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Adolescents' nutritional status and its association with physical fitness, physical activity attitudes, and sleep duration

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Background: The nutritional status of adolescents is a crucial determinant of their overall health and physical fitness. The study's primary aim was to determine the differences in physical fitness levels among adolescents with different nutritional statuses. The secondary aim was to explore the relationship between nutritional status and self-reported physical fitness, attitudes toward physical activity, and sleep duration. **Methods:** A total of 235 adolescents aged 16–17 were recruited in the study. The study employed the Zuchora Physical Fitness Index and a self-designed nine-item questionnaire. **Results:** Individuals with normal nutritional status showed higher levels of physical fitness ($p<0.05$) and reported better results in physical education at school ($p<0.05$). No significant differences were observed in the perceived value of physical activity in daily life, sleep duration, self-reported physical fitness, and opinion about the role of physical activity in someone's daily life depending on nutritional status ($p>0.05$). Significant differences were observed in physical fitness depending on sleep duration, self-reported physical fitness, and opinions on physical activity in human life, but only for individuals with normal nutritional status ($p<0.05$). For individuals with underweight, physical fitness varied depending on self-reported physical fitness ($p<0.05$). A weak-to-moderate positive correlation was observed between the perceived value of physical activity and physical fitness ($p<0.05$). **Conclusion:** Keeping normal nutritional status is related to better physical fitness and school performance in physical education, irrespective of perceptions about the importance of physical activity or sleep duration.

Keywords: nutritional status, adolescents, physical fitness

Introduction

Diagnosing nutritional status is a crucial indicator often evaluated through anthropometric and biochemical tests. Anthropometric measurements, such as assessing the body's physiological state based on height and weight, are commonly employed to gauge nutritional well-being. Body mass index (BMI) is the most popular and common method for nutritional status assessment (1). For adults, the current recommendations by the US Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) designate a normal BMI range between 18.5 and 24.9. A BMI ≥ 25 kg/m2 is categorized as overweight, while a BMI ≥ 30 kg/m2 is classified as obese, and severe obesity is characterized by a BMI ≥ 40 kg/m2 (2). BMI is uncomplicated in terms of calculation. Nevertheless, the BMI has notable limitations, particularly in its inability to offer insights into body mass composition, including details on body fat, muscle tissue, and water content. Consequently, the classification of overweight or obesity in individuals with well-developed musculature can often yield inaccurate results (1). Despite that, BMI is easy to calculate, simple to interpret, and does not require specialized equipment for assessment.

Physical activity (PA), in turn, is a health-promoting behavior and engaging in compulsive exercise is a commonly used strategy to offset caloric intake or reduce body weight. It seems that practicing physical activity appears to have a positive influence on adolescents, increasing self-esteem and producing a more positive body image. On the other hand, a lack of physical activity can negatively affect motor development and health, while also increasing the risk of developing chronic conditions (3,4). The studies showed a positive relationship between physical activity, positive health effects and physical fitness. Current guidelines suggest that children and adolescents should engage in at least 60 minutes of MVPA (moderate to vigorous physical activity) per day, along with muscle and bone strengthening activities at least 3 days per week (5). Physically fit adolescents have shown higher levels of PA knowledge, more positive attitudes towards PE, and have engaged in less sedentary behavior than those who are physically unfit, regardless of their weight status (6).

Physical fitness is related to the health of the whole body and is defined as the ability to undertake and solve difficult motor tasks in various life situations. Studies show a link between BMI

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and health-related physical fitness. Lower scores on physical fitness tests are achieved by overweight children (7). This is also confirmed by other studies, showing, that better performances of physical fitness were attained by adolescents in the mid-range of the BMI distribution, while performances of youth at the low and high ends of the BMI distribution performed lower (8).

Sleep can be defined as a reversible behavioral state of impaired consciousness through a reduction in sensory and motor activity. Sleep is an essential factor which determines overall health, and it is important to keep its appropriate quality and duration. The most recent recommendations from the National Sleep Foundation are 9 to 10 hours of sleep per day for children 6 to 13 years of age and 8 to 10 hours for adolescents aged 14 to 17 years. Furthermore, the literature has shown that sleep impacts elements of athletic performance including both physical and cognitive performance, recovery, injury risk, and mental well-being (9). Research shows that short sleep duration is a risk factor for obesity in children and adolescents due to poor diet and less physical activity (10).

