



The role of organised sport participation in physical activity and energy expenditure patterns among Serbian adolescents: an objective monitoring study

El papel de la práctica deportiva organizada en los niveles de actividad física y gasto energético de adolescentes serbios: un estudio mediante monitorización objetiva

Authors

Milan Pašić¹

¹ University "Union – Nikola Tesla", Belgrade, (Serbia)

Corresponding author:
milan.pasic@fzs.edu.rs

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Abstract

Introduction: Physical activity was an important component of adolescent health, while energy expenditure represented a key component of daily energy balance.

Objective: This study examined differences in objectively measured physical activity and energy expenditure between sport participants and non-sport participants, stratified by sex, across school and weekend days.

Methodology: The study included 115 adolescents (53 boys, 62 girls; age 14.0 ± 0.6 years) from a primary school in Belgrade, classified as sport participants ($n = 63$) or non-sport participants ($n = 52$). Physical activity and energy expenditure were objectively assessed using the SenseWear Pro3 Armband over two school days and two weekend days.

Results: Girls who participated in organised sport had higher total energy expenditure ($p = .023$, $g = 0.59$) and physical activity energy expenditure ($p = .007$, $g = 0.70$) than non-sport participants. On weekend days, they also showed higher total energy expenditure ($p = .007$, $g = 0.71$), physical activity energy expenditure ($p = .001$, $g = 0.88$), vigorous physical activity ($p = .001$, $g = 0.86$), and total physical activity ($p = .003$, $g = 0.78$). Boys showed no significant differences between groups.

Discussion: The findings were consistent with previous evidence indicating stronger associations between organised sport participation and objectively measured physical activity among girls than boys, particularly on weekend days.

Conclusion: Organised sport participation was associated with higher physical activity and energy expenditure, particularly among girls. Targeted strategies for non-sport-participating girls and on non-school days may be important for improving activity levels.

Keywords

Metabolic equivalent; physical activity patterns; sedentary behaviour; wearable device; weekend behaviour.

Resumen

Introducción: La actividad física fue importante para la salud durante la adolescencia, mientras que el gasto energético representó un componente clave del equilibrio energético diario.

Objetivo: Este estudio examinó las diferencias en la actividad física y el gasto energético medidos objetivamente entre adolescentes que practicaban deporte y aquellos que no lo practicaban, según el sexo y el tipo de día, diferenciando entre días escolares y días de fin de semana.

Metodología: El estudio incluyó a 115 adolescentes (53 varones y 62 mujeres; edad: $14,0 \pm 0,6$ años) de una escuela primaria de Belgrado, clasificados como participantes en actividades deportivas ($n = 63$) o no participantes ($n = 52$). La actividad física y el gasto energético se evaluaron objetivamente mediante el dispositivo SenseWear Pro3 Armband durante dos días escolares y dos días de fin de semana.

Resultados: Las mujeres que participaban en actividades deportivas organizadas presentaron mayor gasto energético total ($p = .023$, $g = 0.59$) y gasto energético derivado de la actividad física ($p = .007$, $g = 0.70$) que las no participantes. Durante los días de fin de semana, también mostraron valores superiores de gasto energético total ($p = .007$, $g = 0.71$), gasto energético derivado de la actividad física ($p = .001$, $g = 0.88$), actividad física vigorosa ($p = .001$, $g = 0.86$) y actividad física total ($p = .003$, $g = 0.78$). No se observaron diferencias significativas entre los grupos en los varones.

Discusión: Los resultados fueron consistentes con evidencia previa que indicaba diferencias más consistentes entre participantes y no participantes en las mujeres que en los varones, particularmente durante los días de fin de semana.

Conclusión: La participación en actividades deportivas organizadas se asoció con mayores niveles de actividad física y gasto energético, particularmente entre las mujeres. Las estrategias dirigidas a las mujeres que no participaban en actividades deportivas y a los días no escolares podrían ser importantes para mejorar los niveles de actividad física.

Palabras clave

Comportamiento durante el fin de semana; comportamiento sedentario; dispositivo portátil; equivalente metabólico; patrones de actividad física.



Introduction

Physical activity (PA) is a key modifiable determinant of health and development during adolescence, with regular participation linked to improved cardiometabolic, musculoskeletal, and psychosocial outcomes (World Health Organization, 2020). It is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (EE) above resting levels (Caspersen et al., 1985). Regular participation in PA is associated with improved cardiorespiratory fitness, healthier body composition, metabolic health, skeletal development, and psychological well-being. Systematic reviews further confirm that higher PA levels and reduced sedentary behaviour are linked to more favourable health outcomes in youth (Zhang et al., 2020).

Despite these benefits, a substantial proportion of adolescents do not meet the World Health Organization recommendations of at least 60 minutes of moderate-to-vigorous physical activity (MVPA) per day (World Health Organization, 2020). In parallel, a consistent decline in PA during adolescence is reported across populations, often accompanied by increased sedentary behaviour and unfavourable changes in health indicators (Harding et al., 2015; Metcalf et al., 2015; Sember et al., 2020; Štefan et al., 2018). Recent school-based research also highlights the potential of physical education to provide an engaging context for promoting PA among adolescents through innovative educational approaches (Saucedo-Araujo et al., 2025).

