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CONTENT/ SOMMAIRE/ INHALT/ CUPRINS

Maria-Andreea COTEAȚĂ, Florin TROFIN, Associations Between Effort Capacity and Cognitive Processes in Basketball Players 5

Dragoș NEAGU, Simona PETRACOVSCHI, The Benefits of Dry-Land Training for Swimmers: A Systematic Review 27

Kamel BERROUDJ, Amina CHAFAA, Abdelmounaim MEFTI, Rana KOUADRI, Exploring the Relationship Between Body Image and Self-Confidence Dimensions Among Female Sport Students 47

Maria Daniela MACRA-OȘORHEAN, Ildiko MANASSES, Adrian-Claudiu PAȘCAN, Ana-Maria NEAGU, Velu-Sebastian BARTHA, Study on Stress Management in Sport Organizations * *Studiu privind managementul stresului în cadrul organizațiilor sportive* 59

Remus VĂIDĂHĂZAN, Iulia JULEAN, Velu-Sebastian BARTHA, Ancuța NUȚ, The Role of the Educational Manager in High Schools in Cluj-Napoca as Centres of Excellence in the Local Community * *Rolul managerului educațional în liceele din Cluj-Napoca ca centre de excelență în comunitatea locală* 73

Ștefan CIOBANU, Beatrice Aurelia ABALAȘEI, Correlations Between Body Composition Indicators and Performance in Sprint and Agility Tests Among Handball Referees 85

Marian-Petre PRĂJESCU, Beatrice-Aurelia ABALAȘEI, Artificial Intelligence in Tennis. A Social Perspective 101

Dan-Mihai ROHOZNEANU, Considerations Regarding the Parents' Opinions About Physical Education Lesson in the Secondary Schools of Reşiţa 117

Cosmin PRODEA, Leonida Horea ŞTEFĂNESCU, Raoul Ştefan ZANCA, Physical Education and Sport in Romania: Between Ideal, Reality, and Prospects for Reform * *Educaţia fizică şi sportul în România: între ideal, realitate şi perspective de reformă* 131

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Associations Between Effort Capacity and Cognitive Processes in Basketball Players

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ABSTRACT. Introduction: The game of basketball often involves making quick and efficient decisions and complex technical-tactical actions, which have been shown by researchers to correlate with certain cognitive processes. **Objective:** We aimed to determine this link in a group of 21 basketball players (14.05±0.86 years old) who qualified for the U14 Final Tournament of the Romanian National Championship. **Methods:** We associated 3 types of visual memory (simple, dynamic and numerical) with 3 agility tests (Lane, Illinois, hexagon with randomized visual stimuli), 1 reaction speed test, 1 aerobic (Vameval shuttle) and 1 anaerobic (8x10+10 m) test and the test for determining the explosive force of the lower limbs. **Results:** Data analysis yielded 2 links between effort capacity and players' cognitive level. Numerical memory was correlated with the Lane agility test (p=0.041), and the reaction speed of the dominant upper limb with the fatigue factor yielded by the anaerobic lactacid capacity test (p=0.05). **Conclusions:** Our study demonstrates that an athlete with a significant exertional capacity does not require a high cognitive level, this aspect needs to be demonstrated by future research.

Keywords: *cognitive development, basketball skills, agility, memory, neurocognition.*

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INTRODUCTION

The executive system, over the ages, has been difficult to fully define. Executive functions include higher cognitive abilities that facilitate the understanding of complex or abstract concepts, help to solve problems and unfamiliar situations, and confer the ability to manage tasks (Cristofori et al., 2019). These higher-level cognitive processes control and regulate basic cognitive processes in order to accomplish complex tasks (Diamond A., 2013). Working memory (temporary storage of information and its later use (Diamond A., 2013), cognitive flexibility (adapting to changes in and from the environment by optimally and efficiently regulating behavior (Dajani & Uddin, 2015), and inhibition (the ability to control actions in response to irrelevant stimuli in the environment, related to behavior and attention (Friedman & Miyake, 2017) are the components of executive functions (Miyake et al., 2000).