The motivation to undertake this research was the fact that the examination of the nutritional status of adolescents is crucial in identifying potential health implications associated with being underweight, overweight, and obese. Adolescence is a critical transition period, characterized by rapid growth and development, and any deviation from optimal nutritional status can lead to long-term health consequences in adulthood (11). The prevalence of obesity and overweight among adolescents has significantly increased in recent years, and these conditions are associated with a higher risk of developing chronic diseases such as type 2 diabetes (12). On the other hand, being underweight can have adverse effects on growth and development and may lead to nutrient deficiencies and weakened development potential (13). Additionally, nutritional status seems to be related to motor abilities and the factors it determines. Thereupon, the study's primary aim was to determine the differences in physical fitness levels among adolescents with different nutritional statuses, whereas the secondary objective was to explore the relationship between nutritional status and self-reported physical fitness, attitudes toward physical activity, and sleep duration.

Material and methods

Study group

The present study was conducted on a sample of adolescents, including 235 participants aged between 16 and 17 years, who were recruited from randomly selected high schools in Rzeszów, Poland. The participants were required to meet certain eligibility criteria, including (1) written informed consent, (2) age between 16 and 17 years, and (3) no contraindication to physical activity. Due to incomplete or incorrectly completed survey questionnaires, thirty-three participants were excluded. Consequently, a sample size of 202 subjects was included in the final analysis. The participants in the study were divided into three groups based on their nutritional status. The first group consisted of underweight adolescents (BMI<18.5), the second with normal nutritional status (BMI≥18.5 to <25), and the third group included overweight/obese adolescents (BMI≥25) (18). Study group characteristics are shown in Table 1.

Table 1. Study group description

Variable	Nutritional status	Descriptive Statistics					H	p
		Min.	Max.	Median	Mean	SD		
Age (years)	Underweight	16	17	17	16.85	0.37	3.50	0.174
	Normal Weight	16	17	17	16.92	0.27		
	Overweight/Obese	17	17	17	17	0		
Height (cm)	Underweight	156	190	167	170.74	9.13	1.07	0.587
	Normal Weight	157	190	170	171.51	8.11		
	Overweight/Obese	163	182	170.5	172.93	6.92		
Body weight (kg)	Underweight	42	62	50	50.74	5.36	79.62	<0.001
	Normal Weight	47	85	60	61.93	8.15		
	Overweight/Obese	70	120	83.5	84.57	12.89		
BMI (kg/m2)	Underweight	15.81	18.49	17.58	17.38	0.74	118.83	<0.001
	Normal Weight	18.59	24.90	20.78	20.99	1.63		
	Overweight/Obese	25.31	37.04	26.96	28.22	3.39		

Min - minimum value; Max - maximum value; SD - standard deviation; BMI - body mass index; H - ANOVA Kruskal-Wallis test value; p - p-value

Research procedure

The present study employed two research instruments: an original questionnaire and Zuchora's Physical Fitness Index. At first of the research procedure, the participants filled in the

nine-question questionnaire. The first part of the questionnaire involved four questions and encompassed anthropometric data including age, weight, height, and BMI. The other part consisted of six questions about physical activity attitudes, sleep duration, and self-reported physical fitness. The perceived value of physical activity in daily life was evaluated using a 10-point VAS scale and respondents selected a number from 1 to 10 based on their perception. The other questions in the survey concerned sleep duration, self-reported results in physical education at school, self-reported fitness levels, and opinions about the role of physical activity in someone's daily life and were closed-ended, requiring participants to select a single answer from a given set of options. Upon completion of the questionnaire, respondents underwent a physical fitness assessment which was performed using the Physical Fitness Index proposed by Krzysztof Zuchora. The index includes six trials: speed test, jumping ability test, arm strength test, flexibility test, endurance test and abdominal muscle test (19). In this study, the authors decided to exclude the endurance test. The final score is the sum of points from all attempts. The method employed in the test, including the scoring scheme for individual trials and the establishment of age-specific standards, has been extensively delineated in prior research (20,21). The Zuchora test has been widely used as a tool for assessing physical fitness in various age groups (21). Norms for the test have been developed for specific age categories, allowing for a standardized comparison of results. Furthermore, an advantage of the Zuchora test is its simplicity, as it does not require specialized equipment for testing.

