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IMPACT OF MOTORIC ACHIVEMENT AND DIETARY HABITS ON STUDENTS' CARDIOVASCULAR ENDURANCE

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Abstract: The aim of this study was to identify achievements in motor tests and dietary habits as predictors of cardiovascular endurance among Medical rehabilitation students. The sample included 159 Medical rehabilitation students from Novi Sad, Serbia (37 males, 122 females) who attended physical education classes twice a week. The battery of tests from the applicable protocol and dietary questionnaire was used. The exploratory factor analysis and multiple linear regression were applied. The multiple regression analysis determined a statistically significant relationship between specific motor tests and the Shuttle Run Test (R=0.828, p=0.000), but no significant differences between the factors obtained for dietary and the Shuttle Run Test. The findings highlight the importance of tailored exercise and nutrition plans and education on healthy lifestyles and emphasize the need for further research to support overall health.

Keywords: motor skills, dietary habits, cardiovascular endurance, students

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Introduction

In the past decades, increased attention has been given to physical activity, an element of a healthy lifestyle, as an essential factor in maintaining and improving health. Physical activity represents any body movement that increases human energy expenditure, such as walking in the park, climbing stairs, carrying groceries from the store to home, and even professional sports disciplines like running, weightlifting, etc. (Bouchard et al., 2012; Hoffman, 2009; Rani, 2021). Physical activity contributes to the improvement of quality of life, as well as the reduction of cardiovascular morbidity and mortality (Dhuli et al., 2022). Regular physical activity offers numerous benefits, such as improving motor skills, maintaining a healthy body weight, and enhancing overall health, including lowering the risk of heart disease and depression. (Bouchard et al., 2012).

Structured physical activity is not just about exercise; it is about refining motor skills, encompassing a wide range of characteristics related to body performance. This knowledge is essential for overall health and well-being. Motor skills such as muscular endurance, muscular strength, cardiorespiratory endurance, flexibility, and explosive strength are key elements for a healthier lifestyle (Colella et al., 2023; Rinne et al., 2010; Wrotnjak et al., 2006).

There are two types of muscular endurance: aerobic (cardiovascular) and anaerobic. Aerobic exercise consists of various exercises and physical activities that stimulate the heart and lungs long enough to benefit the body (Dayananda et al., 2024). Aerobic physical activities include running, walking, hiking, skating, cycling, and swimming. These exercises require continuous and rhythmic body movements that involve and activate large body muscle groups (Dayananda et al., 2024). Therefore, this type of activity contributes to increased maximum breathing capacity and heart rate, thus positively impacting the improvement of the cardiovascular system (Reiss, Stricker, 2013). In childhood and adolescence, cardiorespiratory endurance is inversely related to physiological risk factors for chronic diseases, such as high blood pressure, hyperglycemia, obesity, atherogenic lipid profiles, insulin resistance, hemostatic and inflammatory markers, and clustering of metabolic risk factors (Pate et al., 2006).

Anaerobic physical activities require short, explosive muscle efforts that quickly deplete energy reserves. Some examples of anaerobic physical activity include strength training (such as weightlifting or bodyweight exercises like pull-ups and push-ups), high-intensity interval training (HIIT), quick sprints, and explosive sports such as boxing, javelin throw, discus throw, and jumps (Hill, Kupalov, 1929). Anaerobic endu-

rance is associated with all activities performed at maximum or sub-maximum intensity (Stojanović, 2014).

Muscular strength is the motor ability to overcome internal and external forces with human muscle force (Suchomel et al., 2016). Muscular endurance refers to the motor ability to perform a specific movement for an extended period without reducing efficiency, or rather the ability to maintain activity at a consistent intensity over time (de la Motte, 2017). The movement speed built on strength defines explosive muscle effort, determined by the size of the overcome resistance (Peterson et al., 2006). Explosive strength is crucial in fast sports disciplines like sprinting, jumping, and throwing (Haff et al., 2001). However, it is significant in everyday activities such as lifting heavy objects or instantly accelerating while walking or running.

In today's sedentary lifestyle, it is necessary to maintain and improve flexibility. Reducing the risk of back problems, joint issues, and other musculoskeletal disorders is becoming increasingly important. This awareness is crucial in our modern, often desk-bound, lives (Van Roy, Borms, 2008).