Structural plasticity of gray matter and white matter can be enhanced by physical exertion in children and adolescents (Xiong et al., 2018, Migueles et al., 2020). Physical activity may contribute to alter brain activation patterns in the performance of certain tasks (Chaddock-Heyman et al., 2013), help to optimize brain structure and functional networks (Migueles et al., 2020), and subsequently lead to improved executive function (Xue et al., 2019) in children and adolescents.

Zhou et al. (2024) found a link between executive function and physical ability among children, specifically between speed, agility, and lower limb strength with inhibitory control. Likewise, Giuriato et al. (2024) concluded that cognitive factors may hold an important role for physical performance in adolescent soccer players.

Positive correlations between physical activity and the development of executive functions were also found by Li et al. (2020) and Contreras-Osorio et al. (2021). Significant effects were found on working memory and inhibition, moderate effect was found on cognitive flexibility (Li et al., 2020). In contrast, Contreras-Osorio et al. (2021) concluded significant influences on all three components.

The cognitive-perceptual components of decision making, such as reaction time, perception and anticipation, visual processing, and spatial recognition, are significantly involved in the direction-shifting ability, which includes rapid and precise reactions played in response to specific external stimuli (Šimonek et al., 2017, Spasic et al., 2015). The implications of these components in direction changing ability are important in the game of basketball, as they are the basis of players' agility (Popowczak et al., 2021).

Xu et al. (2022) established that playing basketball favors the optimization of cognitive functions, such as cognitive flexibility and working memory. This direction is met if the frequency is a minimum of two practices per week. The game of basketball requires a high level of concentration, especially since it is characterized a sport that requires complex skills, with players performing in a dynamic environment in which they must provide optimal responses to the unpredictable game conditions imposed (Chiu et al., 2020, Ke et al., 2021).

Other researchers have emphasized the significance of the relationship between practicing a more cognitively complex and cognitively engaging physical activity on executive functions compared to one that is not at the same level of complexity (Diamond & Ling, 2016, Ishihara et al., 2017; de Greeff et al., 2018, Vazou et al., 2019).

Four months of physical activity has been shown to improve executive functions, but following an open skills sport, such as basketball, improved inhibition and working memory in young exercisers (Madinabeitia-Cabrera et al., 2023).

Scanlan, Humphries, Tucker & Dalbo (2014) concluded that cognitive measures most influenced the performance acquired on agility testing in basketball players, with the authors suggesting incorporating reaction and decision-making drills into basketball training programs. Khudair, van Biesen, Pérez-Tejero & Hettinga (2021) specified that in the game of basketball players are required to make quick and efficient decisions, this aspect has high cognitive implications (Tenenbaum et al., 1993). Also, in this open-skills sport, memory, selective attention, and inhibitory control in decision making play a very important role (Chiu et al., 2020), Pinilla-Arbex et al. (2021) determined the link between cognition and decision making by using a basketball-specific decision-making task.

MATERIALS AND METHODS

Sample

The tests were conducted in June 2023. A total of 21 basketball players (3 Point Guard, 4 Shooting Guard, 3 Small Forward, 3 Power Forward and 8 Center) were selected who met the requirements of being enrolled in the same sports club, possessed a valid sports card with a valid medical visa and were members of a junior basketball team between the ages of 13 and 15 years. Of the 21 players, 18 had body measurements (176.95±9.27 cm, 73.6±6.08 kg, 21.25±1.48 kg/m2).

The basketball players were born in 2008-2009 (14.05±0.86 years) and had a sports experience of 4.66±2.43 years, with the highest experience of 10 years and the lowest of 1 year (Table 1).

The athletes were evaluated over two days. The first day comprised anthropometric measurements and body analysis, reaction speed, explosive force, cognitive ability (memory) and agility, and the hexagon agility test with random stimuli, anaerobic lactacid capacity and aerobic capacity were on the second day.

