Examination of Physical fitness, Body weight, Self-esteem, Body image and Eating attitudes among Adolescents

Ph.D. dissertation

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List of abbreviations

BAT: Body Attitude Test

BAT-B: Body Attitude Test- Better

BAT-W: Body Attitude Test- Worse

BMI: Body Mass Index

CR: Cognitive Restraint

CV: Cardiovascular

CVD: Cardiovascular Disease

EAT: Eating Attitude Test

EE: Emotional Eating

HFZ: Healthy Fitness Zone

HSSF: Hungarian School Sport Federation

IBM: International Business Machines Corporation

NIZ: Needs Improvement Zone

PA: Physical Activity

PE: Physical Education

PS: Personal System

RSES: Rosenberg Self-Esteem Scale

SBSH: Subjective Body Shape

SE: Self-esteem

SPSS: Statistical Product and Service Solutions

UE: Uncontrolled Eating

WHO: The World Health Organization

Introduction

Adolescence is a transition from childhood into young adulthood during which adolescents experience physical, behavioral, cognitive, emotional, and social developmental changes. Adolescence is an important period in a person's life when main health behaviors can develop that may have a lifelong impact. Puberty include rapid acceleration in physical growth, changes in body composition, metabolic changes, brain development, psychological and sexual maturation, and changes in social role.

The worldwide prevalence of obesity among adults as well as in children and adolescents has markedly increased over the past three decades leading to the so-called obesity epidemic. According to the latest data in related literature, the presence of childhood and adolescent obesity, defined as a body mass index (BMI) ≥ 95th percentile of the sex-specific BMI-for age, is as high as 18.5% in the USA, and 15% in Europe. The prevalence of obesity in adolescence has stabilized at a high level in developed countries but is still increasing in developing countries. In Hungary, according to a recent survey, in which 6824 children and adolescents (54 % boys), aged 3-18 years were examined, 14.1% of the boys and 12.6% of the girls were found to be overweight, while 7.5% of the boys and 5.5% of the girls were obese. About 80% of obese adolescents remain in this condition as an adults. Adolescents with BMIs above the 85th percentile are more likely to be obese by age 35 than their normal weight counterparts. Besides the many short-term effects of obesity such as cardio-metabolic, respiratory, musculoskeletal, endocrine, psychosocial effects, and increased cancer risk, a high percentage of children and adolescents track their obesity into adulthood resulting in several chronic diseases and even premature death.

Better mental health during adolescence predicts better general health and fewer risky health behaviors during young adulthood. Self-esteem (SE) is generally defined as the overall evaluation of oneself, and interchangeably referred to as one's overall selfconcept or self-view. Lower self-esteem can be a causal factor for depression, anxiety, eating disorders, high-risk behaviors, and social functioning. In adolescence, a decline in the level of self-esteem can be observed, especially among girls. Additionally, overweight, and obese adolescents frequently experience low SE.

Body image is determined by how individuals perceive or feel in relation to the size and outline of their own body. It is well known that girls are more dissatisfied with their body image than boys in adolescence. Body dissatisfaction may lead to adverse physical and mental health consequences, including depression, anxiety, low self-esteem, and eating disorders.

Unhealthy eating attitudes and behaviors are quite common among young people, and overweight and obesity imply a particularly high risk of developing such behaviors. The three most frequently studied areas regarding eating attitudes are uncontrolled eating (UE), cognitive restraint (CR), and emotional eating (EE). UE refers to an inclination to overeat, including the feeling of losing control. CR suggests a tendency to consciously restrict food intake rather than using physiological cues (i.e., hunger and satiety) as regulators of eating. Finally, emotional eaters tend to eat in response to emotional triggers

rather than real physiological needs. Emotional eating also implies or predicts weight gain and difficulty of losing weight.
Better cardiorespiratory fitness has a positive effect in combating depression, anxiety, mood status, self-esteem, and is seemingly associated with higher performance in education.

Focus and Aims of the present work

Association between Obesity and Overweight and Cardiorespiratory and Muscle Performance in Adolescents

Physical fitness and body weight are important markers of children's and adolescents's physical health. Obesity has become a major epidemic in the 21st century. The incidence of overweight and obesity among children and adolescents has risen even more dramatically in the past decades than in adults. Obesity is associated with a high incidence of well-known cardiovascular risk factors such as dyslipidemia, hypertension and diabetes, and pathological processes may already begin in childhood. Low levels of physical activity, cardiorespiratory fitness and sedentary behavior are associated with the prevalence of obesity. An interesting question is how physical fitness and body weight relate to each other. There are many data in the literature on this topic, but the results are diverse. The goal of our first study was to examine the possible association between obesity and overweight and cardiorespiratory and muscle performance during a 4-year follow up period in adolescents. The BMI-for age and the physical performance of adolescents, 360 girls and 348 boys, between 14–18 years of age was measured twice a year, and the correlation between overweight and obesity and cardiorespiratory and muscle performances were investigated.

Examination of Self-Esteem, Body Image, Eating Attitudes and Cardiorespiratory Performance in Adolescents

In addition to physical fitness, mental health is another important element of adolescent health.
Self-esteem, body image, eating attitudes are important component of mental health. There is a well-known relationship between body dissatisfaction, low self esteem and disordered eating attitudes. It is thought that body dissatisfaction has an indirect impact on eating behaviours, and that self-esteem and negative emotions are the intermediate mechanisms through which the effect is transmitted. An important question is how real body weight and physical fitness effect these mechanisms. In our second work, we aimed to investigate the correlations depicted in areas of self-esteem, body image, eating attitudes and BMI-for-age and cardiorespiratory performance among adolescent boys and girls. We also examined whether there is a gender difference concerning our physical and psychological variables.

Association between Obesity and Overweight and Cardiorespiratory and Muscle Performance in Adolescents

Materials and methods

Subjects

A total of 708 students from four-grade high school classes were enrolled in the study (360 girls with an average age of 14.2 ± 0.4 years, and 348 boys with an average age of 14.1 ± 0.4 years) at the beginning of high school (9th grade) in Baranya county, Hungary. Measurements (body weight and height, cardiorespiratory and muscle performance) were performed twice a year (autumn and spring) for 4 years, until the end of high school (12th grade). The inclusion criteria were as follows: students who had just started high school and agreed to participate in the study. Exclusion criteria were any medical conditions that prevented student attending physical exercise classes or did not agree to participate in the study. A written informed consent was obtained from the adolescents for the measurements and the anonymous use of data for scientific purposes. Parents were also asked to sign the form to allow the measurements and data handling. The study was approved by the Regional Ethics Committee of the University of Pecs.