Dietary habits are subject to numerous changes and are influenced by various factors, such as fast food, processed products, high intake of refined carbohydrates, insufficient consumption of fruits and vegetables, and increased consumption of processed meat products, cigarettes, alcohol, sugar-sweetened beverages, which have become trends in nutrition that accompany modern lifestyles (Insel, 2014). As a consequence of an unhealthy lifestyle, obesity has become a leading global health issue in recent decades (Caprio et al., 2020). It has long been identified as an aesthetic rather than a health problem. Research has shown that obesity is on the rise, not only in developed Western countries but also in fewer developing countries, where underweight is also present (Poskitt et al., 2009). Obese children have a higher risk of developing cardiovascular diseases in adulthood compared to their normal-weight peers. Obesity negatively affects daily activities and decreases the quality of life (Vaccaro, Huffman, 2016). Poor fruit and vegetable intake, insufficient physical activity, and increased screen time appear worldwide (Vaccaro, Huffman, 2016).

Physical activity positively impacts an individual's health and well-being, contributing to developing or maintaining physical abilities. The aim of this study is to identify achievements in motor tests (Standing Long Jump, Grip Strength Test, Sit and Reach Test, Sit-ups for 60 seconds, Push-ups, Shuttle Run Test) and dietary habits as predictors of cardiovascular endurance among students related to Basic and Additional Nutrition (the two-factor structure of dietary habits among Medical rehabilitation students).

Methods

The current research, a comprehensive empirical cross-sectional study, delved into the cardiovascular endurance of Medical rehabilitation students from Novi Sad, Serbia. This central outcome variable was intricately related to a set of predictor variables, meticulously examining these students' motor achievements and dietary habits. The other outcome variable, the results of the Shuttle Run Test, was also thoroughly investigated. The predictor variables included dietary-related behaviors and motor test achievements: Standing Long Jump, Grip Strength Test, Sit-ups for 60 seconds, Sit-and-Reach Test, and Push-ups.

The empirical part of the study was conducted with utmost adherence to the applicable protocol of the System for Monitoring the Physical Growth and Development of Student Motor Skills in Physical Education and Health Classes, along with a dietary questionnaire constructed by the authors. Ethical considerations were paramount, with training provided for the examiners and the initial sample of respondents carefully defined. The sample, consisting of first-, second-, and third-year Medical rehabilitation students at the University of Novi Sad who attended physical education classes twice a week, was selected with the highest ethical standards. The Declaration of Helsinki further bolstered the integrity of this study, and all procedures involving research study participants were approved by each participant voluntarily providing written informed consent before participating.

Standing Long Jump

The test evaluates the explosive strength of the lower extremities. The participant stands behind feet aligned with shoulder-width. In this position, the participant must bend their knees, swing their arms, push off firmly, and jump as far as possible. The participant should land on both feet and maintain an upright body position. Three attempts should be made, and the best result is recorded (Milanović et al., 2019).

Sit-ups for 60 Seconds

Sit-ups assess the trunk's muscular endurance and strength. The participant starts lying on their back on a mat with knees bent at 90°, feet aligned with hip-width, and arms crossed over their chest with palms on opposite shoulders. The examiner holds the participant's feet to the ground. At the start signal, the participant lifts their torso into a sitting position as quickly as possible, ensuring that their elbows touch their thighs before lying back down. This lifting and returning to the starting position

should be performed as fast as possible for 60 seconds. The result is the total number of correctly performed sit-ups (Milanović et al., 2019).

Grip Strength Test

This test measures the isometric strength of the upper body. The participant squeezes the grip for at least two seconds continuously, performing the test twice alternately. The participant determines the optimal range, and a short rest is allowed between measurements. For each measurement, the first tested hand is chosen randomly. The elbow must be fully extended, and the dynamometer should not touch any body part except the hand being measured. Both hands are measured twice, and all results are recorded. The best attempt for each hand is taken (in kg, with a precision of 0.5 kg) (Milanović et al., 2019).

Sit-and-Reach Test

Sit-and-Reach test assesses flexibility. The participant sits on the floor with both legs extended. The hands are extended, with palms next to each other. The participant must perform a deep forward bend and push the ruler as far as possible with their middle fingers without swinging or rocking. The legs must remain fully extended during the task. The task is repeated three times, and all three results are recorded. The result is the reach distance in centimeters (Milanović et al., 2019).