The legal representative of each athlete initially signed a voluntary participation agreement, and the research was conducted in accordance with the Declaration of Helsinki.

Table 1. Subject demographics data

Parameter	Mean	Standard deviation (±)	Minimum value	Maximum value
Age (years)	14.05	0.86	13	15
Sports experience (years)	4.66	2.43	1	10
Height (cm)	176.95	9.27	153.00	193.00
Body mass (kg)	64.11	9.73	43.5	77.90
BMI (kg/m^2)	20.57	1.86	16.80	22.90
Body fat (%)	15.85	3.10	11.40	22.20
Muscle mass (%)	41.69	2.35	36.40	45.00
Right upper limb fat (%)	20.09	5.28	3.90	26.20
Left upper limb fat (%)	21.29	5.22	3.70	27.90
Right lower limb fat (%)	20.39	3.18	14.80	27.10
Left lower limb fat (%)	20.91	3.14	15.60	27.10
Basal metabolic rate (kcal)	1733.40	145.24	1416.00	1959.00

Determining variables

Anthropometry: The height of the players, who were not wearing footwear, was determined using a Bosh rangefinder and Handy 10625B LCD digital Handy 10625B LCD digital level to help calibrate the rangefinder laser effectively.

Tanita and Omron analyzers were used to measure body mass (kg), BMI (kg/m^2), body fat (%), segment fat (%), muscle mass (%) and basal metabolic rate (kcal).

Agility: Three tests were applied to determine agility: the Lane test, the Illinois test and the hexagon agility test with randomized visual stimuli.

Lane agility test: marking with cones a rectangle 5.8 m long and 4.9 m wide; speed running on the first length, followed by lateral movement to the right along the width, running backwards in the direction of travel on the second length of the rectangle, then will perform the second lateral movement to the left to the starting point, will touch the cone with the left hand, and will perform the route again to reach the starting point.

The Illinois test: running the course with changes of direction; sprint in a straight line (10 m) and running in a serpentine fashion between 4 cones placed 3.3 m apart.

Hexagon agility test with randomized visual stimuli: formation of a hexagon with 2 m sides, and inside it a square with 40 cm sides is marked; the athlete placed inside the square, at the sound signal played by the Blazepod system, will have to move as quickly as possible towards the unit that has lit up and return after each touch inside the square. The aim is to touch as many Blazepod units as possible in 20 seconds.

Reaction speed: **The reaction speed test** was applied using T-reaction software (Cojocariu A., 2011). The athletes were seated on a chair, in front of them the laptop was positioned on a table, the keyboard with the 3 keys was placed on the thighs and the hands on the side keys. Twenty red circles were randomly displayed on the left or right half of the laptop, and the players had to press the key corresponding to the side on which the circle appeared in the shortest possible time.

Anaerobic lactate capacity was measured using the 8x10+10 m test (Trofin & Abalașei, 2019). The fatigue factor of the 8x10+10 m test was also calculated.

Aerobic capacity was determined by the Vameval shuttle test (Trofin et al., 2018).

Lower limb explosive force was tested by a vertical free-arm jump (Free Jump) on the Just Jump platform. The lower limb explosive power explosive strength factor (LPEF) was measured by applying the protocol of 4 consecutive free-arm vertical jumps.

Cognitive ability (memory): **The simple visual memory** test consisted of selecting one or more squares, depending on the level, which were highlighted for 2 seconds. Using the Human Benchmark online platform, the test displayed 9 squares organized in the shape of a larger square, and for the first level, out of the 9 squares, 3 of the squares were displayed white for 2 seconds, then the athlete had to select the memorized squares that were displayed white.

The dynamic visual memory test, similar to the previous one, except that the white color of a square will last about 0.3 seconds, then the evaluated athlete has to press on the memorized square. At the next levels, where several white squares are lit consecutively, the athlete has to press the squares in the order of their color change.

The numerical memory test was applied using the same platform. A number consisting of a digit appears for a few seconds, then the athlete has to write down the memorized number. The visualization time of the number and the digits of the number increase with each level.