Body Weight, BMI, and Obesity Measurements

Body weight was measured to the nearest 0.1 kg using an electronic digital body weight weighing scale. To screen for overweight and obesity, BMI and sex- and age-specific BMI-for-age were calculated using the BMI-for-age BMI growth charts. Adolescents with a BMI-for-age ≥95th percentile were considered obese, between the 85th and 95th percentiles were classified as overweight, and with a BMI-for-age of <85th percentile were considered normal. The cut-off value for underweight was less than the 5th percentile of the BMI-for-age.

Measurements of Cardiorespiratory Performance

For the assessment of the cardiorespiratory performance of the adolescents, the 12-min run–walk test was used. The students ran, jogged, or walked on a flat course as far as they could in 12 min, and the distance covered was recorded in meters.

Measurements of Muscle Performance

Muscle performance was assessed using three motor tests.
Standing long jump test was used to assess muscular fitness as previously described. Push-up test was used to assess muscular endurance as previously described. Sit-up test was used to assess muscular endurance as previously described.

Statistical Analysis

The significance level was defined as $p < 0.05$. IBM SPSS statistical software (New York city, USA), version 11.0.1 was used to conduct descriptive analyses and to describe the sample. According to the Kolmogorov–Smirnov normality test, data collection revealed a significant deviation from the normal distribution. Therefore, the nonparametric Friedman test together with the post-hoc analysis through Wilcoxon signed-rank tests were conducted with a Bonferroni correction to analyze potential changes between gender groups, and the nonparametric Kruskal–Wallis test was performed to describe potential changes between the different weight subgroups. A gender specific sample size and power analysis was performed for the investigated population using PS program version 3.1.2

Results

Results from Gender Within-Groups Analyses

Changes in the BMI-for-Age during the 4 years

At the beginning of our study, 4 percent of the girls were underweight, 75 percent normal weight, 15 percent overweight, and 6 percent obese. With respect to the boys, 6 percent were underweight, 69 percent normal weight, 15 percent overweight, and 10 percent obese. In the spring of 12th grade, 8 percent of the girls were underweight, 75 percent normal weight, 12 percent overweight and 5 percent obese. With respect to the boys, 7 percent were underweight, 72 percent normal weight, 11 percent overweight, and 10 percent obese. Among girls, the average baseline BMI-for-age of 20.52 ± 2.87 did not increase significantly during the 4-year observational period, as it was 21.01 ± 3.05 at the end of the 12th grade ($p = 0.120$). Similarly, there was no significant change in the average BMI-for-age of the boys. It was 20.80 ± 3.75 in the autumn of 9th grade, and 22.01 ± 3.71 in the spring of 12th grade ($p = 0.100$).

Cardiorespiratory Performance of Boys and Girls during the four years

There was a statistically significant difference between the 4-year run–walk test results of genders (girls: $\chi2(2) = 52.32$, $p < 0.001$; boys: $\chi2(2) = 93.64$, $p < 0.001$). There were significant differences between the 9th grade autumn and 12th grade spring run-walk test results among boys ($Z = -4.726$, $p < 0.001$, $\eta2 = 11.99$) (Figure 1A). Among girls, only a seasonal variation could be observed (there was no significant difference between the 9th grade autumn and 12th grade autumn data in girls; $Z = -0.569$, $p = 0.569$, $\eta2 = 12.01$).

Muscle Performances of Boys and Girls during the four years

The lower limb dynamic, the strength and endurance of hip flexors and abdominal muscles, shoulder and arm muscle strength, significantly improved during the four years in both girls {1: $\chi 2(2) = 67.147$, $p < 0.001$; 2: $\chi 2(2) = 183.16$, $p < 0.001$; 3: $\chi 2(2) = 148$, $p < 0.001$} and boys {1: $\chi 2(2) = 336.395$, $p < 0.001$; 2: $\chi 2(2) = 73.169$, $p < 0.001$; 3: $\chi 2(2) = 210.542$, $p < 0.001$}. There were significant differences between the 9th grade autumn and 12th grade spring results of the standing long jump distance (boys $Z = -10.404$, $p < 0.001$, $\eta 2 = 11.95$; girls $Z = -4.153$, $p < 0.001$, $\eta 2 = 12.004$) (Figure 1B), sit-up test (boys $Z = -3.269$, $p < 0.001$, $\eta 2 = 12.003$; girls $Z = -8.073$, $p < 0.001$, $\eta 2 = 11.98$) (Figure 1C), and push-up test results (boys $Z = -6.946$, $p < 0.001$, $\eta 2 = 11.98$; girls $Z = -5.746$, $p < 0.001$, $\eta 2 = 11.99$) (Figure 1D).

