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Differences in Physical Fitness, Quality of Life and Level of Physical Activity Among Adolescents Based on BMI: An Observational Study

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Abstract

Adolescence is an important transitional phase in life, central in the development of capabilities related to health and well-being, and where future patterns of adult health are established. Overweight and obese adolescents are at a higher risk of developing many chronic non-communicable diseases. Moreover, overweight and obesity negatively impact physical fitness (PF), quality of life (QoL) and levels of physical activity (PA). In this context, the aim of this study was to examine differences in PF, QoL, and PA level among adolescents based on BMI. The sample consisted of one hundred thirthy-nine (N=139) high school graduates (4th grade, aged 18 years, 43.7% girls). The Eurofit Fitness Test Battery was used to assess PF, whereas QoL questionnaire adolescent form and PA questionnaire (IPAQ-SF) were employed for QoL and PA level, respectively. One-way ANOVA and Tukey post-hoc were conducted for comparisons ($p<0.05$). Main findings of this study indicate that there were significant differences among three groups (underweight, normal weight, overweight) in PF, QoL, and physical activity levels among adolescents ($p<0.05$; 0.03; 0.01, respectively) in favour of normal weight group. In conlusion, adolescents who are normal weight tend to have better PF, QoL and PA level in comparison with adolescents who are underweight and overweight. Those results underline the importance of spreading awareness about the harmfulness of an increased BMI (body mass index), i.e., the trend of increasing obesity in today's society.

Keywords: *fitness level, well-being, physical activity, dietary status, adolescents, obesity*

Introduction

Adolescence is a life phase marked by various biological, psychological, and social transformations (Lizandra & Gregori-Font, 2021). Many scholars categorize adolescence into three stages: early (10 to 13 years), middle (14 to 16 years), and late (18 to 21 years) (Arnett, 2008). Each of these stages is sensitive to the development of habits and routines, where decisions are often shaped by environmental influences, potentially impacting their future and playing a key role in promoting healthy lifestyles during this period (Duno & Acosta, 2019; Mitraković et al., 2016). Thus, it is essential to take into account all factors that support the development of socially responsible and capable individuals, particularly the ones that can affect the individuals' health. However, there is limited attention given to the effects that can have a relationship with the health of adolescents (WHO, 2020), physical fitness (PF), quality of life (QoL), levels of physical activity (PA), and BMI (body mass index). Overweight and obesity are major modern challenges that can adversely affect adolescent health (WHO, 2020). Given that adolescents with overweight and obesity are at a heightened risk of experiencing these issues throughout their lives (WHO, 2020), the need for timely intervention is evident. A scoping review of current clinical practice guidelines, consensus statements, and position papers demonstrates that lifestyle interventions targeting weight maintenance or weight loss, such as are

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recommended as the first-line treatment for pediatric obesity (Alman et al., 2021). The treatment involves a respectful, stigma-free, family-centered approach that integrates various components and focuses on diet, physical activity, sedentary habits, and sleep patterns (Jebeile et al., 2020; Lister et al., 2023). Unfortunately, the current practice shows a different reality, as there are currently 390 million overweight and obese children and adolescents aged 5–19 worldwide (Vasiljević, 2018). In this regard, by understanding the differences in PF, QoL, and PA level in relation to BMI, we can make recommendations that are significant for the holistic psychobiosocial development of adolescents.

Obesity can impact various aspects of children's and adolescents' lives, including their psychological well-being, cardiovascular health, and overall physical health (Horesh et al., 2021). The link between obesity and serious health outcomes underscores its significance as a public health concern for young people (Jebeile et al., 2021). Adolescents who are overweight or obese face an increased risk of developing diabetes, cardiovascular diseases, cancer, hypertension, and various chronic non-communicable diseases (Davis et al., 2011). Moreover, overweight and obesity negatively impact PF (Dewi et al., 2021; Qui et al., 2022), QoL (Mollerup et al., 2017; Van de Pas et al., 2023) and levels of PA (Raustorp et al., 2004; Dewi et al., 2011; Mateo-Orcajada et al., 2022). Additionally, adolescent obesity is a growing global health concern, with rates rising in low- and middle-income countries and remaining high in many high-income nations (Pulgarón, 2013). Obesity in childhood often persists into adulthood, leading to increased risks of cardiometabolic and psychosocial complications, as well as early mortality (Horesh et al., 2021).

Moreover, body mass index (BMI) is a good tool for assessing obesity risk factors in adolescents (Freedman, 2022). BMI is categorised according to the WHO (2017) specialised for the age of 5 to 19 years for adolescents: ≤18.4 (underweight/undernourished); (normal body mass/normal nutritional status) 18.5–24.1; (24.2–28.1) (overweight); and ≥28.2 (obesity) (Weir & Jan, 2024). From these classifications, it is very important to investigate the differences in PF, QoL, and PA level in relation to BMI. More than a quarter of children with excessive body fat go undetected due to BMI's low sensitivity, despite its high specificity in identifying excess adiposity. (Javed, et al., 2015).