Statistical analysis

Descriptive statistics used mean and standard deviation. Data processing was done with GraphPad Prism 9.3.0 (GraphPad Software Inc.). Pearson correlation was applied and its coefficient (r) was calculated to determine the relationship between effort capacity and cognitive level. The values of r led to the assessment of the level of correlation as follows: 1–perfect, above 0.75–strong, above 0.50 and below 0.75–moderate, above 0.25 and below 0.50–acceptable, and below 0.25–weak (Colton, 1974). The threshold value for statistical significance of the tests used was set at 0.05.

RESULTS

The evaluation of the athletes involved 11 tests to measure their exercise capacity and cognitive level. The data recorded for the cognitive tests by 19 of the 21 players are presented in **Table 2** and for the physical tests in **Table 3**.

Table 2. Mean, standard deviation, and minimum and maximum values of the results obtained on cognitive tests

Parameter	Mean	Standard deviation (±)	Minimum value	Maximum value
Numerical memory	7.21	1.51	4.00	10.00
Simple visual memory	7.79	1.58	5.00	11.00
Dynamic visual memory	6.89	2.62	3.00	13.00
Dominant upper limb reaction speed (ms)	307.98	32.44	254.00	395.33
Non-dominant upper limb reaction speed (ms)	318.85	32.87	277.31	388.75
Average reaction speed (ms)	313.41	29.11	267.70	392.04

*ms - miliseconds

With regard to the arithmetic mean and standard deviation of the numerical memory, 7.21±1.51 levels are highlighted, meaning that the range of values within normal limits is from 5.7 to 8.72. Looking at simple visual memory, the subjects returned an average of 7.79 levels with a dispersion indicator of 1.58, resulting in a range with a minimum limit of 6.21 levels and a maximum limit of 9.37 levels. The central tendency and the deviation from it yield values of 6.89±2.62 levels when testing dynamic visual memory. The minimum threshold being 4.27 levels and the maximum 9.51 levels. The reaction speed of the upper limbs implies a standard deviation from the mean of the results of 307.98±32.44 ms in the dominant hand of the athletes and 318.85±32.87 ms in the non-dominant hand, with a range of values between 275.54 and 340.42 ms, respectively 285.98 and 351.72 ms.

Table 3. Mean, standard deviation, and minimum and maximum values of the results obtained on physical tests

Parameter	Mean	Standard deviation (±)	Minimum value	Maximum value
Free Jump (cm)	50.79	7.43	38.37	64.81
4 jumps - FPEF	1.27	0.46	0.59	2.50
Lane Agility Test (s)	13.17	0.67	11.61	14.55
Illinois Agility Test (s)	17.04	0.67	15.53	18.34
Random Visual Stimulus Hexagon Agility Test (s)	1.85	0.29	1.54	2.79
8x10+10 (s)	30.53	1.48	27.84	33.01
8x10+10 (%)	6.16	2.03	3.77	11.62
F.O.-8x10+10	0.53	0.24	0.28	1.16
VamEval – VO_2max	52.52	4.51	45.35	60.71

The lower limb explosive force is 50.79±7.43. The explosive power factor was recorded as 1.27±0.46. The minimum threshold of the dispersion values is 12.50 s and the maximum threshold is 13.84 s in the Lane test, with a mean and standard deviation of 13.17±0.67 s. In the Illinois test, the minimum threshold is 16.37 s and the maximum threshold is 17.71 s, with a mean and standard deviation of 17.04±0.67. The hexagon agility test with randomized visual stimuli was completed by players in 1.85±0.29 s.

Anaerobic lactate capacity (8x10+10 m test) was determined in players with a mean and standard deviation of the 140 m distance covered times of 30.53±1.48 s. The fatigue factor returned from the test is 0.53±0.24. The maximum volume of oxygen (VO_2max) acquired by the athletes following the VamEval test is 45.01±19.28 ml·kg-1·min-1.