Adolescence is a critical developmental period characterised by biological, psychological, and social changes that may negatively affect PA patterns. Increasing academic demands, changes in social environment, and motivational shifts contribute to reduced participation in both structured and unstructured PA. Previous studies identify gender and motivation as important factors associated with adolescent PA behaviour (Labrador & Ventola, 2023; Paredes Román et al., 2025). In addition, differences in PA perception and behavioural patterns are observed between adolescents with different levels of engagement in PA (Gutiérrez-Higuera et al., 2023).

Organised sport is widely recognised as an important context for higher levels of PA and physical fitness in youth. Adolescents involved in organised sports generally demonstrate higher levels of PA and physical fitness than their non-sporting peers (Carlisle et al., 2019; Malina et al., 2025; Pacífico et al., 2018). Recent evidence similarly indicates that adolescent athletes report higher levels of PA and more favourable anthropometric characteristics than non-athletes (Radhyan et al., 2026). Longitudinal studies further suggest that sustained sport participation is associated with more favourable trajectories of PA and body composition from childhood into adolescence (Basterfield et al., 2015; Telford et al., 2016). Recent evidence also suggests that participation in organised sport may be associated with more favourable body composition profiles among students (Butnariu, 2025).

The relationship between sport participation and total daily activity is not always straightforward. Some studies indicate that higher training loads may be partially compensated by reduced non-exercise PA, suggesting that increased sport participation does not necessarily lead to higher total daily activity (Carlsohn et al., 2011; Machado-Rodrigues et al., 2012). Sex differences in PA patterns are well documented, with boys generally exhibiting higher levels of MVPA and greater participation in organised sport compared with girls (Mehtälä et al., 2020; Vilhjálmsdóttir & Kristjansdóttir, 2003).

From a physiological perspective, total energy expenditure (TEE) consists of resting EE, thermic effect of food, and PA energy expenditure (PAEE), with PAEE being the most variable component (Malina et al., 2004). In adolescent athletes, accurate estimation of EE is particularly important due to increased training demands and potential risks of energy imbalance (Kapri et al., 2023; Muñoz-Aristizábal & Vi-darte Claros, 2025). Previous research demonstrates significant differences in EE between sport participants and non-participants, highlighting the relevance of organised sport to daily EE (Carlsohn et al., 2011; Machado-Rodrigues et al., 2012).

Traditional self-report methods for assessing PA are limited by recall bias and measurement error. Objective monitoring using accelerometers and wearable devices is the preferred approach for assessing free-living PA and EE in youth (Evenson et al., 2015; Fuller et al., 2020). Recent research using accelerometry has also highlighted the contribution of physical education to adolescents' daily MVPA and attainment of PA recommendations (Costa et al., 2024). Studies using objective monitoring demonstrate higher PA levels in sport participants compared with non-sport participants (Jovanovic et al., 2026;



Kapri et al., 2023; Toivo et al., 2023). These approaches provide more valid and reliable estimates of both PA patterns and EE under real-life conditions.

Although Pašić et al. (2014) previously examined objectively measured PA and EE in Serbian adolescents, that study did not specifically focus on differences between adolescents participating in organised sport and those not participating in organised sport. No study has specifically compared these groups using objective monitoring in Serbian adolescents. In addition, whether differences between sport participants and non-sport participants vary according to type of day (school days versus weekend days) remains insufficiently explored.

Although the data for the present study were collected in 2011, they provide an important objective baseline for understanding PA and EE among Serbian adolescents. Baseline measurements obtained using wearable monitoring devices can provide a useful reference for interpreting subsequent changes in adolescent PA patterns, particularly in the context of the continuing public health concern regarding insufficient PA and sedentary behaviour among adolescents.

The present study addresses the need for objective assessment of differences in PA levels and EE between adolescents engaged in organised sport and those who are not. By examining these differences according to sex and type of day, the study also seeks to provide a more detailed understanding of how organised sport participation relates to daily activity patterns and EE during adolescence. Understanding these differences may provide valuable insights into the potential role of organised sport participation in supporting active lifestyles during adolescence.

The aim of this study is to objectively assess and compare PA levels and EE between adolescent sport participants and non-sport participants aged 13–15 years. Additionally, the study examines differences according to sex and type of day (school days versus weekend days). The findings may contribute to a better understanding of the relationship between organised sport participation, daily PA patterns, and energy demands during adolescence.

Method

Study design and participants

This study was conducted as part of a broader national project aimed at monitoring physical fitness and PA among elementary school children in Serbia. A cross-sectional design was used to examine differences in objectively measured PA and EE between adolescents engaged in organised sport and their non-sporting peers. This is a quantitative, descriptive-comparative study, as it examines differences in PA and EE between predefined groups (SP vs. NSP) without establishing causal relationships.

Participants were recruited from one randomly selected primary school in Belgrade. Of the 254 seventh- and eighth-grade students (aged 13–15 years) invited to participate, 157 (62%) agreed. After excluding participants who did not meet the minimum wear-time criteria (≥ 21 hours/day for at least four days), the final sample consisted of 115 adolescents (53 boys, 62 girls), with a mean age of 14.0 ± 0.6 years. The final sample size was determined by the number of eligible participants from the broader project who met the predefined accelerometer wear-time criteria. No significant differences in body mass index (BMI) or sum of skinfolds were observed between included and excluded participants (all $p > 0.05$). The final sample should be considered representative only of the participating school cohort rather than the general adolescent population. Biological maturation was not assessed in this study. The age range (13–15 years) is relatively narrow, which reduces the potential confounding effect of maturational differences. Furthermore, no a priori sample-size calculation was performed, as this study represents a secondary analysis of an existing dataset; the achieved sample size and associated statistical power should therefore be considered a limitation when interpreting non-significant findings, particularly in smaller subgroups (e.g., boys' NSP, $n = 18$).