There are previous studies that have investigated differences, based on BMI, in PF (Pahkala et al., 2013; Dewi et al., 2021; Qui et al., 2022), QoL (Pahkala et al., 2013; Chen et al., 2014), and PA level (Raustorp et al., 2004; Dewi et al., 2021; Mateo-Orcajada et al., 2022). However, there is no study, to the best of our knowledge, that has combined all the mentioned variables. To be specific, Qin et al. (2022) showed that lower values of BMI lead to increased values of VO2max, strength, and balance in adolescents, which was confirmed by Dewi et al. (2021), and Pahkala et al. (2013) displayed that adolescents who showed normal or lower values of BMI exhibit a higher VO2max. Regarding QoL, Keating et al. (2011) showed that normal BMI range values, as well as lower BMI values (Chen et al., 2014), lead to higher QoL. On the other side, it was shown that high BMI values lead to worse QoL in adolescents (Mollerup et al., 2017; Van de Pas et al., 2023). Furthermore, Mateo-Orcajada et al. (2022), Raustorp et al. (2004) and Dewi et al. (2021) showed that adolescents with normal BMI values also have a higher PA level compared to adolescents who fall into the overweight category, with no conflicting evidence, to the to the best of our knowledge. Although there are studies that investigate the associations and influence of the mentioned variables, there is no study assessing the differences in PF, QoL, and PA level in relation to BMI. Understanding these differences allows us to gain a better understanding of adolescents' overall development, and by presenting differences in a large number of variables, we can develop guidelines that are relevant to adolescents and aim to prevent the risk factor of obesity, in this case BMI. Based on all the above, the aim of this study was to examine differences in PF, QoL, and PA level among adolescents based on BMI. The study hypothesized that there would be significant differences in PF, QoL, PA levels among adolescents with varying BMI in favour of those who are normal weight in comparison with underwirght or overweight adolescents.

Methods

Participants

This study was an observational study using a stratified sampling design. It utilised a two-component cross-sectional design consisting of a cross-sectional survey encompassing three questionnaires and a cross-sectional PF test. In total, one hundred thirthy-nine (N=139) high school graduates (4th grade, aged 18 years, 43.7% girls) were recruited and gave their written consent to participate in this research. G power analysis (ES 0.5, ANOVA, power level 0.80, alpha 0.05) determined that the sufficient number of respondents for this study was 156 (Faul, 2007), which is a slight deviation from the actual number of respondents who participated in this study. The subjects were divided into 3 groups based on BMI classification (Weir & Jan, 2024). Namely, all respondents fell into group I (underweight, N=33, mean BMI=17.67±4.1), group II (normal weight, N=78, mean BMI=21.9±7.2) and group III (overweight, N=28, mean BMI=26.4±3.9). Participants in the study were adolescents who consented to participate (with parental consent where necessary) and had available anthropometric data for categorizing BMI. Eligible participants were required to attend regular physical education classes and have no chronic illnesses or medical restrictions that might impact PF or daily activity levels. Adolescents were excluded if they had conditions limiting PA, had been advised by a physician to restrict such activity, or were engaged in external structured fitness programs that could influence PF outcomes. The reserach procedure was conducted within the ethical standards of the Helsinki Declaration of 1964 and according to Resolution 466/12 of the Ministry of Health. Additionally, this study protocol was carried out in accordance with the ethics committee of the Faculty of Sport and Physical Education, University of Niš, number 04-2035/2. The data were collected and analysed anonymously.

Procedures

Before conducting the study tests and survey, all participants were notified of the study's purpose through an informational letter. The research team gave a thorough explanation of the survey and guided the adolescents on how to complete a three-page electronic questionnaire, which contained questions about their quality of life (QoL) and physical activity (PA) levels. Researchers administered the survey and assisted participants with any questions or difficulties in understanding the content. Testing took place on two occasions, each lasting 90 minutes. In the morning, body composition was measured, while PF was measured later.

Measurements of variables

Body composition

Body composition was measured using a Martin antropometer and the bioelectrical impedance OMFRON BF 511 (Kyoto, Japan) (Đurašković 2001; Beleigoli et al., 2019).

Body height was measured using an anthropometer according to Martin (Martin metal anthropometer - GPM Swiss Made). During the measurement, the examinee stands barefoot on a flat and firm surface. His head is in a position that meets the requirement of the Frankfurt horizontal (the Frankfurt horizontal is a line connecting the lower edge of the left orbit and the upper edge of the left external auditory opening). The examiner stands on the

left side of the subject and controls whether the anthropometer is placed vertically and directly on the longitudinal side of the body. The measurement result is read with an accuracy of 0.1cm (Beleigoli et al., 2019; Omron Healthcare, 2024).

OmronBF511 - Body Weight (BW), Body Mass Index (BMI), Body fat percentage (BF%), muscle mass percentage (MM%) of the subjects were determined using a tetrapolar bioimpedance device - Omron BF511 (Kyoto, Japan), which measures with an accuracy of 0.1kg, 0.1kg/m2 The researcher takes the display unit and enters age, gender and height, after which the minimally dressed and barefoot subject stands on the main unit of the device (body mass is then read). After the body mass of the subject is shown on the display, the meter hands her the display unit, which he/she grabs firmly by the handles arms fully extended in front. The sound signal informs that the measurement of parameters of the subject's body composition has been completed. Subjects did not eat breakfast or drink water in the morning before the body composition test.