Statistical analysis

The data collected was subjected to statistical analysis using the Statistica 13.3 program. Descriptive statistics, including the number of participants, percentage, mean, standard deviation, lower and upper quartile, median as well as minimum and maximum values, were computed for all variables. The analysis of the quantitative variables entailed the use of both parametric and non-parametric tests. The selection of a parametric test was contingent on the satisfaction of its fundamental assumptions, which included the adherence of the variables under study to the normal distribution, verified through the Shapiro-Wilk test. Variables that showed normal distribution were subjected to Student's t-test (for two groups) or one-way ANOVA (for three or more groups). Alternatively, variables that lack normal distribution were analyzed using the non-parametric Mann-Whitney U test (for two groups) or the Kruskal-Wallis test (for three or more groups). The evaluation of qualitative data was performed using Pearson's Chi-square. Additionally, the association between two quantitative variables was determined using Spearman's rank correlation coefficient. Statistical significance was assumed if $p < 0.05$.

Results

A comparison of physical fitness levels among adolescents with different nutritional statuses showed statistically significant differences (p=0.034). The highest median was observed in the normal weight group (21). This comparison is shown in Table 2.

Table 2. Physical fitness levels of adolescents with different nutritional status

	Zuchora Test Results						
Nutritional status	**Min**	**Max**	**Q1**	**Median**	**Q3**	**H**	**p**
Underweight	13	29	18	19	23		
Normal Weight	13	29	19	21	23	6.74	0.034
Overweight/Obese	15	26	17	19	20		

Min – minimum value; Max – maximum value; Q1 - lower quartile; Q3 - upper quartile; H - ANOVA Kruskal-Wallis test value; p - p-value

We have found no statistically significant differences between the perceptions of the value of physical activity in daily life among adolescents with different nutritional statuses (p=0.762). A detailed analysis is shown in Table 3.

Table 3. The perceived value of physical activity in daily life by nutritional status

	The perceived value of physical activity in daily life						
Nutritional status	**Min**	**Max**	**Q1**	**Median**	**Q3**	**H**	**p**
Underweight	2	10	5	7	8		
Normal Weight	2	10	6	7	8	0.54	0.762
Overweight/Obese	5	10	5	6.5	7		

Min – minimum value; Max – maximum value; Q1 - lower quartile; Q3 - upper quartile; H - ANOVA Kruskal-Wallis test value; p - p-value

Statistically significant results were obtained when comparing self-reported results in physical education at school among adolescents with different nutritional statuses (p=0.008). Most respondents declaring "very good" results in physical education at school came from the normal weight group (60.4%). However, among the underweight, overweight, and obese groups, the majority of respondents reported "good" results (46.15% and 71.43%, respectively). No significant differences were observed in sleep duration, opinion on the importance of physical activity in everyday life, and self-reported physical fitness depending on adolescent nutritional status. The above results are shown in Table 4.

Table 4. The comparison of sleep duration, opinions on the importance of physical activity in everyday life, self-reported results in physical education at school, and self-reported physical fitness adolescents with different nutritional status

Variable	Underweight		Normal Weight		Overweight/ Obese		χ2	p
	n	%	n	%	n	%		
Sleep duration								
Less than 6h	16	41.03%	53	35.57%	7	50.00%	5.14	0.274
7-8h	17	43.59%	86	57.72%	6	42.86%		
More than 9h	6	15.38%	10	6.71%	1	7.14%		
Self-reported results in physical education at school								
Very good	16	41.03%	90	60.40%	3	21.43%	13.68	0.008
Good	18	46.15%	43	28.86%	10	71.43%		
Satisfactory or unsatisfactory	5	12.82%	16	10.74%	1	7.14%		
Self-reported physical fitness								
Very good	8	20.51%	41	27.52%	2	14.29%	3.36	0.499
Good	21	53.85%	72	48.32%	6	42.86%		
Satisfactory or unsatisfactory	10	25.64%	36	24.16%	6	42.86%		
Opinion about the role of physical activity in someone's daily life								
Outstanding or important	33	84.62%	119	79.87%	11	78.57%	0.49	0.782
Marginal or irrelevant	6	15.38%	30	20.13%	3	21.43%		

n - numbers of subject; % - percent; χ2 - chi-square test value; p - p-value

In the next step of the analysis, we checked whether there existed any variations in physical fitness with respect to sleep duration, self-reported results in physical education at school, self-reported physical fitness, and opinions about the role of physical activity in someone's daily life within each of the nutritional status groups. Statistically significant differences were obtained in all studied variables (p<0.05) among the group of people with normal weight. Additionally, statistically significant differences were obtained in the group of underweight people when comparing physical fitness with self-reported physical fitness (p=0.041). The above results are shown in Table 5. In the table, the data are depicted as mean (±SD) for parametric tests and as a median (Q_1-Q_3) for non-parametric tests.