Participants were classified based on self-reported sport participation into:



- Sport participants (SP; $n = 63$) – adolescents engaged in organised sports training within sports clubs, in addition to regular physical education classes, for at least 6 months and a minimum of two sessions per week.
- Non-sport participants (NSP; $n = 52$) – adolescents not engaged in any organised sports activities outside compulsory physical education.

In boys, 66% were SP, with basketball (28.6%), football (22.9%), and handball (17.1%), followed by judo, water polo, and tennis (5.7% each), and karate, swimming, American football, taekwondo, and dance (2.9% each). Boys participated in an average of 4.4 hours of training per week.

In girls, 45.2% were SP, with volleyball (25.0%), followed by folk dance and athletics (14.3% each), taekwondo and dance (10.7% each), and capoeira, squash, fencing, karate, handball, fitness, and tennis (3.6% each). Girls participated in an average of 3.9 hours of training per week. Sport-specific characteristics were not included as covariates in the main analysis. Although participants reported a wide range of sports, from high-intensity intermittent team sports to artistic and individual activities, this study categorised adolescents primarily by their participation status.

Participation was voluntary. Written informed consent was obtained from parents or legal guardians, and the study was approved by the Institutional Ethics Committee Faculty of Sport and Physical Education, University of Belgrade (approval number: 2363-2/16), and all procedures adhered to the Declaration of Helsinki. All procedures were conducted in accordance with ethical standards for research involving minors.

Procedure

Data collection was conducted during the spring period (March–June 2011) under standardised school-based conditions. Following anthropometric assessments, participants were fitted with monitoring devices and received standardised instructions regarding use and compliance. Device wear time was monitored throughout the recording period.

After completion of monitoring, participants filled out a structured questionnaire under supervision, providing information on sport participation (type, frequency, weekly training duration, and competition level).

Variables

Independent variables included sex (boys/girls), sport status (SP/NSP), and day type (weekdays/weekend days). Dependent variables were objectively measured PA and EE outcomes: Total energy expenditure (TEE; kJ/kg/day); Physical activity energy expenditure (PAEE; kJ/kg/day). Time spent in sedentary behaviour (Sedentary time; 1.5–2.9 METs), moderate PA (MPA; 3–5.9 METs), vigorous PA (VPA; 6–8.9 METs), very vigorous PA (VVPA; >9 METs), and total PA (>3 METs), all expressed in minutes per day.

To further assess adherence to recommended PA levels, the number of monitored days on which each participant accumulated ≥ 60 minutes of MVPA and ≥ 20 minutes of VPA was determined. For MVPA, participants were classified according to the number of monitored days on which they accumulated ≥ 60 minutes (World Health Organization, 2020). For VPA, based on the Healthy People 2010 recommendation for adolescents of ≥ 20 minutes of vigorous PA on at least three days per week (US Department of Health and Human Services, 2004), participants who accumulated ≥ 20 minutes of VPA on at least three of the four monitored days were considered to meet the VPA criterion.

Anthropometric measurements

Anthropometric measurements were conducted in the morning, with participants barefoot and wearing light clothing. Body height was measured to the nearest 0.1 cm using a Seca stadiometer (Seca Instruments Ltd., Hamburg, Germany), and body mass was assessed to the nearest 0.1 kg using a calibrated Tanita BC-587 digital scale (Tanita Europe GmbH., Sindelfingen, Germany). BMI was calculated as mass (kg) divided by height squared (m^2).

Skinfold thickness was measured on the left side of the body to the nearest 0.1 mm using a Holtain caliper (Holtain Ltd., Wales, UK) at five sites: biceps, triceps, subscapular, suprailiac, and calf. The sum of five skinfolds (S5SF) was calculated as an anthropometric indicator of body composition.



Anthropometric variables, including S5SF, were used to characterize the sample and to compare organised-sport and non-organised-sport participants; they were not included as covariates in the main analyses.

Physical activity and energy expenditure assessment

PA and EE were objectively assessed using the SenseWear Pro3 Armband (BodyMedia Inc., Pittsburgh, PA, USA), a multi-sensor device worn over the right triceps muscle. The device integrated a two-axis accelerometer, heat flux sensor, galvanic skin response sensor, skin temperature sensor, and near-body ambient temperature sensor. Proprietary algorithms (SenseWear Professional software, version 6.1) were used to estimate EE and PA duration. Although newer wearable technologies have become available in recent years, the SenseWear Pro3 Armband was widely used and validated in pediatric and adolescent populations due to its multisensor approach combining accelerometry with physiological signals (Arvidsson et al., 2009; Sorić & Mišigoj-Duraković, 2010). Previous validation studies demonstrated acceptable reliability for estimating EE under free-living conditions, particularly when compared with traditional self-report methods.

Participants wore the device continuously for four consecutive days (two weekdays and two weekend days), removing it only during water-based activities. Data were recorded in 1-minute epochs. Only recordings with at least 21 hours of wear time per day were included in the final analysis.

Data analysis

Given that sex differences in PA and EE were previously reported in this sample (Pašić et al., 2014), the present study employed a sex-stratified analytical approach to examine the effects of organised sport participation separately for boys and girls. The sex-stratified analyses were intended to describe sport-participation differences within boys and girls separately and were not intended to provide a formal test of a sex-by-sport interaction.