BMI is categorised according to the data of the World Health Organisation (WHO, 2017) specialised for the age of 5 to 19 years for adolescents: less than the fifth percentile ≤18.4 (underweight/); from the 5th to the 85th percentile (normal body mass/) 18.5 - 24.1; from the 85th to the 95th percentile 24.2 - 28.1 (overweight) and or above the 95th percentile ≥ 28.2 (obesity).

Physical fitness

PF was assessed using the EUROFIT fitness test battery (Adam et al., 2003) to evaluate cardiorespiratory fitness, muscular strength, balance, speed and coordination of the upper limbs, and flexibility. These assessments were conducted during physical education classes.

Cardiorespiratory fitness was measured by the 20 m shuttle run test, requiring participants to run back and forth between two lines set 20 meters apart. The starting speed was 8.5 km/h, increasing by 0.5 km/h each minute, with the pace indicated by an audio signal. The test concluded when the adolescents either stopped due to fatigue or failed to reach the line by the audio signal. For analysis, the stages completed were recorded, and maximum oxygen consumption (mL/kg/min) was calculated using the equation by Léger et al. (1989) ($Y = 31.025 + 3.238 \times \text{speed} - 3.248 \times \text{age} + 0.1536 \times \text{age} \times \text{speed}$). This test was performed once.

Muscular strength was assessed using two tests: the standing long jump, which evaluates explosive leg strength by asking participants to jump as far as possible from an upright stance using both feet on a jump platform, and handgrip strength, measured with a Jamar hand dynamometer, validated for adolescent populations (Trajković et al., 2024). Two trials were performed with the dynamometer, standing with the elbow flexed at 90°. Participants took 2 trials, both with dominant and non-dominant hand and better value was recorded. Additionally, in sit up test participants aim to complete as many sit-ups as possible in 30 seconds. Participants lie on a mat with bent knees, feet flat and held by a partner, and interlock fingers behind head. On "Go," participants lift chest until their upper body is vertical, then return to the floor. Test lasts 30 seconds, ensuring their back touches the floor each time. In the bent arm hang test, the subject is positioned with their chin level with a horizontal bar, using an overhand grip, hands shoulder-width apart. Timing begins once released, and they must hold this position as long as possible. Timing ends when the chin drops below the bar or the head tilts back to keep the chin level (Adam et al., 2003).

Balance was evaluated using the flamingo balance test. The individual was requested to stand barefoot on the wooden beam (50cm long, 5cm high, 4cm broad) with the tested leg and bend the free leg at the knee. Both hands should be on the iliac crests. Participants were told to hold this position for as long as they could. A stopwatch was used to record each time the person lost balance, whether by falling off the beam, letting go of the foot being held, or removing hands from the body. The test is done three times, and the best time (longest duration balancing in each position on the beam) is recorded (Oja & Tuxworth, 1995).

Speed and coordination of the upper limbs were assessed using the plate tapping test, which is done by measuring the time for the dominant hand to touch two discs 80cm apart 25 times while the other hand is fixed between the two discs. The best time to make 25 back-and-forth movements is recorded (Oja & Tuxworth, 1995).

Flexibility was evaluated using the sit-and-reach test, which specifically measures the flexibility of the lower back and hamstring muscles. Participants were instructed to sit barefoot on the floor with their legs fully extended and feet flat against a box, then reach forward along a measuring line as far as they could. The furthest position reached was recorded in centimeters over two attempts (Castro-Piñero et al., 2009).

Quality of Life

Quality of life (QoL) was measured using the Youth Quality of Life Instrument—Short Form (YQOL-SF) questionnaire (Patrick et al., 2002). This questionnaire included 15 items, with responses rated on a scale from 0 (not at all) to 10 (a great deal or completely). The scores were summed and converted to a 0–100 scale, where a higher score indicates a higher QoL. The final overall QoL score was calculated according to the YQOL-SF guidelines: COMPUTE Item1_tscore = ((Item1_score-0)/10)*100; item #7 (I feel alone in my life) was reverse-scored before summing, ensuring that a higher score reflects a higher QoL.

Physical activity levels

The International Physical Activity Questionnaire (IPAQ short-version), which has been validated for use with adolescents (Lee, 2011) and further adjusted to Serbia (Simonović et al., 2024) was used to gather data on time spent in PA. The IPAQ records all the PA performed in the previous week. The results were converted into units of metabolic equivalent of task (METs) following the IPAQ specifications: Walking MET-minutes/week =3.3* walking minutes per day; no of days per week in which walking was reported; Moderate MET-minutes/week =4.0* moderate intensity minutes per day * no of days per week in which moderate intensity activity was reported; Vigorous MET- minutes per week =8.0* Vigorous intensity minutes per day * no of days per week in which vigorous intensity activity was reported; Total physical activity MET-minutes/week = Walking + Moderate + Vigorous MET minutes/week scores.

Statistical analysis

All collected data were analyzed using the Statistical Package for the Social Sciences, version 21.0 (IBM SPSS 21.0, SPSS Inc., Chicago, USA). Descriptive statistics, including the mean and standard deviation, were calculated for each variable (Table 1). The normality of the data distribution was confirmed with the Kolmogorov-Smirnov test. To determine group differences, ANOVA and the Tukey post hoc test were applied (Table 3), with statistical significance set at $p<0.05$.