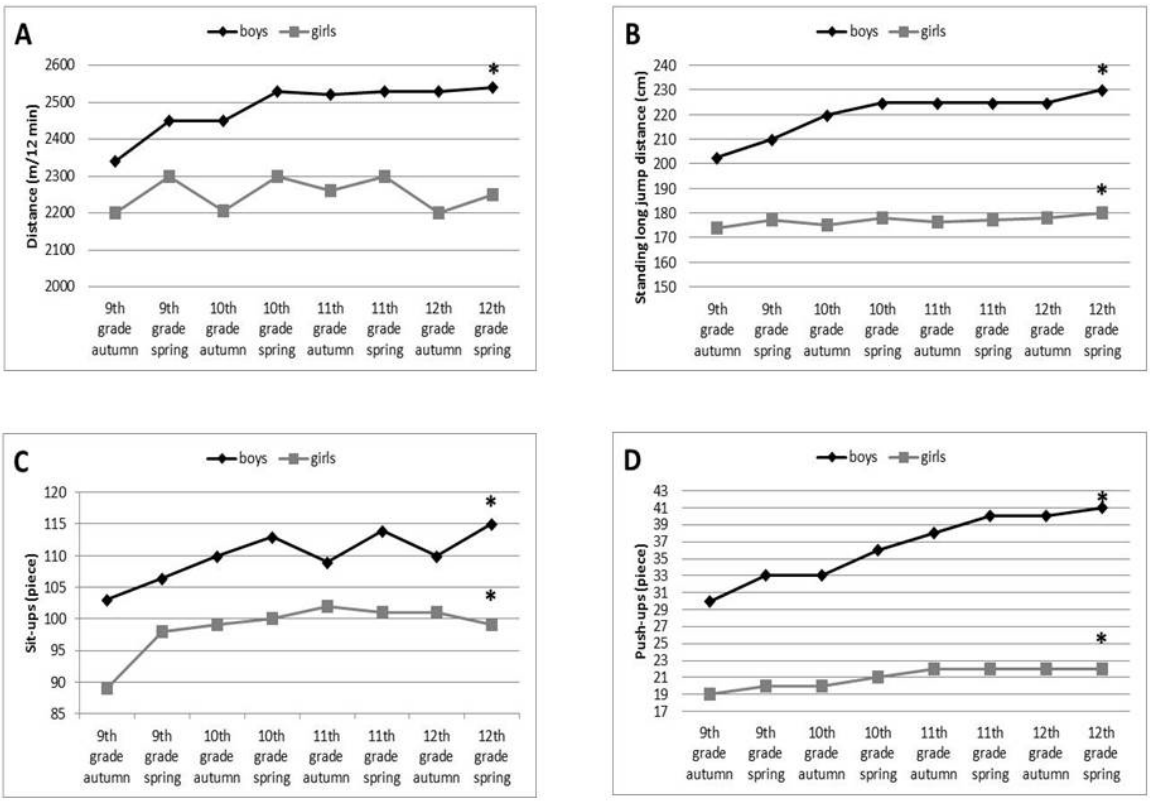

Figure 1. Changes in muscle strength and aerobic fitness between 9th and 12th grade in both genders. Significant improvement was detected in boys' aerobic capacity according to 9th grade autumn and 12th grade spring data (data are shown as median, * = $p < 0.05$). However, only a seasonal variation was revealed in girls' aerobic capacity during the 4 years (**A**). Significant improvement was detected in leg dynamic muscle strength (measured with long jump distance) (**B**), in the strength and endurance of abdominal muscles (measured by sit-up tests) (**C**), shoulder and arm muscles (measured by push-up tests) (**D**) in both genders during the 4-year observational period (data are shown as median, * = $p < 0.05$).

Results from Between-Weight-Groups Analyses

Association between obesity and overweight and cardiorespiratory performance

The Kruskal–Wallis H test showed a significant association between weight status and run-walk test results: the performance of overweight and obese girls was significantly lower than that of classmates with normal weight in the 9th grade ($\chi2(2) = 102.943$, $p < 0.001$, $\eta2 = 0.292$), and in the 12th grade ($\chi2(2) = 96.844$, $p < 0.001$, $\eta2 = 0.274$). Similar results were observed among boys in 9th grade ($\chi2(2) = 109.655$, $p < 0.001$, $\eta2 = 0.33$) and in 12th grade ($\chi2(2) = 86.406$, $p < 0.001$, $\eta2 = 0.258$) (Figure 2A). Mean rank values are shown in Table 1.

Table 1. Mean rank values by the Kruskal–Wallis test for between-weight-group analyses.

GIRLS						
performance type	9th grade			12th grade		
	obese	overweight	normal	obese	overweight	normal
run-walk	19.61	102.06	207.97	15.21	102.37	208.8
lower limb	65.77	150.18	193.78	28.66	169.88	191.42
hip flexor and abdominal muscle	37.45	140.99	198.26	29.21	153.57	194.29
shoulder and arm muscle	39.09	159.69	194.77	21.71	158.38	193.1
BOYS						
	9th grade			12th grade		
performance type	obese	overweight	normal	obese	overweight	normal
run-walk	22.97	129.59	200.5	27.37	165.21	195.11
lower limb	70.74	143.93	192.39	35.53	160.86	195.38
hip flexor and abdominal muscle	44.19	174.15	192.62	48.09	161.28	196.98
shoulder and arm muscle	75.28	159.66	188.1	54.29	159.66	192.52

Association between Obesity and Overweight and Lower Limb Performance

The performance of overweight and obese girls was significantly lower than that of normal weight girls in 9th grade ($\chi2(2) = 37.85$, $p < 0.001$, $\eta2 = 0.102$). In 12th grade, only obese girls provided significantly lower performance $\chi2(2) = 44.341$, $p < 0.001$, $\eta2 = 0.121$). Similar results were found among boys in 9th grade ($\chi2(2) = 50.906$, $p < 0.001$, $\eta2 = 0.148$), and in 12th grade ($\chi2(2) = 82.886$, $p < 0.001$, $\eta2 = 0.247$) (Figure 2B). Mean rank values are shown in Table 1.

Association between Obesity and Overweight and Hip Flexor and Abdominal Muscle Performance

Nonparametric analyses revealed an association between weight status and hip flexor and abdominal muscle strength in the adolescents. The median maximal performance of overweight and obese girls was significantly lower in 9th grade compared with normal weight girls ($\chi2(2) = 58.752$, $p < 0.001$, $\eta2 = 0.163$). In 12th grade, only the obese girls' performance was lower ($\chi2(2) = 47.980$, $p < 0.001$, $\eta2 = 0.132$). Among boys, only obesity was associated with worsened results of the sit-up tests, but no

association between overweight and abdominal muscle performance could be observed ($\chi2(2) = 65.282$, $p < 0.001$, $\eta2 = 0.193$) neither in 9th nor in 12th grade ($\chi2(2) = 68.863$, $p < 0.001$, $\eta2 = 0.204$) (Figure 2C). Mean rank values are shown in Table 1.

Association between Obesity and Overweight and Shoulder and Arm Muscle Performance

The push-up data were inversely associated only with obesity in girls ($\chi2(2) = 48.853$, $p < 0.001$, $\eta2 = 0.134$ in 9th grade; $\chi2(2) = 51.102$, $p < 0.001$, $\eta2 = 0.141$ in 12th grade) and similarly in boys (in 9th grade $\chi2(2) = 41.229$, $p < 0.001$, $\eta2 = 0.118$; in 12th grade: $\chi2(2) = 57.717$, $p < 0.001$, $\eta2 = 0.169$). The performance of overweight boys and girls was similar to the normal weight peers also in 9th and 12th grade (Figure 2D) (Table 1).