For each participant, weekday values were averaged across the two recorded weekdays, weekend values were averaged across the two recorded weekend days, and the all-days value was calculated across all four monitored days. These participant-level summary values were then used in the between-group analyses.

Normality of data distribution was assessed using the Shapiro–Wilk test. Parametric statistical procedures were applied due to approximate normal distribution of most variables and the robustness of parametric tests to minor deviations.

Differences between SP and NSP were analysed using independent samples t-tests separately for each sex. Effect sizes were calculated using Hedges' *g* with correction for small sample bias and interpreted as small (≥ 0.20), moderate (≥ 0.50), and large (≥ 0.80).

To account for multiple comparisons across outcome measures and time periods, the Benjamini-Hochberg procedure was used to control the false discovery rate (FDR) at $q = .05$. The FDR correction was applied to the set of SP-versus-NSP comparisons for the PA and EE outcome measures within each sex. Categorical guideline comparisons were analysed separately, with the relevant comparisons treated as a distinct family of tests.

All analyses were conducted using IBM SPSS Statistics (version 26.0), with statistical significance set at $p < 0.05$.

Results

Anthropometric characteristics and body composition

Anthropometric characteristics and body composition parameters are presented in Table 1. No significant differences in age are found between SP and NSP within either boys (13.9 ± 0.5 vs. 14.0 ± 0.5 years, $p = .572$) or girls (14.1 ± 0.6 vs. 14.0 ± 0.6 years, $p = .874$), indicating good comparability of the groups with respect to age.



No statistically significant differences between SP and NSP are found for body mass, body mass index, or the sum of five skinfolds in either boys or girls (all $p > 0.05$). Among boys, SP shows higher mean body height compared with NSP (1.69 ± 0.09 vs. 1.64 ± 0.12 m), with a moderate effect size ($g = 0.50$). This difference approaches but did not reach statistical significance ($p = .081$). Among girls, NSP exhibits higher values of the sum of five skinfolds compared with SP (65.9 ± 28.0 vs. 56.4 ± 19.9 mm), suggesting a tendency toward greater subcutaneous adiposity in the NSP group. This difference is also not statistically significant ($p = .139$). Wider confidence intervals are observed in several variables among boys NSP (e.g., body mass: 95% CI [46.7–67.7 kg]; sum of skinfolds: [41.5–76.4 mm]), reflecting the smaller sample size and greater inter-individual variability in this subgroup.

Table 1. Anthropometric characteristics and body composition of adolescents by sex and sport status

	Boys (n = 53)			Girls (n = 62)		
	SP (n = 35) Mean $\pm$ SD [95% CI]	NSP (n = 18) Mean $\pm$ SD [95% CI]	p (g)	SP (n = 28) Mean $\pm$ SD [95% CI]	NSP (n = 34) Mean $\pm$ SD [95% CI]	p (g)
Age (years)	13.9 $\pm$ 0.5 [13.7–14.1]	14.0 $\pm$ 0.5 [13.7– 14.3]	.572 (0.16)	14.1 $\pm$ 0.6 [13.8– 14.3]	14.0 $\pm$ 0.6 [13.8– 14.2]	.874 (0.16)
Body height (m)	1.69 $\pm$ 0.09 [1.67– 1.73]	1.64 $\pm$ 0.12 [1.58– 1.71]	.081 (0.5)	1.65 $\pm$ 0.06 [1.62– 1.67]	1.63 $\pm$ 0.05 [1.61– 1.65]	.278 (0.36)
Body mass (kg)	63.3 $\pm$ 14.1 [58.4– 68.2]	57.2 $\pm$ 21.2 [46.7– 67.7]	.215 (0.37)	55.4 $\pm$ 8.3 [52.1– 58.6]	56.2 $\pm$ 14.7 [51.1– 61.3]	.793 (0.07)
BMI (kg/m ²)	21.7 $\pm$ 3.4 [20.6– 22.9]	20.7 $\pm$ 5.1 [18.1– 23.2]	.356 (0.26)	20.4 $\pm$ 2.4 [19.4– 21.3]	21.1 $\pm$ 5.0 [19.4– 22.8]	.468 (0.18)
S5SF (mm)	56.8 $\pm$ 28.4 [47.0– 66.5]	58.9 $\pm$ 35.1 [41.5– 76.4]	.807 (0.07)	56.4 $\pm$ 19.9 [48.7– 64.2]	65.9 $\pm$ 28.0 [56.1– 75.7]	.139 (0.39)

Values are presented as mean $\pm$ standard deviation with 95% confidence intervals; CI = confidence intervals; BMI = body mass index; S5SF = sum of five skinfolds (biceps, triceps, subscapular, spina iliaca, and gastrocnemius); SP = sport participants; NSP = non-sport participants; g = Hedges' effect size; 0.20, 0.50, and 0.80 represent thresholds for small, moderate, and large effects, respectively.

The results indicate no statistically significant differences in anthropometric and body composition characteristics between SP and NSP in either sex.

Total energy expenditure and physical activity energy expenditure

Results for TEE and PAEE are presented in Table 2. Among girls, SP showed significantly higher TEE and PAEE than NSP for all days and weekend days, with the largest differences observed during weekend days.