Table 5. The comparison of physical fitness levels in underweight, normal weight and overweight or obese with different sleep duration, results in physical education at school, self-reported physical fitness, and opinion about the role of physical activity in someone's daily life

Sleep duration					
	Less than 6h	7-8h	More than 9h	H/F	p
Underweight	19.81 ± 3.83	21.47 ± 3.97	18.00 ± 2.61	F=2.09	0.139
Normal weight	19.85 ± 2.82	21.30 ± 3.43	21.20 ± 2.90	F=3.49	0.033
Overweight/Obese	17 (16-19)	19 (19-20)	22 (22-22)	H=5.50	0.064
Self-reported results in physical education at school					
	Very good	Good	Satisfactory or unsatisfactory	H/F	p
Underweight	21.5 (18.5-26)	19.5 (18-21)	18 (15-18)	H=4.23	0.121
Normal weight	21.60 ± 2.90	19.79 ± 3.31	18.81 ± 3.53	F=8.62	<0.001
Overweight/Obese	19 (19-26)	18.5 (17-20)	16 (16-16)	H=2.96	0.228

	Self-reported physical fitness				
	Very good	Good	Satisfactory or unsatisfactory	H/F	p
Underweight	22.75 ± 4.68	20.29 ± 2.81	18.20 ± 4.24	F=3.50	0.041
Normal weight	22.41 ± 2.78	20.92 ± 2.94	18.64 ± 3.20	F=15.72	<0.001
Overweight/Obese	21 (16-26)	19 (18-19)	19 (17-20)	H=0.18	0.916
	Opinion about the role of physical activity in someone's daily life				
	Outstanding or important	Marginal or irrelevant		t/z	p
Underweight	20.52 ± 3.52	18.83 ± 5.56		t=-0.98	0.333
Normal weight	22 (19-23)	18.5 (16-20)		z=-4.49	<0.001
Overweight/Obese	19 (17-19)	20 (15-20)		z=-0.16	0.876

H - ANOVA Kruskal-Wallis test value; F - one-way ANOVA; z - Mann–Whitney U test value; t - t-test value; p - p-value

Finally, we went ahead to investigate potential associations between physical fitness levels and the perceived value of physical activity in daily life. The findings of the study revealed statistically significant correlations within the underweight group (p=0.042) and the normal weight group (p<0.001), as well as in the entire population (p<0.001). The underweight group showed a weak positive correlation between the study variables (R=0.33), while the normal weight group showed a moderate correlation (R=0.45). Interestingly, such a correlation was not observed in the group of overweight or obese. The details of these correlations are presented in Table 6.

Table 6. Relationship between physical fitness levels and perceived value of physical activity in daily life

	The perceived value of physical activity in daily life							
	Underweight		**Normal weight**		**Overweight/Obese**		**Total**	
	R	**p**	**R**	**p**	**R**	**p**	**R**	**p**
Zuchora Test Results	0.33	0.042	0.45	<0.001	-0.28	0.335	0.40	<0.001

R – Spearman's rank correlation coefficient; p – p-value

Discussion

This study aimed to determine the differences in physical fitness levels among adolescents with distinct nutritional statuses and to investigate the association between physical fitness levels and attitudes toward physical activity, physical fitness, and sleep quality. In our study adolescents with normal nutritional status exhibited higher physical fitness levels compared to other study groups. These results match those observed in study by Qin et al. (17). A possible explanation for this might be the fact that underweight individuals often have insufficient muscle mass and low energy reserves, which can limit their ability to perform strenuous physical activity. On the other hand, overweight and obese individuals typically have excess body fat, which can increase the workload on the cardiovascular and respiratory systems, making physical activity more difficult and less efficient.

In our study, no significant differences were found between the perceived value of physical activity in daily life and the nutritional status of individuals. This finding is somewhat surprising given the fact that other research shows that engaging in organized exercise enhances the perceived value of physical activity among participants (18). This inconsistency may be because our study only assessed the perceived value of physical activity in daily life based on a single question, which may not have been comprehensive enough to capture all aspects related to perceived physical activity and nutritional status. Other aspects which can determine the perceived value of physical activity include socioeconomic status, dietary habits, overall lifestyle, or personal preferences.

Another finding was that individuals with normal nutritional status reported better physical education results than those who were underweight and overweight/obese. This finding is noteworthy as no prior research has examined this aspect. The attainment of better results in physical education at school among individuals with normal nutritional status can be attributed to several factors, which include the enhanced availability of energy substrates, more optimal body composition, and higher muscle strength and endurance. Additionally, scientific literature has provided ample evidence that participating in physical education classes can result in numerous health benefits (19,20).