Push-Ups

This test evaluates the muscular strength and endurance of the upper body. Men perform the test from a standard starting position (hands extended directly beneath the shoulders, back straight, head aligned with the spine, and toes on the floor), while women start in a kneeling position (legs together and crossed at the ankles, with the lower part of the foot resting on the floor in a plantar flexion position, back straight, hands aligned with shoulder-width, and knees as the support). The participant lowers their body until their chin touches the ground and then raises it by extending the elbows. The stomach should not touch the floor. Throughout the protocol, both men and women must keep their backs straight and push to an extended elbow position. The result is the number of performed push-ups without breaks between repetitions. The test ends if the participant strains too much or disrupts the execution technique in two consecutive repetitions (Ostojić, 2023).

Shuttle Run Test

The test evaluates aerobic capacity and cardiorespiratory endurance by requiring participants to run between two lines, 20 meters apart, at a pace dictated by an audio signal from a CD. The participant must have both feet across the line at each audio signal. The test is designed to push the participant's limits, starting at a speed of 8.5 km/h (20 meters in 9 seconds) and increasing by 0.5 km/h every minute. The goal of the test is to run as many laps as possible, with the test ends when the participant can no longer keep up with the required pace or when they fail to cross the line three times in a row when the sound signal is heard. Each level contains a certain number of segments (Milanović et al., 2019).

Dietary Questionnaire

For the exploratory factor analysis, the part of the survey with answers "always," "often," "sometimes," and "never" were taken, which are as follows:

- Do you eat breakfast?
- Do you have breakfast, lunch, and dinner?
- Do you eat at least 200g of vegetables every day?
- Do you drink at least 1-1.5 liters of water every day?
- Do you eat at least 200g of fruit every day?
- Do you have dessert with your meals?
- Do you drink wine/beer during meals?
- Do you drink at least two glasses of milk or yogurt every day?

Statistical data analysis was conducted using the IBM SPSS Statistics 20 software. Descriptive statistics parameters were calculated for the obtained data, providing practical insights for future research. Exploratory factor analysis was applied to discover the factor structure of the dietary habits of medical rehabilitation students, offering practical implications for dietary interventions that generated the following factors: Basic Nutrition and Additional Nutrition. Multiple linear regression was used to estimate the relationship between achievements in motor skills tests (Standing Long Jump, Grip Strength Test, Sit-ups for 60 seconds, Sit-and-Reach Test, and Push-ups) and dietary habits with the results of the Shuttle Run Test, providing potential for inspiring future studies on improving cardiovascular endurance.

Results

The characteristics of the sample were presented (Table 1), as were the results of the exploratory factor analysis (Tables 2 and 3), and an overview of the relationships between motor test performance, dietary habits, and the cardiovascular endurance of Medical rehabilitation students (Table 4).

Table 1. General sample characteristics

	Grade	**N (%)**
Male	First-year	6 (3.8)
	Second-year	15 (9.4)
	Third-year	16 (10.1)
	Total	37 (23.3)
Female	First-year	42 (26.4)
	Second-year	16 (10.1)
	Third-year	28 (17.6)
	Total	122(76.7)

Note: N-number

The exploratory factor analysis of dietary habits

The exploratory factor analysis was applied to verify the factor structure of dietary habits among Medical rehabilitation students. Conforming to the items with multiple-choice responses (always, often, sometimes, and never), the exploratory factor analysis was conducted. The data were exposed to parallel factor analysis to determine significant factors, and results obtained along the Guttman-Kaiser criterion for factor extraction were also presented.

The data were suitable for correlation (p=0.000), as determined by the KMO test of sphericity. The commonalities reflect the common variance in the data structure after the factors were extracted.

According to the Guttman-Kaiser criterion, four characteristic eigenvalues had values higher than 1 (Table 2), and according to parallel factor analysis, two characteristic eigenvalues explain a higher percentage of variance than their random counterparts at the 95th percentile criterion (Table 3).