There were 45 associations between the results obtained by the athletes. Considering the data in ***Table* 4**, the association of the cognitive parameter, numerical memory, with the 9 physical parameters can be observed.

Table 4. Pearson correlation (r) between numerical memory and physical parameters

Parameter 1	Parameter 2	Pearson correlation coefficient (r)	Coefficient of determination (R^2)	Number of subjects (N)	p
Numerical memory	*Free Jump (cm)*	-0.174	0.03	19	0.475
Numerical memory	*4 jumps – FPEP*	0.262	0.07	19	0.279
Numerical memory	*Illinois (s)*	-0.314	0.10	19	0.190
Numerical memory	*Lane (s)*	**-0.473***	0.22	19	0.041
Numerical memory	*Random Visual Stimulus Hexagon Agility (s)*	-0.103	0.01	16	0.706
Numerical memory	*8x10+10 (s)*	0.187	0.03	16	0.489
Numerical memory	*8x10+10 (%)*	0.434	0.19	16	0.093
Numerical memory	*F.O. 8x10+10*	0.368	0.14	16	0.161
Numerical memory	*VamEval – VO_2max*	0.194	0.04	16	0.471

It can be emphasized that the Pearson correlation coefficients fall within the minimum correlation ranges. Out of the 9 associations, the smallest coefficient is that of the correlation with negative direction between numerical memory and the hexagon agility test with random visual stimuli (r = -0.103), and with positive direction, the smallest correlation coefficient is that of the association of numerical memory with the 8x10+10 anaerobic lactate test (r = 0.187).

As for the association of numerical memory with the Lane agility test, a correlation coefficient of -0.473 was observed, which gives the correlation a negative direction and a moderate magnitude, as it is close to the upper limit of acceptable to moderate degree of association (r = -0.473, p = 0.041).

The correlation between numerical memory and the Lane test measure of agility has a coefficient of determination of 0.22. Thus, there is a probability that 22% of the analyzed memory changes are followed by Lane test changes in

the athletes' developmental framework or in a subsequent evaluation. The trend of a change in one parameter will be followed by the other according to the direction of the correlation (inverse).

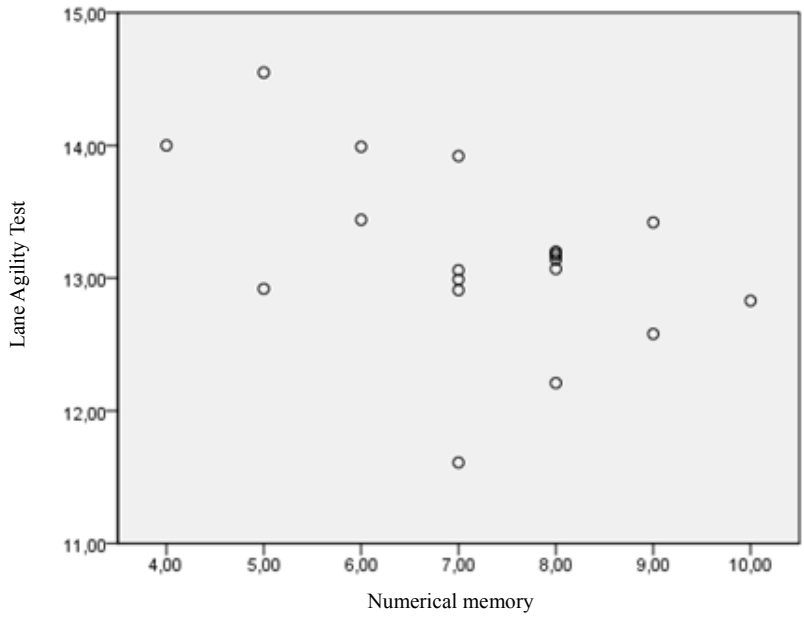

Figure 1. Pearson correlation graph between Lane agility test and numerical memory

Considering the graph presented in **Figure 1**, an acceptable negative to moderate correlation has been defined, determining an inversely proportional relationship between the two parameters. Thus, if the result of the Lane test is good, the result of the numerical memory is with the same tendency.