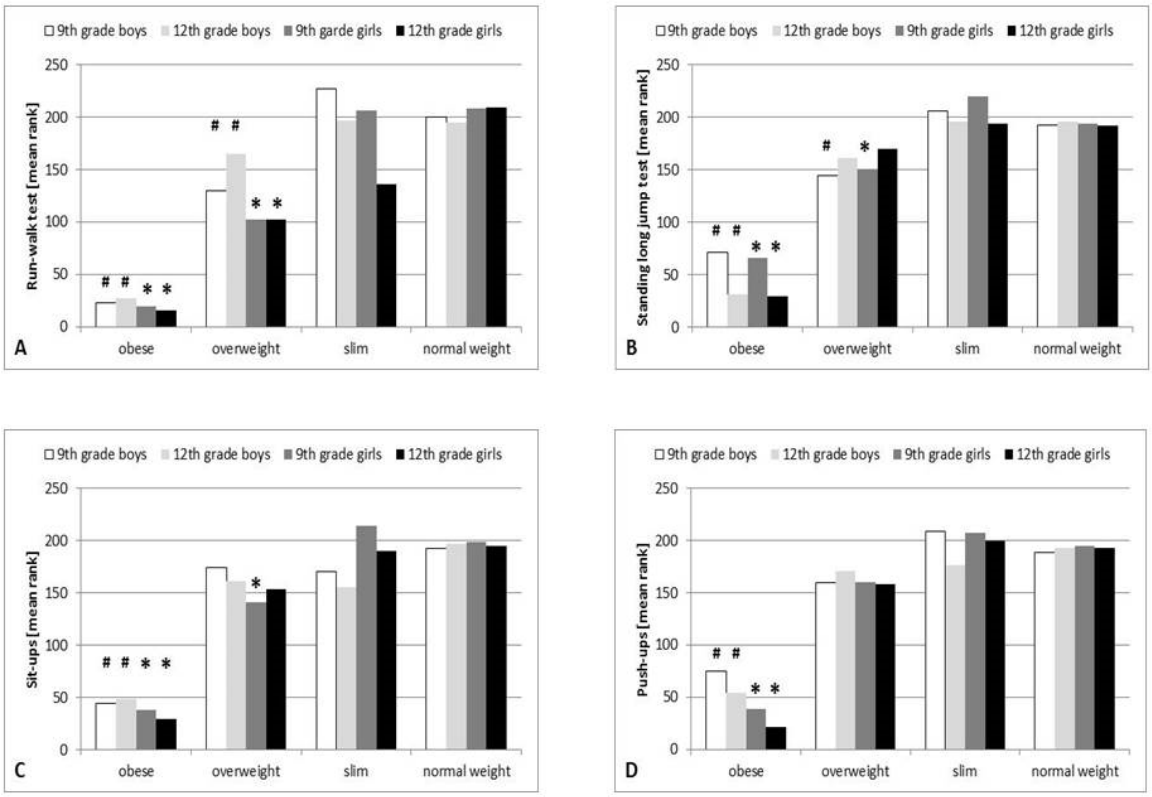

Figure 2. Association between body mass index (BMI)-for-age and aerobic and muscular fitness in adolescents. Run-walk test results are influenced by weight status in both genders (data are shown as mean rank, * = $p < 0.05$ for obese and overweight girls vs. normal weight girls; # = $p < 0.05$ for obese and overweight boys vs. normal weight boys) (**A**). Long jump test data were only influenced by obesity among 12th grade students (girls and boys, data are shown as mean rank, * = $p < 0.05$ for obese girls vs. normal weight girls; # = $p < 0.05$ for obese boys vs. normal weight boys) (**B**). Sit-up test results were significantly associated with obesity, performance, and gender (data are shown as mean rank, * = $p < 0.05$ for obese girls vs. normal weight girls; # = $p < 0.05$ for obese boys vs. normal weight boys) (**C**). Push-up test results were significantly influenced by obesity, but not by overweight in both genders (data are shown as mean rank, * = $p < 0.05$ for obese girls vs. normal weight girls; # = $p < 0.05$ for obese boys vs. normal weight boys) (**D**).

Regression Analyses

Multivariate linear regression and stepwise analyses of the data from baseline BMI, sit-up and cardiorespiratory performance in 11th grade were performed to predict cardiorespiratory performance at the end of the observational period. These variables statistically significantly predicted changes in cardiorespiratory performance ($F(5, 342) = 9752.34$, $p < 0.0005$, $R2 = 0.993$).

Examination of Self-Esteem, Body Image, Eating Attitudes and Cardiorespiratory Performance in Adolescents

Materials and Methods

Study Participants

A total of 374 students from fourth-grade high school classes were enrolled in our prospective study (209 girls with an average age of 16.4 ± 1.08 years, and 165 boys with an average age of 16.5 ± 1.03 years). Written informed consent was obtained from all the participating adolescents for the measurements and the anonymous use of data purely for scientific purposes. Parents were also asked to sign the form authorizing the measurements and data handling. The study was approved by the Regional Ethics Committee of the University of Pecs (7522-PTE 2018) and was performed in 2018.

Measurements

Body weight see in page 5 as Body weight, BMI, and Obesity Measurements

Questionnaires

Questionnaires were completed by all study participants. Prior to completion students were instructed to read the questions carefully and to devote sufficient time to answer the questions.

Rosenberg Self-Esteem Scale

We used the Hungarian version of the Rosenberg Self-esteem Scale to measure students' global self-worth by measuring both negative and positive feelings regarding the inner self. The 10-item scale is uni-dimensional. All items are answered using a 4-point Likert scale ranging from strongly agree to strongly disagree. Higher scores refer to higher self-esteem.

EAT-26

The Eating Attitudes Test measures three aspects of eating behaviors. Cognitive restraint (CR) is a conscious effort by individuals to control what they eat to maintain or lose weight. Uncontrolled eating (UE) defines excessive eating in response to a loss of control over the food. Emotional eating (EE) is the need to overeat when an individual is unable to cope with emotionally negative situations and moods. The total value consists of tallying the scores regarding the three factors. Higher scores in the respective scales are indicative of greater cognitive restraint, uncontrolled, or emotional eating.

BAT

The Body Attitude Test (BAT) is a self-report questionnaire including 20 items, scored on a 6-point Likert-scale. The test measures the subjective body experience and the attitudes toward the individual's body, such as dissatisfaction with their own body, depersonalization of the body, complex feelings regarding overweight, lack of trust in one's own body, hyperactivity and restlessness. The cut-off score is 36. Higher scores reflect diminished levels regarding attitudes toward one's own body.

The descriptives of the psychological variables are depicted in Table 2. The internal reliability of each scale reached a good level: Rosenberg Self-esteem Scale (Cronbach's $\alpha = 0.88$), The BAT (Cronbach's $\alpha = 0.83$), The Eating Attitudes Test (Cronbach's $\alpha = 0.81$).

Table 2. Descriptives regarding the psychological variables. Mean refers to the average scores of each psychological scale and SD is the standard deviation. The Minimum and Maximum values show what were the lowest and highest scores the subjects circled. Skewness is a measure of symmetry, or more precisely, the lack of symmetry of the data, while Kurtosis is a measure of whether the data are heavy-tailed or light-tailed relative to a normal distribution.