Table 2. The Guttman-Kaiser criterion for factor extraction

	Eigenvalue	Proportion of Variance	Cumulative Proportion of Variance
Do you eat breakfast?	1.879	23.490	23.490
Do you eat at least 200g of fruit every day?	1.458	18.223	41.713
Do you eat at least 200g of vegetables every day?	1.070	13.371	55.084
Do you have dessert with your meals?	1.023	12.782	67.866
Do you drink wine/beer during meals?	0.854	10.677	78.543
Do you have breakfast, lunch, and dinner?	0.695	8.683	87.226
Do you drink at least two glasses of milk or yogurt every day?	0.675	8.439	95.666
Do you drink at least 1-1.5 liters of water every day?	0.347	4.334	100.000

Table 3. The parallel factor analysis

	Real-data eigenvalues	Mean of random eigenvalues	95 percentile of random eigenvalues
Do you eat breakfast?	1.000000	1.346058	1.475605
Do you eat at least 200g of fruit every day?	2.000000	1.217473	1.308176
Do you eat at least 200g of vegetables every day?	3.000000	1.118236	1.173340
Do you have dessert with your meals?	4.000000	1.031669	1.085049
Do you drink wine/beer during meals?	5.000000	0.949412	1.007833
Do you have breakfast, lunch, and dinner?	6.000000	0.865738	0.920880
Do you drink at least two glasses of milk or yogurt every day?	7.000000	0.783545	0.848470
Do you drink at least 1-1.5 liters of water every day?	8.000000	0.687869	0.753916

After the parallel analysis, the exploratory factor analysis was repeated with a fixed number of factors for extraction (2). Based on the values of commonalities, the items "Do you drink beer/wine during meals?" and "Do you drink at least two glasses of milk every day?" were excluded. The values of these items were less than 0.30.

The generated factors from the parallel factor analysis were: 1. Basic Nutrition and 2. Additional Nutrition. The obtained two-factor model explains 53.715% of the variance, Basic Nutrition measures 30.221% of the variance, and Additional Nutrition

measures 23.493% of the variance. Geomin rotation was used, and the matrix pattern is shown in Table 2. The table shows only the statistically significant loadings at the 0.05 level, i.e., those with a value higher than 0.30.

The Basic Nutrition factor grouped the items "Do you eat breakfast" (0.886) and "Do you have breakfast, lunch, and dinner?" (0.830). Remarkably, these two items saturate the mentioned factor almost equally.

Multiple linear regression

The multiple regression analysis determined a statistically significant relationship between the set of predictors, results of the motor tests, and the Shuttle Run Test (R=0.828, p=0.000). Therefore, no statistically significant relationship between Basic and Additional Nutrition and the Shuttle Run Test appeared (R=0.254, p=0.082). The multiple correlation coefficient between the results of the motor tests and the Shuttle run test was 0.828. The set of predictors explained 6.8% of the variance in the outcome of the criterion variable. The predictors that influence the criterion variable are shown in Table 4.

Table 4. Multiple linear regression

Model	B.	S.E.	Beta	t	p	95.0%	CI for B
Standing Long Jump	0.190	0.052	0.414	3.654	**0.000**	0.087	0.294
Right Hand Grip	-0.261	0.255	-0.159	-1.024	0.309	-0.770	0.247
Left Hand Grip	0.441	0.255	0.259	1.729	0.088	-0.067	0.949
Sit and reach	0.053	0.145	0.026	0.363	0.717	-0.237	0.342
Push-ups	0.161	0.093	0.144	1.727	0.088	-0.025	0.348
Sit-ups for 60s	0.451	0.171	0.281	2.639	**0.010**	0.111	0.792

Note: B: estimate, S.E: standard error, CI: confidence interval, p≤0.05

The Standing Long Jump explained 0.5% of the criterion variable, while the Sit-ups explained 4.5%.

Discusion

The research was conducted to identify achievements in motor tests (Standing Long Jump, Grip Strength Test, Sit-ups for 60 seconds, Sit-and-Reach Test, and Push-ups) and dietary habits related to Basic and Additional Nutrition as predictors of cardio,-vascular endurance in Medical rehabilitation students. The Shuttle Run Test evalua-

tes cardiovascular endurance. In addition, the relationships between the listed motor tests and the Shuttle Run Test, as well as dietary factors and the Shuttle Run Test, were examined.