Results

Descriptive parameters of PF, QoL, PA levels and the normality of the data distribution are shown in Table 1. The average height of participants was 175.8±10.2cm, while the average body weight was 70.7±8.2kg. The average values of body fat percentage were 22.8±7.2%, while the average values of body muscle percentage were 34.5±9.4%. Given that the average BMI was 22.8±7.2, it can be said that most of the participants had normal BMI (Table 1).

Table 1. Descriptive Statistics And Data Normality Of Distribution.

Variables	Mean ± Std. Dev.	K-S (Sig.)
BH (cm)	175.8±10.2	0.980
BW (kg)	70.7±8.2	0.946
BMI (kg/m2)	22.8±7.2	0.948
BF%	23.1±7.2	0.759
Muscle (%)	34.5±9.4	0.779
Flamingo (s)	3.2±2.7	0.852
PTT(s)	15.2±12.2	0.739
S&R (cm)	21.2±12.1	0.101
SLJ (cm)	173.3±29.4	0.846
HsD (kg)	37.7±9.1	0.846
HsND (kg)	34.7±8.7	0.811
Sit-ups (rep)	22.03±4.4	0.911
Pull-ups (s)	8.51±7.1	0.582
V̇O2max (ml/kg/min)	28.8±8.9	0.605
QoL	66.3±19.6	0.742
PA level (METs)	3505.9±2731.3	0.801

Legend: K-S (Sig.) – Kolmogorov Smirnov test; BH (cm) – body height; BW (kg) – body weight; BMI – body mass index (kg/m2); BF% – body fat percentage (%); Muscle (%) – muscle mass percentage; PTT – plate tapping test; S&R – sit and reach test (cm); SLJ – standing long jump (cm); HsD – handgrip strength dominant hand (kg); HsND – handgrip strength non-dominant hand (kg); VO2max – maximal oxygen uptake (mL/(kg·min); QoL – quality of life; PA level – physical activity level; rep – repetitio; METs – metabolic equivalent of task.

Furthermore, Kolmogorov-Smirnov test determined that there are no data that deviate from the normal distribution. Considering that all adolescents have been categorized into 3 groups based on the aforementioned BMI classification, the following table shows the frequencies of participants in different BMI groups (Table 2):

Table 2. Participants Divided By BMI Classification.

BMI	Frequency	BMI (mean ± SD)
Underweight	N=33	17.67±4.1
Normal weight	N=78	21.9±7.2
Overweight	N=28	26.4±3.9

Legend: BMI – body mass index; N – number of participants.

Table 3. Differences Between Groups (ANOVA).

Variables	Group 1 (underweight) mean ± SD	Group 2 (normal weight) mean ± SD	Group 3 (overweight) mean ± SD	ANOVA (p-value)	Tukey post Hoc test (Multiple Comparisons) (p-value)		
					I vs. II	II vs. III	I vs. III
Flamingo (s)	3.3±2.5	3.4±2.6	3.1±2.3	0.050*	0.110	0.049*	0.048*
PTT (s)	15.1±12.1	15.2±12.2	15.0±11.9	0.210	0.220	0.190	0.110
S&R (cm)	22.9±11.8	21.2±12.1	20.0±10.8	0.050*	0.049*	0.049*	0.030*
SLJ (cm)	179.8±29.4	172.9±29.4	159.3±19.5	0.030*	0.049*	0.020*	0.000**
HsD (kg)	35.3±7.1	37.9±6.1	41.2±9.1	0.020*	0.049*	0.040*	0.010**
HsND (kg)	31.7±7.6	34.7±7.7	39.7±7.9	0.049*	0.030*	0.047*	0.020*
Sit-ups (rep)	20.03±4.1	22.03±4.2	26.03±4.5	0.000**	0.480*	0.040*	0.010**
Pull-ups (s)	9.31±7.3	8.51±7.1	2.46±4.1	0.000**	0.060	0.010**	0.001**
$VO2_{max}$(ml/kg/min)	30.7±9.1	28.8±8.9	21.0±10.8	0.001**	0.048*	0.031*	0.001**
QoL	64.9±18.9	66.3±19.6	61.8±18.2	0.041*	0.110	0.032*	0.047*
PA level (METs)	3298.4±2731.3	3641.9±2731.3	2891.9±2543.3	0.010**	0.040*	0.010**	0.000**

Legend: mean-arithmetic mean; SD-standard deviation; *-statistical significance (p<0,05); ** - statistical significance (p≤0.001); PTT – plate tapping test; S&R – sit and reach test (cm); SLJ – standing long jump (cm); HsD – handgrip strength dominant hand (kg); HsND – handgrip strength non-dominant hand (kg); $VO2_{max}$ – maximal oxygen uptake (mL/(kg·min); QoL – quality of life; PA level – physical activity level; rep – repetition; METs – metabolic equivalent of task.

Additionally, ANOVA was used to determine differences between groups, and a Tukey post Hoc test to determine magnitude of difference between groups (Table 3).

