor skills or motivation to be involved in PA, mostly of MPA intensity, in their free time, and in accordance with their abilities.

The girls from NW group spent most of their time in LPA and this suggests that the problem of inactivity in youth, i.e. low-intensity activities, is not related only to OW population, but it is a normal behavior of adolescents of this age, especially girls. OW girls spent less time in total PA during all days of measurement, as well as during weekend, they were also less physically active compared to NW girls. NW girls spent more time in MPA during schooldays, as well as in VVPA over the entire time period, and during schooldays and weekend days. OW girls had lower relativized TEE value during all four days of measurement, and also during two schooldays and weekend days. When it comes to relativized PAEE, OW girls had lower PAEE value during weekend in relation to NW girls.

A very large percentage of students, boys (92%) and girls (88%) in our study managed to achieve at least 60 min of MPA per a day, while a much smaller percentage of adolescents met the stricter criteria of 20 or more minutes of VPA during ≥ 3 days. The percentage of girls who managed to meet this criterion was especially low.

What should be paid attention to in the future is an increased risk for further growth (increase) in body weight due to the lack of PA in some groups. There is a need in the studies of this type to establish a causal link, with the aim of considering, through subsequent interventional studies, the ways to increase PA in adolescents through a variety of programs, both during classes and in extracurricular activities as well as to raise the awareness of parents for quality leisure time or the promotion of the contents with increased PA.

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Conflict of interest

The authors declare no conflict of interest.

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