The empirical part of the research was conducted at the beginning of the school year during physical education classes for Medical rehabilitation students. The sample consisted of first-year (30.2%), second-year (19.5%), and third-year students (27.8%) (76% female, 24% male).

The significant predictors in the set of motor tests were the Standing Long Jump and the Sit-ups for 60 seconds. In both cases, better test results led to better cardiovascular endurance, indicating that students with stronger trunk flexor muscles and better explosive strength of the lower extremities also had better cardiovascular endurance. The obtained results align with assumptions formed through previous pedagogical practice.

The results of the exploratory factor analysis of dietary habits showed that the structure of habits is significant for the diet of Medical rehabilitation students. However, the structure needed to confirm the well-known thesis that diet is crucial in maintaining health and cardiovascular endurance (Vitale & Getzin, 2019). Furthermore, the importance of physical activity and healthy nutrition for improving cardiovascular endurance and overall health (Bouchard et al., 2012; Petrović et al., 2010) also did not align with the results, as there is no statistically significant relationship between the set of dietary predictors and the Shuttle Run Test.

The results have multiple implications. First, educating students about healthy dietary habits and regular physical activity is also emphasized to improve physical fitness (Ostojić, 2023). Additionally, the results may help develop a modified physical exercise program and nutrition plan according to individual student needs.

This study presents several limitations that should be considered when interpreting the results. The research was conducted exclusively on Medical rehabilitation students from one university, limiting the generalizability of the findings to a broader student population or other educational contexts. The sample was predominantly female (76%), which could influence dietary and physical activity patterns, potentially skewing the results. The reliability of the Additional Nutrition factor was low, as indicated by a Cronbach's Alpha coefficient ranging from -0.132 to 0.449, which suggests that the four items used to assess this factor may not reliably measure the intended construct. As a cross-sectional study, causal relationships cannot be established. Longitudinal research would be required to explore how changes in motor skills or dietary habits affect cardiovascular endurance over time. The dietary habits were assessed through self-report, which can introduce biases such as social desi-

rability (participants may report what they think is socially acceptable) or inaccurate recall (participants may not accurately remember their dietary habits).

Despite the limitations, this study also has several notable strengths. The study's unique approach of combining physical fitness assessments with dietary habit analysis offers a multidimensional perspective on factors influencing cardiovascular endurance, enlightening the audience with a comprehensive understanding. Using standardized and well-established motor tests (e.g., Shuttle Run, Sit-ups, Grip Strength, and Standing Long Jump) enhances the reliability and validity of the physical fitness measurements. The findings directly affect curriculum development and health promotion among university students, particularly those studying in health-related fields. This study provides valuable baseline data that can be used to design longitudinal or intervention-based studies, especially within student populations with varying academic backgrounds. By highlighting the role of motor fitness and nutrition in cardiovascular health, the study contributes to the growing body of evidence supporting preventive health measures in young adults.

Conclusion

Conducting longitudinal studies could track the impact of changes in dietary habits and physical activity on cardiovascular endurance over a more extended period. Moreover, research involving a more extensive and diverse sample could provide additional insights into the composite interaction between diet, physical exercise, and cardiovascular endurance. Future research and interventions in this field could contribute to general health.

The research on motor test achievements and dietary habits provides a deeper understanding of the relationship between physical activity, diet, and health. The knowledge gained from this research is instrumental in identifying the factors that influence cardiovascular endurance and in devising strategies to improve student health.

By preventing health problems and enhancing our understanding of nutrition, we can develop strategies to reduce the risk of heart disease and other health issues among students. Education about healthy habits can have long-term benefits for people's health, given the modern lifestyle. The results of this research could significantly impact students' understanding of the importance of a healthy diet and adequate physical activity.

This current research could serve as a foundation for promoting a healthy lifestyle among the student population. It can improve the physical education curriculum by

providing insights into the effectiveness of the program. Moreover, it underscores the importance of theoretical lectures, which are increasingly necessary for better understanding and acceptance of a healthy lifestyle in today's world.

Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization: D. S., Investigation: S. M., Theoretical framework: D. S., Data curation: S. M., Resources: S. Đ., S. M., Writing – original draft: D. S., S. M., Writing – review & editing: S. Đ., All authors have read and agreed to the published version of the manuscript.

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