Psychological Variable	Mean	SD	Minimum	Maximum	Skewness/Kurtosis
Self-esteem (RSES)	28.91	6.32	12	40	−0.251/−0.471
Body attitudes (BAT)	24.02	7.70	13.13	55	0.865/0.960
Uncontrolled eating (EAT-UE)	19.29	5.18	9	33	0.339/−0.391
Cognitive restraints (EAT-CR)	14.92	3.74	6	26	0.080/−0.352
Emotional eating (EAT-EE)	10.24	4.98	6	24	0.598/0.725

Data Analysis

Sample size and power analysis were performed for the overall population grouped by gender and BMI-for-age using power and sample size calculation program version 3.1.2. The sample size of $n = 9$ per group needed to detect a true difference of $d = 6.017$ in Rosenberg self-esteem with 95% power, where type I error probability is $\alpha = 0.05$. Effect size analysis showed $d = 0.631$ (according to Cohen).

To analyze the psychological and physical variables we used Independent Samples *t*-tests, one-way ANOVA, Correlation analysis and Multivariate linear regressions after using the Kolmogorov–Smirnov test to check the normality of the data distribution. The normality test revealed a not significant result in all parameters ($p > 0.05$).

The Independent Samples *t*-tests were used to check the gender differences of the psychological variables.

Differences of BMI and shuttle run test (grouped by gender and BMI-for-age) as well as the psychological variables were evaluated by a one-way repeated ANOVA statistical test using Tamhane posthoc test.

Bivariate correlation analysis was performed calculating Spearman's correlation coefficient (rho). Multiple regression analysis with various models considering the principle of multicollinearity was performed to reveal which factors could predict Self-esteem, BAT, Uncontrolled eating, Cognitive restraints, Emotional eating and shuttle run test.

Results

BMI-for-Age

With respect to the boys, 10 percent were underweight, 63 percent normal weight, 19 percent overweight, and 8 percent obese (Figure 3A).

At the time of measurement 4 percent of the girls were underweight, 74 percent normal weight, 16 percent overweight, and 6 percent obese (Figure 3B).

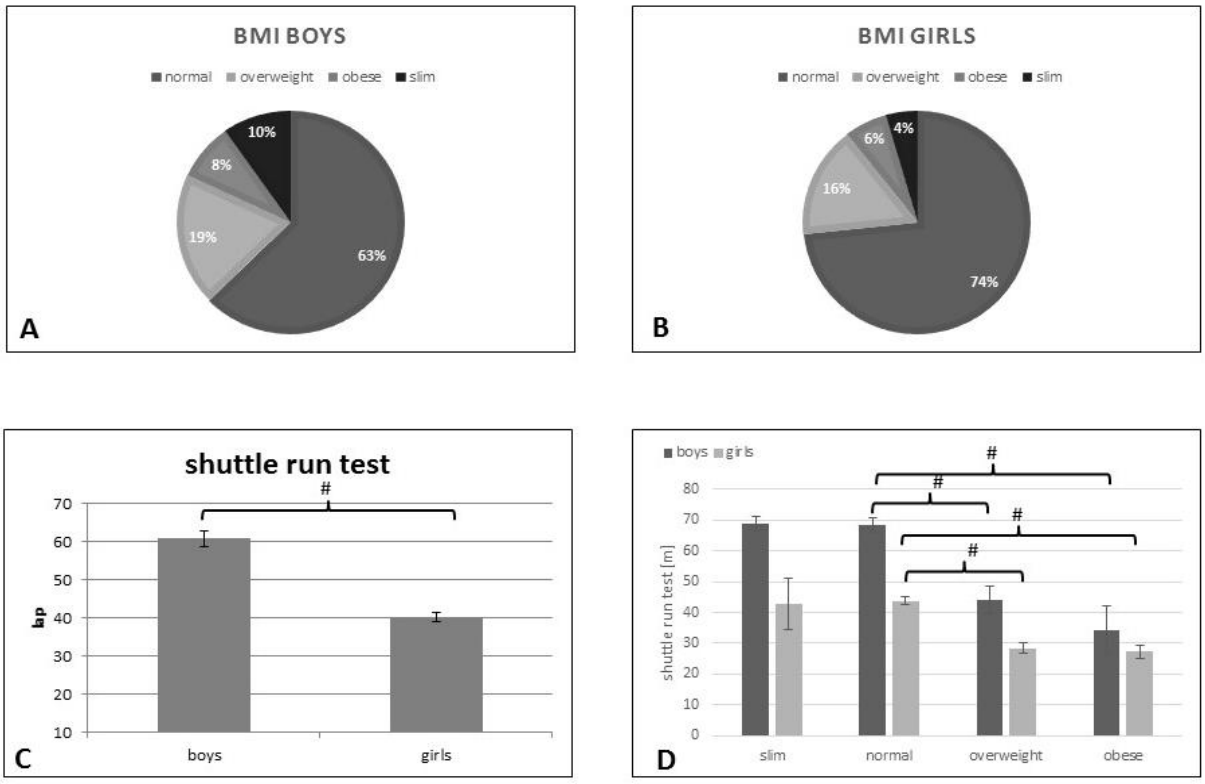

Figure 3. BMI-for-age in boys (A) and girls (B). Our results depicted significant differences in gender specific (C) and BMI-for-age specific shuttle run test (D) (data are shown as mean ± S.E.M, # = $p < 0.001$).

The 20 m Shuttle Run Test Results

According to the 20 m shuttle run test data, 65% of boys (54 lap≥) and 59% of girls (38 lap≥) were in the Healthy Fitness Zone (HFZ). 35% of boys (≤45 lap) and 41% of girls (≤28 lap) were in the Needs Improvement zone (NIZ). The boys completed an average of 60.83 ± 25.79 laps. The girls accomplished 40.22 ± 16.34 laps. Students who meet the standards are classified as being in the Healthy Fitness Zone (HFZ), whereas students who fall below the standards are classified as being in Needs Improvement Zone (NIZ).

The analysis of the gender differences detected significantly lower shuttle run test results among girls than when compared with boys (40.2 ± 1.13 vs. 60.8 ± 2.0; $p < 0.001$) (Figure 3C).

We observed no significant differences in shuttle run test results between slim and normal (68.81 ± 2.35 vs. 68.32 ± 2.46), as well as between overweight and obese boys (44.09 ± 4.65 vs. 34.4 ± 7.94), however, we discovered significantly lower performance in the obese and overweight boys than when compared with their classmates with normal BMI-for-age (Figure 3D).