Table 2. Total energy expenditure and physical activity energy expenditure in adolescents by sex and sport status

		Boys (n = 53)			Girls (n = 62)		
		SP (n = 35) Mean $\pm$ SD [95% CI]	NSP (n = 18) Mean $\pm$ SD [95% CI]	p (g)	SP (n = 28) Mean $\pm$ SD [95% CI]	NSP (n = 34) Mean $\pm$ SD [95% CI]	p (g)
TEE (kJ/kg/day)	All days	199.2 $\pm$ 25.8 [190.4–208.1]	193.0 $\pm$ 24.5 [180.8–205.2]	.402 (0.26)	181.6 $\pm$ 21.5 [173.3– 189.9]	169.8 $\pm$ 18.1 [163.5–176.1]	.023 (0.59)
	Weekdays	208.8 $\pm$ 26.9 [199.6–218.1]	203.5 $\pm$ 28.4 [189.4–217.6]	.505 (0.19)	185.2 $\pm$ 23.0 [176.3– 194.1]	177.1 $\pm$ 18.8 [170.5–183.6]	.132 (0.38)
	Weekend days	184.7 $\pm$ 40.7 [170.7–198.7]	177.2 $\pm$ 24.7 [164.9–189.5]	.475 (0.21)	176.2 $\pm$ 24.6 [166.7– 185.8]	159.0 $\pm$ 23.6 [150.7–167.2]	.007 (0.71)
PAEE (kJ/kg/day)	All days	87.0 $\pm$ 32.3 [75.9– 98.1]	79.0 $\pm$ 25.7 [66.2– 91.7]	.363 (0.26)	64.4 $\pm$ 21.8 [55.9– 72.8]	50.1 $\pm$ 18.5 [43.6– 56.5]	.007 (0.7)
	Weekdays	96.8 $\pm$ 33.7 [85.2– 108.4]	90.2 $\pm$ 31.5 [74.6– 105.9]	.497 (0.2)	67.9 $\pm$ 22.9 [59.1– 76.8]	58.2 $\pm$ 21.4 [50.7– 65.6]	.089 (0.44)
	Weekend days	72.4 $\pm$ 46.8 [56.3– 88.4]	62.0 $\pm$ 26.2 [49.0– 75.1]	.390 (0.25)	59.0 $\pm$ 26.6 [48.7– 69.3]	37.9 $\pm$ 19.9 [30.9– 44.8]	.001 (0.88)

Values are presented as mean $\pm$ standard deviation with 95% confidence intervals. TEE = total energy expenditure; PAEE = physical activity energy expenditure; SP = sport participants; NSP = non-sport participants; g = Hedges' effect size; 0.20, 0.50, and 0.80 represent thresholds for small, moderate, and large effects, respectively. Benjamini-Hochberg false discovery rate correction was applied separately within each sex.



In boys, no significant differences are observed between SP and NSP in TEE or PAEE across any time period (all $p > 0.05$), with effect sizes ranging from trivial to small ($g = 0.19$ – 0.26), although SP consistently shows slightly higher mean values. After applying the Benjamini-Hochberg correction, none of the TEE or PAEE differences between SP and NSP boys remain significant. Among girls, the all-days and weekend-day differences in both TEE and PAEE remain significant after correction, while the weekday differences in both measures do not reach significance.

Wider CIs were observed in boys, particularly during weekend days, consistent with greater inter-individual variability and the smaller sample size in this subgroup.

Physical activity patterns

Results for PA levels are presented in Table 3. Among girls, SP accumulate significantly more total PA than NSP on all days ($p = .013$, $g = 0.65$) and during weekend days ($p = .003$, $g = 0.78$), with the largest difference observed during weekend days; the difference during weekdays does not reach significance ($p = .092$, $g = 0.44$). Girls in the SP group also show higher MPA and VPA, with the largest differences generally observed during weekend days (VPA: $p = .001$, $g = 0.86$); VVPA differences are significant on all days and weekdays but not during weekend days ($p = .879$, $g = 0.05$).