Significant differences are shown among the three groups (underweight, normal weight, and overweight) in PF, QoL and PA level of adolescents hinged on BMI, based on ANOVA and post-hoc Tukey tests (Table 3). For the flamingo test of balance group II (3.4±2.6, p=0.05) scored higher than group III (3.1±2.3, p=0.05), while there were no significant difference with group I (3.3±2.5, p=0.11). Furthermore, in the plate tapping test there we no significant differences between groups (p=0.21). Additionally, in sit and reach test, group I (22.9±11.8) scored significantly higher than both group II (21.2±12.1) and group III (20.0±10.8), where all pairwise comparisons were significant (p=0.04). Next, in the standing long jump test, group I (179.8±29.4) scored higher than group II (172.9±29.4) and group III (159.3±19.5). All intergroup comparisons were significant (p=0.01). Likewise, in the handgrip strength test with dominant hand group 3 (41.2±9.1) showed significantly better scores than group II (37.9±6.1) and group I (35.3±7.1), and the Tukey post hoc test confirmed differences in score (p=0.02), making group III (overweight) the best at this test. On the other side, we saw the same trend in handgrip strength with non-dominant hand where group III (39.7±7.9) showed better scores than group II (34.7±7.7) and group I (31.7±7.6), with Tukey post-hoc confirming the pairwise differences (p=0.03). In the sit-ups test, group I (20.03±4.1) showed better results than group II (22.03±4.2) and group III (26.03±4.5) and post-hoc analysis confirmed those intragroup differences (p=0.03). Furthermore, in the pull ups test group I (9.31±7.3) demonstrated higher scores than group II (8.51±7.1) and group III (2.46±4.1), with the post-hoc test confirming the differences between group II and III (p=0.01) and I and III (p=0.00), while there were no differences between group I and II (p=0.06). In the shutle run test (VO2max) group I (30.7±9.1) scored higher than group II (28.8±8.9) and group 3 (21.0±10.8), with ANOVA showing significant differences (p=0.01) and Tukey post-hoc confirming differences in specific groups (p=0.03). Moreover, ANOVA revealed significant differences (p<0.049) in QoL of groups I (64.9±18.9), II (66.3±19.6) and III (61.8±18.2). Additionally, Tukey post-hoc confirmed differences between groups II and III (p=0.03) and I and III (p<0.048), while there were no differences within groups I and II (p=0.11). At last, ANOVA displayed differences (p=0.01) in IPAQ PA level scores (MeTS) in group I (3298.4±2731.3) group II (3641.9±2731.3) and group III (2891.9±2543.3), with post-hoc confirming differences where all pairwise comparisons were significant: group I and II (p=0.04), group II and III (p=0.01) and group I and III (p<0.001).

Discussion

This study aimed to examine differences in PF, QoL, and PA level among adolescents based on BMI. Therefore, the main findings of this study indicate that there were significant differences among three groups (underweight, normal weight, overweight) in PF, QoL, and PA levels among adolescents, that implies adolescents who are normal weight tend to have better PF, QoL and PA level in comparison with adolescents who are underweight and overweight.

Adolescents undergo growth and notable changes in body composition, which affect their responses to exercise and overall physical fitness (PF) (Bélanger et al., 2015). The findings of this study indicated significant differences in PF among the three groups (underweight, normal weight, overweight). Specifically, the results revealed significant variations across all PF variables (flamingo test, sit-and-reach test, standing long jump, handgrip strength for the dominant hand, handgrip strength for the non-dominant hand, sit-ups, pull-ups, and VO2max - maximal oxygen uptake), except for the plate tapping test. Those differences shown in Table 3 were in accordance with previous studies (Pahkala 2013; Dewi et al., 2021; Qui et al., 2022). Namely, Qin et al. (2022) showed that lower values of BMI lead to increased values of VO2max, strength and balance of adolescents, which was confirmed by Dewi et al. (2021). Additionally, Pakhala et al. (2013) showed that adolescents who showed normal or lower values of BMI displayed a higher VO2max, which is in line with the results of this study. Given that BMI is an indicator of a good image of body composition (Wellens et al., 1996), it can be suggested that the results of this study are expected. Namely, by showing a normal or lower BMI value, adolescents tend to perform better in PF tests (in other words, to have an overall better PF) due to the lower distribution of body fat associated with a lower BMI value, as well as lower body weight. While underweight adolescents may show advantages in aerobic activities due to lower body mass, this does not imply an ideal health status, as being underweight can pose risks to overall health, particularly when it results from inadequate nutrition or other health issues that compromise strength and physical resilience.

Adolescence is a crucial transitional stage in life, vital for developing skills related to health and well-being, and it is during this period that future patterns of adult health are formed (Sawyer et al., 2012). There has been a growing emphasis on understanding, enhancing, and assessing adolescents' quality of life (QoL) (Langeland et al., 2019), as QoL is shaped by both individual and environmental factors (Ferrans et al., 2005). The findings of this study exibited a significant differences (p=0.05) in QoL of group I, II and III. Furthermore, post-hoc confirmed differences between II and III and I and III, while there were no differences within groups I and II, indicating that group II (normal weight) displayed the highest QoL scores, following group I (underweight) and group III showing lowest QoL scores overall. These results are consistent with previous literature, which shows that a normal (Keating et al., 2011) as well as a lower level of BMI (Chen, 2014) lead to a better QoL, while a high BMI (Keating et al., 2011; Van de Pas et al., 2023) is an indicator of a worse QoL in adolescents. The results of our and previous studies are expected, given that it has already been shown that adolescents who have predispositions to obesity have impaired QoL (Van de Pas et al., 2023). Namely, increased BMI is associated with the occurrence of chronic diseases (Mandoh et al., 2023), so we can assume that one of the mechanisms that leads to better QoL in adolescents could hypothetically be the lower frequency of diseases and problems related to them. Therefore, adolescents who have a normal or lower BMI level show a better QoL overall.