The scientific literature has already attempted to investigate differences in physical fitness results depending on sleep duration (21). According to our research, individuals who slept seven to eight hours displayed higher levels of physical fitness compared to those who slept less than six or more than nine hours, but only in individuals with normal nutritional status. No such differences were observed in individuals who were either underweight or overweight. The authors assume that for individuals,

who were either underweight or overweight/obese, the relationship between sleep and physical fitness could be affected due to underlying health conditions or lifestyle factors. What is more, several scholarly publications have provided evidence indicating that different sleep duration has a diverse impact on various aspects of physical fitness, including but not limited to flexibility, muscle strength, and endurance (22).

In adolescents with a normal nutritional status, it has also been shown that physical fitness varies depending on the self-reported results in physical education and opinions on the role of physical activity in human life. Again, these differences were not observed in underweight and overweight/obese individuals. It is possible that in underweight and overweight/obese individuals, the impact of physical education and opinions on physical activity may be overshadowed by the more pressing health concerns related to their weight status.

We found that there was a significant difference in physical fitness levels depending on self-reported physical fitness among underweight and normal nutritional status individuals. We observe no such difference among overweight/obese adolescents. One possible explanation for the observed difference in physical fitness levels among underweight and normal nutritional status individuals, but not overweight/obese adolescents, could be the fact that physical fitness is strongly correlated with body composition (23,24).

The present study also investigated whether there exists a correlation between the perceived value of physical activity in daily life and physical fitness. Analysis of the results showed a weak-to-moderate positive correlation between these variables in individuals with underweight and normal nutritional status but also the entire population. However, interestingly, no such correlation was observed in individuals with overweight and obesity. This can be explained by the fact that overweight and obese individuals could not be aware of the importance of physical activity in a healthy lifestyle or do not perceive physical activity as a health indicator and a valuable and necessary aspect of their lives. This finding is supported by other studies in the area linking physical activity with physical fitness. Osipov et al. (25) found that individuals who were more physically active had better physical fitness outcomes compared to those who were less active.

Limitation of the Study

A limitation of this study is that nutritional status was figured out by the BMI indicator. BMI is a commonly used measure of nutritional status, but it has several limitations. The authors are aware that the analysis of bioelectrical impedance would be more beneficial for this study. Also, the study did not include the socioeconomic status of the participants. It is possible that individuals from different socio-economic backgrounds may have different nutritional status and physical fitness levels. Probably, individuals from lower socioeconomic backgrounds may have limited access to healthy food options, exercise facilities or resources which can lead to poor nutritional status and negatively impact physical fitness. Further studies, which take these variables into account, will need to be undertaken.

Despite its limitations, the study certainly adds to our understanding of adolescents' physical fitness and the factors it determines.

Conclusions

The key finding emerging from this study is that keeping a normal nutritional status is crucial for enhancing physical fitness in adolescents. The second finding is normal nutritional status aids better results in physical education at school. The third finding is the existence of a positive correlation between the perceived value of a person's physical activity and physical fitness.

The findings of our study suggest that individuals with underweight or overweight may face difficulties in developing physical fitness as compared to those with normal nutritional status. Future research could explore the role that diet, and nutrition play in physical fitness, particularly among individuals who are overweight or obese. Furthermore, given the widespread use of social media among children and adolescents, it may be useful to explore the potential of these platforms as a means of delivering health education and exercise interventions. And then, such interventions could be tailored to the specific needs and preferences of this population.

Practical implications

The findings from our study make several contributions to the current literature. Firstly, these results add to the rapidly expanding field of adolescents' physical fitness, which aids in formulating interventions to optimize their health. Secondly, supplies a deeper insight into how a range of factors like nutritional status, sleep, and attitudes toward physical activity determine physical fitness levels. Most importantly, our findings call for the implementation of well-designed nutrition education programs in schools to ensure that students receive proper guidance and education on keeping healthy eating habits in achieving optimal physical fitness. Additionally, from a practical point of view, the study's findings can also be used to develop effective interventions to improve physical fitness outcomes among teenag-

ers with overweight and obesity. Thus, our findings open new areas for research related to the physical fitness of adolescents. They serve as encouragement for further in-depth investigations because several questions still remain to be answered. Therefore, the insights gained from our study could be of assistance in designing future studies that should examine the underlying mechanisms that link nutritional status and physical fitness.

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