Table 3. Daily physical activity patterns in adolescents by sex and sport status

		Boys (n = 53)			Girls (n = 62)		
		SP (n = 35) Mean $\pm$ SD [95% CI]	NSP (n = 18) Mean $\pm$ SD [95% CI]	p (g)	SP (n = 28) Mean $\pm$ SD [95% CI]	NSP (n = 34) Mean $\pm$ SD [95% CI]	p (g)
Sedentary time (min/day)	All days	220.7 $\pm$ 43.9 [205.6–235.8]	189.7 $\pm$ 66.6 [156.6–222.8]	.047 (0.57)	276.5 $\pm$ 65.1 [251.2–301.7]	262.1 $\pm$ 49.8 [244.7–279.5]	.33 (0.25)
	Weekdays	242.1 $\pm$ 63.1 [220.4–263.7]	199.0 $\pm$ 74.2 [162.1–235.9]	.031 (0.63)	296.8 $\pm$ 68.4 [270.3–323.3]	291.4 $\pm$ 63.7 [269.2–313.6]	.751 (0.08)
	Weekend days	199.4 $\pm$ 42.0 [185.0–213.8]	180.4 $\pm$ 63.7 [148.7–212.0]	.197 (0.36)	256.1 $\pm$ 72.7 [228.0–284.3]	232.8 $\pm$ 56.1 [213.2–252.4]	.159 (0.36)
MPA (min/day)	All days	158.4 $\pm$ 47.3 [142.2–174.6]	168.0 $\pm$ 58.9 [138.8–197.2]	.522 (0.18)	152.9 $\pm$ 52.1 [132.7–173.1]	126.5 $\pm$ 42.7 [111.6–141.4]	.032 (0.55)
	Weekdays	178.9 $\pm$ 48.4 [162.3–195.5]	188.9 $\pm$ 58.5 [159.8–218.0]	.511 (0.19)	156.6 $\pm$ 49.5 [137.4–175.8]	145.0 $\pm$ 47.7 [128.3–161.6]	.352 (0.24)
	Weekend days	127.7 $\pm$ 65.3 [105.2–150.1]	136.7 $\pm$ 75.0 [99.4–174.0]	.653 (0.13)	147.3 $\pm$ 70.6 [119.9–174.7]	98.8 $\pm$ 45.7 [82.9–114.7]	.002 (0.79)
VPA (min/day)	All days	66.8 $\pm$ 40.4 [53.0–80.7]	50.5 $\pm$ 23.8 [38.7–62.3]	.122 (0.45)	33.1 $\pm$ 18.6 [25.9–40.3]	20.9 $\pm$ 14.9 [15.7–26.2]	.006 (0.7)
	Weekdays	71.0 $\pm$ 43.1 [56.2–85.8]	56.4 $\pm$ 28.9 [42.1–70.8]	.202 (0.37)	34.6 $\pm$ 22.3 [25.9–43.2]	25.0 $\pm$ 19.9 [18.1–32.0]	.08 (0.46)
	Weekend days	60.5 $\pm$ 66.3 [37.8–83.3]	41.7 $\pm$ 30.8 [26.4–57.0]	.259 (0.33)	30.9 $\pm$ 20.8 [22.9–39.0]	14.7 $\pm$ 14.2 [9.8–19.7]	.001 (0.86)
VVPA (min/day)	All days	8.3 $\pm$ 8.5 [5.4–11.3]	4.7 $\pm$ 4.7 [2.4–7.0]	.100 (0.48)	3.4 $\pm$ 3.0 [2.3–4.6]	1.6 $\pm$ 2.2 [0.8–2.4]	.008 (0.67)
	Weekdays	10.2 $\pm$ 12.1 [6.0–14.3]	5.5 $\pm$ 7.0 [2.0–9.0]	.136 (0.44)	4.2 $\pm$ 4.9 [2.3–6.1]	1.3 $\pm$ 1.6 [0.7–1.8]	.002 (0.73)
	Weekend days	5.6 $\pm$ 10.2 [2.1–9.1]	3.6 $\pm$ 4.6 [1.2–5.9]	.430 (0.23)	2.2 $\pm$ 3.2 [1.0–3.4]	2.0 $\pm$ 4.4 [0.5–3.6]	.879 (0.05)
Total PA (min/day)	All days	232.7 $\pm$ 75.5 [206.7–258.7]	221.8 $\pm$ 69.7 [187.2–256.5]	.613 (0.15)	188.9 $\pm$ 62.4 [164.7–213.1]	150.4 $\pm$ 55.8 [130.9–169.9]	.013 (0.65)
	Weekdays	259.6 $\pm$ 76.6 [233.3–285.9]	252.6 $\pm$ 77.1 [214.2–290.9]	.753 (0.09)	200.5 $\pm$ 62.3 [176.3–224.6]	173.2 $\pm$ 62.5 [151.4–195.0]	.092 (0.44)
	Weekend days	192.3 $\pm$ 106.6 [155.7–228.9]	175.7 $\pm$ 80.6 [135.6–215.8]	.564 (0.17)	171.5 $\pm$ 77.8 [141.3–201.7]	116.2 $\pm$ 61.1 [94.9–137.6]	.003 (0.78)

Values are presented as mean $\pm$ standard deviation with 95% confidence intervals. Sedentary time (1.5–2.9 METs); MPA = moderate physical activity (3–5.9 METs); VPA = vigorous physical activity (6–8.9 METs); VVPA = very vigorous physical activity (>9 METs); Total PA = total amount of physical activity (>3 METs); Sport participants = SP; Non-sport participants = NSP; g = Hedges' effect size; 0.20, 0.50, and 0.80 represent thresholds for small, moderate, and large effects, respectively.

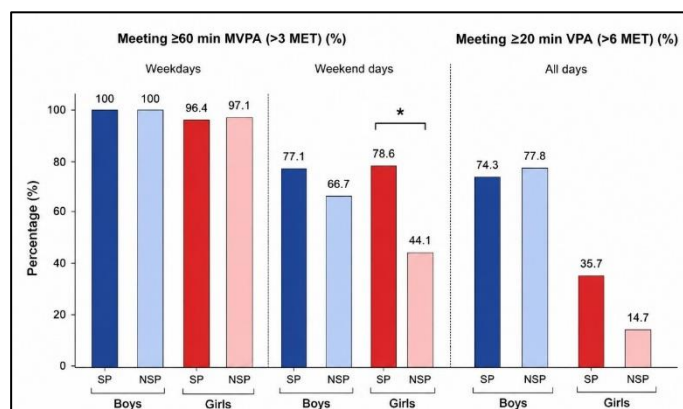
In boys, no statistically significant differences are observed for most PA indicators between SP and NSP. Although significant differences are found in sedentary time on all days ($p = .047$, $g = 0.57$) and weekdays ($p = .031$, $g = 0.63$), other comparisons do not reach statistical significance (all $p > .05$), with effect

sizes ranging from trivial to moderate ($g = 0.09-0.63$), suggesting relatively small differences between SP and NSP in this subgroup. After applying the Benjamini-Hochberg correction, none of the observed differences between SP and NSP boys remain significant. Among girls, eight of the 15 comparisons are statistically significant before correction. After applying the Benjamini-Hochberg correction, seven remain significant (MPA, VPA and total PA during weekend days; VPA, VVPA and total PA on all days; and VVPA on weekdays); only MPA (all days, raw $p = .032$) no longer meets the adjusted significance criterion.