Engaging in PA during adolescence is essential for preventing and treating various chronic diseases, particularly obesity, hypertension, diabetes, and metabolic syndrome (Anderson & Durstine, 2019). Despite its importance, the rate of PA decreases annually by 3.4% in boys and 5.3% in girls from the age of nine until the end of adolescence (Farooq, 2022). The results of this study revealed differences (p=0.01) in IPAQ PA level scores (MeTS) in all groups, where all pairwise comparisons were significant: group I and II, group II and III, and group I and III. Namely, the results prove that adolescents who have a normal BMI (group 1) have the highest level of PA, while, to a slightly lesser extent, adolescents from group 1 (underweight) have a lower level of PA compared to group 1, while adolescents who are classified as overweight have the lowest level of PF activities. Our results are in line with the results of previous studies that show that adolescents with normal BMI values also have a higher PA level compared to adolescents who fall into the overweight category (Raustorp et al., 2004; Dewi et al., 2011; Mateo-Orcajada et al., 2022). The results obtained in

this study were consistent with the results of other studies when we talk about BMI and PA levels. Namely, it has already been proven that a higher PA level affects the improvement of body composition, i.e. BMI (Jaremków et al., 2023), so it is expected to observe that adolescents who have a normal BMI level have a better PA level than their peers who fall into the category of underweight or overweight.

The significant differences we found in our study regarding PF, QoL, and PA levels have practical implications. By understanding these differences, we can gain a clearer picture of adolescents' overall development. Presenting variations across numerous variables can help establish meaningful guidelines aimed at preventing obesity-related risk factors, such as elevated BMI. Firstly, these results show that people who tend to be overweight score worse in the largest number of variables included in this research and thus underline the importance of spreading awareness about the harmfulness of an increased body mass index, i.e., the trend of increasing obesity today. This study highlights the strong association between BMI and PA, PF, and QoL among adolescents, with those in the normal BMI range showing the highest PA levels. Lower activity in overweight adolescents may stem from physical or psychological barriers, suggesting the need for supportive interventions. Future research should use objective measures, larger diverse samples, and explore psychological influences to better understand and address these associations over time.

This study reveals several limitations that must be acknowledged. The small sample size of 139 adolescents restricts the generalizability of the findings to a broader population, particularly those from diverse geographic regions, given that the sample consisted only of adolescents in one country. Another limitation is that no follow-up was done after this cross-sectional study. By doing the follow-up, we would have a better understanding of the changes in the given variables as well as the differences between them. Additionally, the study does not consider the psychological factors that might influence PF and QoL, such as motivation, stress, or fatigue, which can also play a significant role in performance or pre-mentioned QoL. Furthermore, major limitation of the study is the reliance on a IPAQ-SF questionnaire, a subjective measure, rather than an accelerometer, which provides a more objective assessment of PA levels. Furtheremore, another limitation is that QoL form is not validated in Serbian population, but we used translation to Serbian language of valid version. Finally, the difference in the number of respondents by BMI category, could have affected the results given that the sample is small and the differences in the number of respondents per group are large.

Conclusion

In conclusion, the results of this study showed significant differences in the variables of PF, QoL, and PA levels of adolescents from Serbia depending on their BMI, which implies that adolescents who are normal weight tend to have better PF, QoL and PA level in comparison with adolescents who are underweight and overweight. Those results underline the importance of spreading awareness about the harmfulness of an increased BMI, i.e., the trend of increasing obesity in today's society.

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Author Contributions

Conceptualization, S.S., T.I. and T.P-I.; methodology, all authors.; software, S.S., S.M., and A.L.; validation, D.R., I.I., G.P. and T.I.; formal analysis, S.S., A.L. and T.P-I.; investigation, S.S., D.R., S.M. and I.I; data curation, S.S., G.P., T.P-I. and I.I.; writing—original draft preparation, S.S. and T.I.; writing—review and editing, all authors; visualization, D.R., A.L. and T.I.; supervision, S.S., T.P-I., G.P. and I.I.; project administration, S.S., S.M. and I.I. The authors of this article have equal contribution and equal rights over it.

Staments and declarations

Ethical Consideration

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Research Ethics Committee of the Faculty of Sport and Physical Education Nis (protocol code 04-2035/2).

Concent to participate

Informed consent was obtained from all subjects involved in the study.

Concent for publication

All authors have read and agreed to the published version of the manuscript

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article**.**

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Data Availability

Full data coded of the included studies can be shared upon reasonable request from the corresponding author.

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References

Adam, C., Klissouras, V., Ravazzolo, M., Renson, R., Tuxworth, W., Kemper, H. C. G., et al. (1993). *EUROFIT–European Test of Physical Fitness* (2nd ed.). Council of Europe, Committee for the Development of Sport.