The study results exhibited quite similar consequences in studying girls weight groups: there were no significant differences in shuttle run test outcomes between slim and normal nor between overweight and obese, however, we found significant differences between normal and overweight or obese girls' aerobic capacity (42.78 ± 8.5 slim; 43.8 ± 1.28 normal; 28.44 ± 1.57 overweight; 27.23 ± 2.02 obese) (Figure 3C).

Psychological Test Results

The study revealed a significant difference in self-esteem: Girls showed lower self-esteem than when compared with boys (t (374) = 6.62; $p = 0.05$). Girls also reported significantly negative body attitudes (t (374) = −9.12; $p < 0.001$) than when compared with boys and reached higher scores on each of the Eating attitudes subscales. Girls showed signs of uncontrolled eating (t (374) = −3.47; $p = 0.01$), cognitive restraint (t (374) = −5.56; $p < 0.001$) and emotional eating (t (374) = −4.78; $p < 0.001$) more often than when compared with secondary school-aged boys (Figure 4).

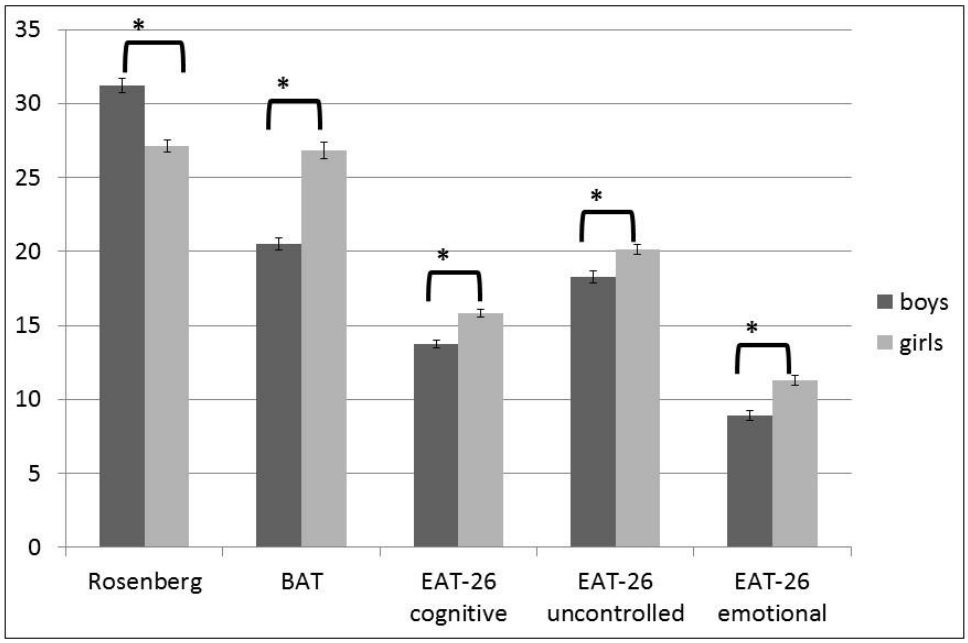

Figure 4. Our results showed significant differences in gender on the psychological tests (data are shown as mean ± S.E.M, * = $p < 0.001$). (Rosenberg = Rosenberg Self-esteem Scale; BAT = Body Attitude Test; EAT-26 = Eating Attitudes test: cognitive restraint, uncontrolled eating, emotional eating).

Psychological tests did not reveal any significant differences in the comprehensive analyses of the weight groups in both boys and girls (Figure 5).

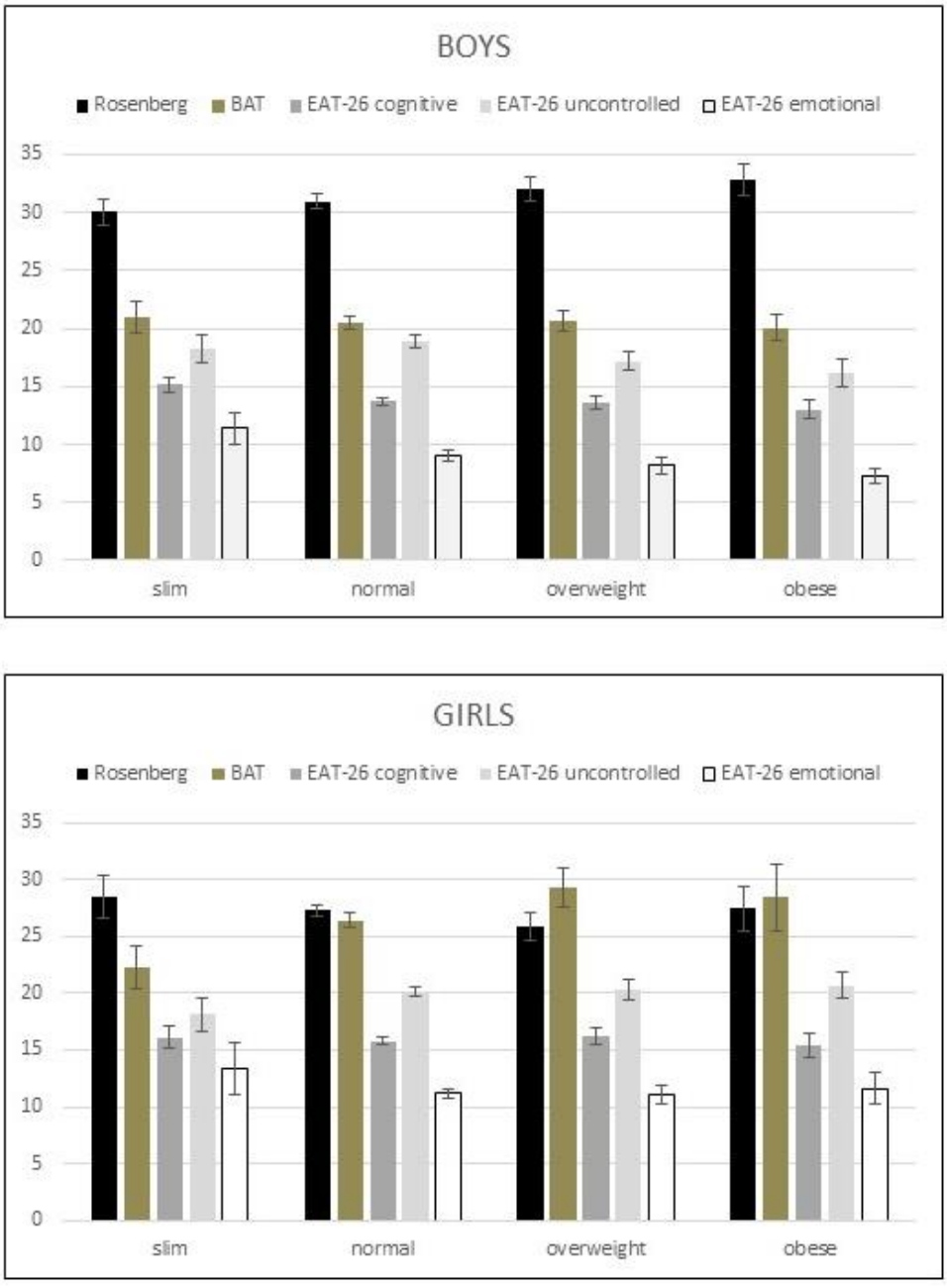

Figure 5. Psychological results in boys and girls showed no significant differences in the weight groups (data are shown as mean ± S.E.M, $p < 0.05$). (Rosenberg = Rosenberg Self-esteem Scale; BAT = Body Attitude Test; EAT-26 = Eating Attitudes test: cognitive restraint, uncontrolled eating, emotional eating).