The findings indicate more consistent differences in higher-intensity PA between SP and NSP among girls than among boys, particularly during weekend days.

When adolescent SP and NSP are compared (Figure 1) in relation to the recommended threshold of 60 minutes of MVPA, all boys (100% SP and 100% NSP) meet the recommendation during weekdays, with no difference between groups. Among girls, almost all participants also meet the weekday threshold, with only one SP and one NSP not meeting the criterion.

Figure 1. Percentage of adolescents meeting the recommended thresholds of at least 60 min of MVPA and 20 min of VPA, stratified by sport participation status



* $p < 0.05$ indicates a statistically significant difference between groups. SP = sport participants; NSP = non-sport participants.

During weekend days, fewer participants meet the recommendation: eight SP boys (22.9%) and six NSP boys (33.3%) do not accumulate 60 minutes of MVPA. Among girls, a chi-square test of independence reveals a significant difference in favor of SP, $\chi^2(1, n = 62) = 6.210, p = .013$ (Figure 1).

When applying the more stringent criterion of ≥ 20 minutes of VPA on at least three of the four measured days, four NSP boys (22.2%) and nine SP boys (25.7%) did not meet this standard. Among girls, ten SP (35.7%) and five NSP (14.7%) meet the criterion. Regarding the stricter criterion of ≥ 20 minutes of VPA on at least three days per week, consistent with the Healthy People 2010 recommendation for adolescents (US Department of Health and Human Services, 2004), no statistically significant differences are observed between SP and NSP in either boys or girls (all $p > .05$). When this comparison is considered together with the weekend MVPA threshold comparisons as a single family and corrected using the Benjamini-Hochberg procedure, the weekend MVPA difference among girls no longer reaches significance ($q > .05$) and should be interpreted with caution.

Discussion

This study provides an objective assessment of PA and EE in Serbian adolescents using a multi-sensor wearable device. The main findings demonstrate clear sex-specific patterns in the relationship between sport participation and daily activity behaviours. Differences between SP and NSP were more consistently observed among girls than among boys, whereas in boys these effects are generally limited

to selected intensity-related indicators. Such findings highlight a complex relationship between sex, sport engagement, and habitual movement patterns during adolescence.

The observed patterns are consistent with extensive evidence indicating that adolescence is characterised by a progressive decline in PA levels. Research has shown that this decline is particularly pronounced in MVPA, while sedentary time increases with age (Harding et al., 2015; Metcalf et al., 2015; Sember et al., 2020; Štefan et al., 2018). In the present study, weekday activity levels are generally sufficient. Differences between groups become more evident in higher-intensity activities, particularly VPA.

Greater variability observed in boys during weekend days likely reflects higher inter-individual differences in activity patterns within this subgroup, which has also been reported in previous adolescent studies (Jurak et al., 2015). Nevertheless, interpretation should be made cautiously due to subgroup sample size differences.

Importantly, meeting general PA guidelines does not necessarily ensure adequate engagement in high-intensity activity, which is more strongly associated with cardiorespiratory fitness and metabolic health outcomes (Zhang et al., 2020). The substantially lower proportion of NSP girls meeting the VPA criterion, compared with SP girls, was particularly evident during weekend days. This pattern suggests lower engagement in VPA among girls who did not participate in organised sport and indicates that organised sport participation was associated with a greater likelihood of meeting the recommended level of VPA. These findings are consistent with longitudinal evidence suggesting that early sport participation is associated with more favourable PA trajectories during adolescence (Basterfield et al., 2015; Telford et al., 2016).

The pattern of differences between SP and NSP differed by sex. Among girls, SP exhibit significantly higher total EE, total PA time, and higher levels of moderate and vigorous activity compared with NSP. These observations are consistent with previous studies identifying organised sport as a key setting for MVPA accumulation in youth (Machado-Rodrigues et al., 2012; Pacífico et al., 2018; Toivo et al., 2023). Recent evidence from Saudi Arabia similarly shows that adolescent athletes have higher PA levels and lower BMI than non-athletes, providing further evidence of an association between organised sport participation and more favourable activity profiles during adolescence (Radhyan et al., 2026).

The observed effect sizes for TEE and PAEE in girls ($g = 0.59$ – 0.88) indicate meaningful differences in EE between SP and NSP, suggesting that organised sport is associated with more favourable daily activity profiles in this subgroup.

Although no significant anthropometric differences were observed between groups, the observed non-significant differences should not be interpreted as evidence of differences in body composition. These relationships are likely influenced by maturation status, training history, and baseline activity levels, which were not directly controlled in this study (Malina et al., 2004).

Differences between SP and NSP boys are limited and are mainly reflected in sedentary behaviour. This pattern may be compatible with the compensatory activity hypothesis, which proposes that higher structured training loads may be partially offset by reduced spontaneous PA outside organised sport settings (Carlsohn et al., 2011). Because unstructured activity and recovery behaviours were not directly measured in the present study, this interpretation remains hypothetical and was not directly tested.