Alman, K. L., Lister, N. B., Garnett, S. P., Gow, M. L., Aldwell, K., & Jebeile, H. (2021). Dietetic management of obesity and severe obesity in children and adolescents: A scoping review of guidelines. *Obesity Reviews, 22*(1), e13132. https://doi.org/10.1111/obr.13132

Anderson, E., & Durstine, J. L. (2019). Physical activity, exercise, and chronic diseases: A brief review. *Sports Medicine and Health Science, 1*, 3-10.

Arnett, J. J. (2008). *Adolescence and emerging adulthood: A cultural approach* (3rd ed.). Pearson Education.

Bélanger, M., Sabiston, C. M., & Barnett, T. A. (2015). Number of years of participation in some, but not all, types of physical activity during adolescence predicts level of physical activity in adulthood: Results from a 13-year study. *International Journal of Behavioral Nutrition and Physical Activity, 12*, 1-8.

Beleigoli, A., Andrade, A., Diniz, M., Alvares, R., Ferreira, M., Silva, L., Rodrigues, M., Jacomassi, L., Cerqueira, A., & Ribeiro, A. (2019). Validation of anthropometric measures self-reported in a randomized controlled trial of a web-based platform for weight loss. *Studies in Health Technology and Informatics, 266*, 30-36.

Castro-Piñero, J., Chillón, P., Ortega, F. B., Montesinos, J. L., Sjöström, M., & Ruiz, J. R. (2009). Criterion-related validity of sit-and-reach and modified sit-and-reach tests for estimating hamstring flexibility in children and adolescents aged 6-17 years. *International Journal of Sports Medicine, 30*(9), 658-662.

Chen, G., Ratcliffe, J., Olds, T., Magarey, A., Jones, M., & Leslie, E. (2014). BMI, health behaviors, and quality of life in children and adolescents: A school-based study. *Pediatrics, 133*(4).

Davis, A. M., Bennett, K. J., & Befort, C. (2011). Obesity and related health behaviors among urban and rural children in the United States: Data from the National Health and Nutrition Examination Survey 2003–2004 and 2005–2006. *Journal of Pediatric Psychology, 36*(6), 669-676.

Dewi, R. C., Rimawati, N., & Purbodjati, P. (2021). Body mass index, physical activity, and physical fitness of adolescence. *Journal of Public Health Research, 10*(2), 2230.

Duno, M., & Acosta, E. (2019). Body image perception among university adolescents. *Revista Chilena de Nutrición, 46*, 545-553.

Đurašković, R. (2001). *Biologija razvoja čoveka sa medicinom sporta – Praktikum*. S.I.I.C.

Farooq, A., Martin, A., Janssen, X., Wilson, M. G., Gibson, A., Hughes, A., & Reilly, J. J. (2020).

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191.

Ferrans, C. E., Zerwic, J. J., Wilbur, J. E., & Larson, J. L. (2005). Conceptual model of health-related quality of life. *Journal of Nursing Scholarship, 37*(4), 336-342.

Freedman, D. S., Goodwin Davies, A. J., Phan, T. T., Cole, F. S., Pajor, N., & Rao, S., et al. (2022). Measuring BMI change among children and adolescents.

Pediatric Obesity, 17(6).

Horesh, A., Tsur, A. M., Bardugo, A., & Twig, G. (2021). Adolescent and childhood obesity and excess morbidity and mortality in young adulthood—A systematic review. *Current Obesity Reports, 10*, 301–310.

Jaremków, A., Markiewicz-Górka, I., Hajdusianek, W., Czerwińska, K., & Gać, P. (2023). The relationship between body composition and physical activity level in students of medical faculties. *Journal of Clinical Medicine, 13*(1), 50.

Javed, A., Jumean, M., Murad, M. H., Okorodudu, D., Kumar, S., Somers, V. K., Sochor, O., & Lopez-Jimenez, F. (2015). Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents: A systematic review and meta-analysis. *Pediatric Obesity, 10*(3), 234-244.

Jebeile, H., Cardel, M. I., Kyle, T. K., & Jastreboff, A. M. (2021). Addressing psychosocial health in the treatment and care of adolescents with obesity. *Obesity (Silver Spring), 29*, 1413–1422.

Jebeile, H., Kelly, A. S., O'Malley, G., & Baur, L. A. (2022). Obesity in children and adolescents: Epidemiology, causes, assessment, and management. *The Lancet Diabetes & Endocrinology, 10*(5), 351-365.

Keating, C. L., Moodie, M. L., Richardson, J., & Swinburn, B. A. (2011). Utility-based quality of life of overweight and obese adolescents. *Value in Health, 14*(5), 752-758.

Langeland, I. O., Sollesnes, R., Nilsen, R. M., Almenning, G., & Langeland, E. (2019). Examining boys' and girls' health-related quality of life from the first to the third year of upper secondary school: A prospective longitudinal study. *Nursing Open, 6*(4), 1606-1614.

Lee, P. H., Macfarlane, D. J., Lam, T. H., & Stewart, S. M. (2011). Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 8*, 1-11.