The ANOVA analysis detected significant differences between girls BAT-W and BAT-B subgroups in Rosenberg Self-esteem Scale (21.7 ± 0.95 vs. 27.97 ± 0.42; $p < 0.001$) and in the eating attitudes, such as cognitive restraints (17.8 ± 0.69 vs. 15.5 ± 0.27; $p = 0.003$) and emotional eating (13.5 ± 1.04 vs. 10.9 ± 0.37; $p = 0.011$). The results showed significant differences between boys BAT-W and BAT-B subgroups in eating attitudes cognitive restraints subscale (19.0 ± 1.0 vs. 13.7 ± 0.27; $p = 0.03$) (Figure 6).

The first multilinear regression analysis revealed that gender (b = −0.31, t = −6.41, p < 0.001) and subjective body shape predicted self-esteem (b = 0.16, t = 3.23, p = 0.001).

Body attitudes were also influenced by gender (b = 0.39, t = 8.71, p < 0.001) and subjective body shape (b = −0.32, t = −7.09, p < 0.001).

The Uncontrolled eating subscale of the Eating attitudes was only affected by gender (b = 0.18, t = 3.53, p < 0.001), just as the Emotional eating subscale (b = 0.23, t = 4.57, p < 0.001). In this case, however, BMI also played a weaker role (b = −0.12, t = −2.25, p < 0.05).

Cognitive restraint, similarly to self-esteem, showed strong associations with subjective body shape (b = −0.22, t = −4.32, p < 0.001) and gender (b = 0.26, t = 5.27, p < 0.001) (Table 3).

Second multivariate linear regression and stepwise analyses were performed to predict shuttle run test as the dependent variable regarding Rosenberg Self-esteem Scale and BAT values. We revealed that both variables added statistically significantly to the prediction in boys F(2, 163) = 3.189, p = 0.044, R2 = 0.038.

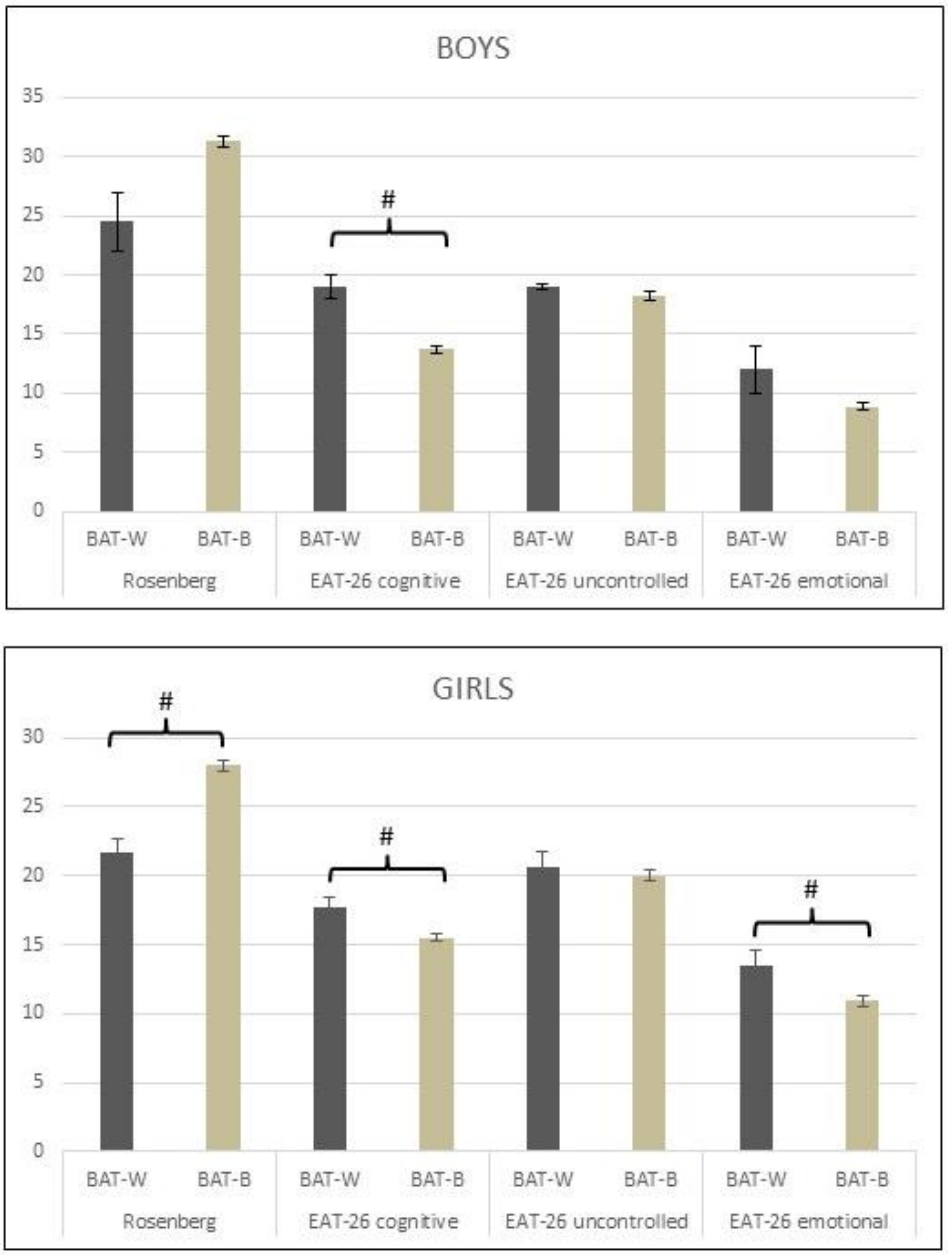

Figure 6. The analysis revealed significant differences between girls BAT-W (those with worse attitudes toward their body) and BAT-B (those with better attitudes toward their body) subgroups in Rosenberg Self-Esteem Scale and Eating attitudes cognitive restraints and emotional eating subscales. Additionally, our data showed significant differences between boys BAT-W and BAT-B subgroups in the cognitive restraints subscale of eating attitudes. (BAT-W: those with worse attitudes toward their body, BAT-B: those with better attitudes toward their body). #: significant difference, $p<0.05$