A key finding of this study is that NSP girls represent the least active subgroup with consistently lower levels of both PA and EE. This aligns with extensive evidence showing that adolescent girls engage in less vigorous PA than boys (Jurak et al., 2015; Vilhjalmsson & Kristjansdottir, 2003). The large effect size observed for VPA during weekend days among girls ($g = 0.86$) indicates a substantial difference in high-intensity activity between SP and NSP during unstructured time. These differences may reflect variations in perceived competence, motivation, and access to organised sport opportunities.

Earlier studies indicate that motivational decline during adolescence is more pronounced among girls, increasing the risk of sport dropout (Labrador & Ventola, 2023). In addition, psychosocial factors such as body image concerns and social environment further contribute to lower participation in PA among adolescent girls (Gutiérrez-Higuera et al., 2023). Collectively, these findings emphasize the need for

targeted, sex-sensitive interventions aimed at increasing participation in sport and vigorous activity among girls.

Assessment of EE in adolescents remains methodologically challenging, particularly in sport-active populations. As noted by Carlsohn et al. (2011), population-specific assumptions regarding PA level are necessary, as adult-based models may lead to biased estimates of energy requirements.

The significant differences in PAEE observed between SP and NSP girls ($g = 0.70\text{--}0.88$) highlight the importance of accurate assessment of EE in adolescent populations, particularly when evaluating differences related to sport participation. The use of the SenseWear Pro3 Armband represents a methodological strength, providing objective, multi-sensor assessment of free-living PA and EE. Previous validation studies support its acceptable reliability in youth populations, although accuracy may vary across activity types and intensities (Evenson et al., 2015; Fuller et al., 2020; Hsu et al., 2016). In line with previous research, wearable monitoring technologies offer valuable insights into habitual activity patterns, consistently demonstrating higher MVPA and lower sedentary time among sport-active adolescents (Marques et al., 2016; Toivo et al., 2023).

Despite the advantages of wearable technology, limitations related to proprietary algorithms and potential measurement error should be acknowledged. Furthermore, differences in short-duration high-intensity movements may still be underestimated depending on device sensitivity.

The findings of this study have important implications for strategies aimed at increasing PA among adolescents. Insufficient PA surveillance remains a challenge in many European countries, limiting the development of effective interventions (Sorić et al., 2021).

The pronounced differences between SP and NSP girls, particularly during weekend days, highlight the association between organised sport participation and higher daily PA levels. School-based programmes combined with accessible community sport initiatives may represent effective approaches for increasing overall PA and reducing sex disparities (Bujosa-Quetglas et al., 2023).

Given the established links between PA, cognitive function, and academic performance, promoting active lifestyles may also have broader educational benefits (Sember et al., 2020; Zhang et al., 2020). Finally, the particularly low activity levels observed in NSP girls underscore the importance of interventions targeting unstructured leisure time, using multilevel approaches that address individual, social, and environmental determinants of behaviour (Mehtälä et al., 2020).

Although the data collection was conducted more than a decade ago (2011), the findings remain relevant because objective assessments of PA and EE among Serbian adolescents are still limited. Since this period, national and international surveillance studies have consistently reported persistent declines in adolescent PA and increasing sedentary behaviour, suggesting that insufficient PA remains an ongoing public health concern. The present study provides valuable baseline objective data that contribute to understanding activity patterns in Serbian adolescents and may serve as a reference point for future monitoring studies.

Finally, the observed variability in some estimates, particularly among boys, suggests that future studies should include larger samples to improve precision and enable more robust subgroup analyses. Objective monitoring should remain a priority in future research to support evidence-based public health strategies.

Conclusions

The present study provided objective evidence that sport participation was associated with PA and EE. These associations were not uniform across sex and day type. More consistent differences between SP and NSP were observed in girls, where sport participation was linked to higher levels of total PA and active EE, particularly during weekend days. In boys, differences between SP and NSP were smaller and less consistent, a pattern that may have been compatible with compensatory activity; however, this interpretation remained speculative because compensatory behaviour was not directly assessed.

NSP girls exhibited the lowest levels of PA in the present sample, particularly during weekends. Although a substantial proportion of adolescents achieved recommended levels of MVPA, engagement in



VPA remained insufficient, particularly among girls. No meaningful differences in body composition indicators were observed between SP and NSP within the same sex, suggesting that adiposity-related outcomes in this age group were likely influenced by multiple factors beyond PA alone.

The findings indicated that organised sport participation was associated with higher PA levels, with the pattern of differences varying by sex and day type. These results highlighted the need for targeted, sex-specific strategies to promote sustained and higher-intensity PA during adolescence. These findings may inform school- and community-based interventions aimed at increasing vigorous-intensity activity among NSP girls and encouraging sustained engagement in organised sport, particularly outside structured school days.

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Declaration of generative AI and AI-assisted technologies in the writing process

AI-assisted language tools were used during the revision process to improve clarity and correct potential linguistic inconsistencies. The author critically reviewed and revised all AI-assisted suggestions and takes full responsibility for the accuracy, integrity, and final content of the manuscript.

Data availability statement

The dataset analysed in the current study is not publicly available due to ethical restrictions related to the inclusion of minors. Data may be available from the corresponding author upon reasonable request and subject to appropriate ethical approval.

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Author Affiliations

Given Name:

Milan

Family Name:

Pašić

Affiliation:

Faculty of Sport, University “Union – Nikola Tesla”, Department of Sports and Physical Education, Belgrade, Serbia

ORCID:

0000-0002-9224-3987



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Authors and translators' details:

Milan Pašić

milan.pasic@fzs.edu.rs

Author, Translator