Léger, L. A., & Lambert, J. (1982). A maximal multistage 20-m shuttle run test to predict VO2 max. *European Journal of Applied Physiology and Occupational Physiology, 49*(1), 1-10.

Lister, N. B., Baur, L. A., Felix, J. F., Hill, A. J., Marcus, C., Reinehr, T., Summerbell, C., & Wabitsch, M. (2023). Child and adolescent obesity. *Nature Reviews Disease Primers, 9*(1), 24.

Lizandra, J., & Gregori-Font, M. (2021). Study of eating habits, physical activity, socioeconomic status, and sedentary lifestyle in adolescents in the city of Valencia. *Revista Española de Nutrición Humana y Dietética, 25*, 199-211. Longitudinal changes in moderate-to-vigorous-intensity physical activity in children and adolescents: A systematic review and meta-analysis. *Obesity Reviews, 21*.

Mandoh, M., Redfern, J., & Mihrshahi, S. (2023). How are adolescents engaged in obesity and chronic disease prevention policy and guideline development? A scoping review. *Global Health Research and Policy, 8*, 9.

Mateo-Orcajada, A., Vaquero-Cristóbal, R., Esparza-Ros, F., & Abenza-Cano, L. (2022). Physical, psychological, and body composition differences between active and sedentary adolescents according to the "Fat but Fit" paradigm. *International Journal of Environmental Research and Public Health, 19*(17), 10797.

Mitraković, D., Batez, M., Simić, M., Mikalački, M., & Janković, M. (2016). The significance of physical activity of young schoolchildren. *Facta Universitatis: Series Physical Education and Sport, 14*(3), 407-414.

Mollerup, P. M., Nielsen, T. R. H., Bøjsøe, C., Kloppenborg, J. T., Baker, J. L., & Holm, J. C. (2017). Quality of life improves in children and adolescents during a community-based overweight and obesity treatment. *Quality of Life Research, 26*(6), 1597-1608.

Oja, P., & Tuxworth, B. (1995). *Eurofit for Adults: Assessment of Health-Related Fitness*. Council of Europe.

Omron Healthcare. (2024). *BF511 Body composition monitor: Instruction manual*. Retrieved June 25, 2024, from https://www.manualslib.com/manual/887289/Omron-Bf511.html

Pahkala, K., Hernelahti, M., Heinonen, O. J., Raittinen, R., Hakanen, M., Lagström, H., et al. (2013). Body mass index, fitness, and physical activity from childhood through adolescence. *British Journal of Sports Medicine, 47*, 71-77.

Patrick, D. L., Edwards, T. C., & Topolski, T. D. (2002). Adolescent quality of life, part II: Initial validation of a new instrument. *Journal of Adolescence, 9*, 287-300.

Pulgarón, E. R. (2013). Childhood obesity: A review of increased risk for physical and psychological comorbidities. *Clinical Therapeutics, 35*, A18–A32.

Qin, G., Qin, Y., & Liu, B. (2022). Association between BMI and health-related physical fitness: A cross-sectional study in Chinese high school students. *Frontiers in Public Health, 10*, 1047501.

Raustorp, A., Pangrazi, R. P., & Ståhle, A. (2004). Physical activity level and body mass index among schoolchildren in south-eastern Sweden. *Acta Paediatrica, 93*(3), 400-404.

Sawyer, S. M., Afifi, R. A., Bearinger, L. H., Blakemore, S. J., Dick, B., & Ezeh, A. C. (2012). Adolescence: A foundation for future health. *The Lancet, 379*(9826), 1630-1640.

Simonović, K., Stanković, A., Šljivić, K., & Nikolić, M. (2024). Validity of the international physical activity questionnaire (IPAQ) for Serbian adolescents in urban areas. *Facta Universitatis: Series Physical Education and Sport, 173-181*.

Trajković, N., Rančić, D., Ilić, T., Herodek, R., Korobeynikov, G., & Pekas, D. (2024). Measuring handgrip strength in school children: Inter-instrument reliability between Takei and Jamar. *Scientific Reports, 14*(1), 1074.

Van de Pas, K. G. H., de Krom, M. A. P., Winkens, B., van Dielen, F. M. H., & Vreugdenhil, A. C. E. (2023). Health-related quality of life in children and adolescents with overweight, obesity, and severe obesity: A cross-sectional study. *Obesity Facts, 16*(3), 282-292.

Vasiljevic, I. (2018). Anthropometric parameters as indicators of obesity in adolescents in Montenegro. *Iranian Journal of Public Health, 47*(11), 1769-1770.

Weir, C. B., & Jan, A. (2024). BMI classification percentile and cut-off points. In StatPearls. Treasure Island (FL): StatPearls Publishing.

Wellens, R. I., Roche, A. F., Khamis, H. J., Jackson, A. S., Pollock, M. L., & Siervogel, R. M. (1996). Relationships between the body mass index and body composition. *Obesity Research, 4*(1), 35-44.

World Health Organization. (2017). BMI-for-age (5-19 years). Report of WHO Expert Committee. Retrieved June 26, 2024, from https://www.who.int/tools/growth-reference-data-for-5to19-years/indicators/bmi-for-age

World Health Organization. (2020). *Obesity: Preventing and managing the global epidemic*. WHO Technical Report Series 894.