Table 3. Results of the regression analysis: standardized β and R2 values. (SBSH: Subjective body shape). *p<.05, **p<.001

Dependent Variables	Predictors				
	Age	**Gender**	**SBSH**	**BMI for Age**	R^2
Self-esteem (RSES)	0.09	−0.31 **	**0.16 ** **	0.07	**0.16 ** **
Body attitudes (BAT)	0.00	**0.39 ** **	**−0.32 ** **	0.01	**0.28 ** **
Uncontrolled eating (UE)	−0.06	0.18	0.06	−0.02	0.04 *
Cognitive restraints (CR)	0.02	**0.26 ** **	**−0.22 ** **	−0.09	**0.12 ** **
Emotional eating (EE)	−0.01	**0.23 ** **	−0.07	−0.12*	0.07 **

Discussion

In our first study we have examined the association between the BMI-for-age and the cardiorespiratory and muscle performance of adolescents between 14 and 18 years of age. Our results show that cardiorespiratory performance increased significantly in boys during the 4 years, meanwhile in girls it only showed seasonal fluctuation. The strength of leg, shoulder and arm and abdominal muscles significantly increased both in boys and girls, but boys showed a more pronounced improvement. There was no significant change in the BMI-for-age during the examined period either in boys nor in girls. An inverse association between obesity and overweight and cardiorespiratory performance of the adolescents regardless of their age and gender was revealed. Worsening muscle performances were associated primarily with obesity. There was no association between overweight and shoulder and arm muscle performance in any age categories neither in girls nor in boys. Overweight was negatively correlated with lower limb strength in 9th grade girls and boys, and with abdominal muscle performance only in 9th grade girls.

In our second work we investigated different psychological characteristics among adolescent boys and girls and examined gender differences and correlations with the BMI-for-age and cardiorespiratory performance. According to our results lower self-esteem and higher scores for BAT and each scale of eating attitudes, such as Uncontrolled Eating (UE), Cognitive Restraints (CR) and Emotional Eat-ing (EE) were measured among adolescent girls compared to boys. Interestingly, not objective body weight but subjective body shape and gender predicted self-esteem and BAT scores and the cognitive restraints in the eating attitudes. Uncontrolled and emotional eating subscales were primarily influenced by gender, while BMI played only a weaker role. Additionally, self-esteem and body image were positively associated with cardiorespiratory performance in the boys, but not among girls.

In our study, no significant correlation was found among the actual weight status and body image satisfaction, neither the eating attitude subscales (Figure 5). According to the literature, there are many

factors influencing body image and eating attitudes. Studies have shown that social media consistently and overly represent idealized body types which potentially contribute to poor body image and disordered eating behaviors which may be underpinned by the beauty and diet industries. Adolescent body image is also heavily influenced by family and social relationships. Adolescents who are exposed to negative body and diet conversations with friends and family members have higher levels of body dissatisfaction and higher BMIs and are manifested in unhealthy eating behaviors later in life.

In our study, positive body image was associated with higher self-esteem and lower cognitive restraints and emotional eating in the eating attitude subscales in girls and with lower cognitive restraints in boys. Girls were more prone to emotional and uncontrolled eating and cognitive restraints, when compared to boys and BMI, had only a weaker role in emotional and uncontrolled eating. It is well-known that eating disorders are more common in women than in men and adolescent girls are at high risk. Girls experience more food-related conflicts than when compared with boys and they also experience more dissatisfaction with their body that may affect weight regulation.

Conclusions

Based on our data great attention should be paid to maintaining normal weight status and physical performance of adolescents since both obesity and overweight are negatively associated with cardiorespiratory performance, and obesity with muscle performance. In addition mental health during adolescence is of utmost importance in overall health. Since adolescence health behaviours can predict adult health status, future research might require a longitudinal follow-up to track changes in attitudes of adolescents about their own body, self-esteem and eating habits and examine other potential mediators among physical and psychological variables, such as the role of social and family influence. It might also be worthwhile to assess mental health from time to time to provide more support for adolescents.

Summary of new findings

Association between Obesity and Overweight and Cardiorespiratory and Muscle Performance in Adolescents

1. The cardiorespiratory performance of adolescent girls and boys was inversely associated with both overweight and obesity, and this association could be observed throughout the 4 years of our study.
2. Obesity has shown an inverse relation with muscle performance regardless of the age and gender of the adolescents.
3. A lower correlation between overweight and the strength of different muscle groups was found and depended on age and gender.

Examination of Self-Esteem, Body Image, Eating Attitudes and Cardiorespiratory Performance in Adolescents

1. Although overweight and obesity were more commonly seen in adolescent boys, girls were more prone to have lower levels of self-esteem, poorer body images and experienced increased problems regarding eating behaviors such as uncontrolled eating, cognitive restraints and emotional eating compared to boys.
2. No significant correlation was found between BMI and psychological test results in either boys or girls.
3. Cardiorespiratory performance was positively associated with self-esteem and body image among boys, and it had a negative correlation with body weight in both genders.
4. Interestingly, not objective body weight but subjective body shape satisfaction and gender predicted self-esteem, body attitude and the cognitive restraints in the eating attitudes.
5. Uncontrolled and emotional eating were primarily influenced by gender, while BMI played only a weaker role.

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Publications of the author

Topic related journal articles

Petrovics, P.; Sandor, B.; Palfi, A.; Szekeres, Z.; Atlasz, T.; Toth, K.; Szabados, E**.** Association between Obesity and Overweight and Cardiorespiratory and Muscle Performance in Adolescents. Int. J. Environ. Res. Public Health. 2020, 18, 134. doi:10.3390/ijerph18010134.

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Other articles

1. Praksch, D**.;** Kovacs, D.; Sandor, B.; **Petrovics, P**.; Kovacs, K.; Toth, K.; Szabados, E. Impact of home- and center- based physical training program on cardio-metabolic health and IGF-1 level in elderly women. European Journal Aging and Physical Activity.

Quartile Ranking: Q2 Impact Factor: 2.65 (2017/2018)

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