A significant relationship is established between the two parameters, as the athlete has a high capacity to retain digits in parallel with the movements on the field involving specific changes of direction.

Referring to **Table 5**, we can observe that, among the values of the correlation coefficients between simple visual memory and the nine parameters, the lowest is that of the association of simple visual memory with the Illinois agility test ($r = -0.021$, $p = 0.932$).

Table 5. Pearson correlation (r) between simple visual memory and physical parameters

Parameter 1	Parameter 2	Pearson correlation coefficient (r)	Coefficient of determination (R^2)	Number of subjects (N)	p
Simple visual memory	*Free Jump (cm)*	-0.172	0.03	19	0.480
Simple visual memory	*4 jumps – FPEP*	-0.270	0.07	19	0.264
Simple visual memory	*Illinois (s)*	-0.021	0.00	19	0.932
Simple visual memory	*Lane (s)*	0.063	0.00	19	0.798
Simple visual memory	*Random Visual Stimulus Hexagon Agility (s)*	-0.428	0.18	16	0.098
Simple visual memory	*8x10+10 (s)*	-0.220	0.05	16	0.412
Simple visual memory	*8x10+10 (%)*	-0.339	0.11	16	0.198
Simple visual memory	*F.O. 8x10+10*	-0.194	0.04	16	0.471
Simple visual memory	*VamEval – VO_2max*	0.091	0.01	16	0.737

As in the previous table, **Table 6** does not show any Pearson correlation coefficient of statistical significance ($p > 0.05$).

Table 6. Pearson correlation (r) between dynamic visual memory and physical parameters

Parameter 1	Parameter 2	Pearson correlation coefficient (r)	Coefficient of determination (R^2)	Number of subjects (N)	p
Dynamic visual memory	*Free Jump (cm)*	0.239	0.06	19	0.324
Dynamic visual memory	*4 jumps – FPEP*	0.017	0.00	19	0.946
Dynamic visual memory	*Illinois (s)*	0.056	0.00	19	0.821
Dynamic visual memory	*Lane (s)*	-0.125	0.02	19	0.610
Dynamic visual memory	*Random Visual Stimulus Hexagon Agility (s)*	0.174	0.03	16	0.519

Parameter 1	Parameter 2	Pearson correlation coefficient (r)	Coefficient of determination (R^2)	Number of subjects (N)	p
Dynamic visual memory	*8x10+10 (s)*	-0.253	0.06	16	0.345
Dynamic visual memory	*8x10+10 (%)*	-0.358	0.13	16	0.173
Dynamic visual memory	*F.O. 8x10+10*	-0.436	0.19	16	0.091
Dynamic visual memory	*VamEval – VO_2max*	-0.007	0.00	16	0.981

The correlations found between dynamic visual memory and the 9 physical parameters are predominantly low, the p level being statistically insignificant.

The data in **Table 7** show the association of dominant upper limb reaction speed with the 9 physical parameters.

Table 7. Pearson correlation (r) between reaction speed of the dominant upper limb and physical parameters

Parameter 1	Parameter 2	Pearson correlation coefficient (r)	Coefficient of determination (R^2)	Number of subjects (N)	p
Dominant upper limb reaction speed	*Free Jump (cm)*	0.182	0.03	19	0.457
Dominant upper limb reaction speed	*4 jumps – FPEP*	0.128	0.02	19	0.601
Dominant upper limb reaction speed	*Illinois (s)*	0.039	0.00	19	0.875
Dominant upper limb reaction speed	*Lane (s)*	-0.243	0.06	19	0.315
Dominant upper limb reaction speed	*Random Visual Stimulus Hexagon Agility (s)*	-0.016	0.00	16	0.954
Dominant upper limb reaction speed	*8x10+10 (s)*	-0.130	0.02	16	0.631
Dominant upper limb reaction speed	*8x10+10 (%)*	-0.467	0.22	16	0.068
Dominant upper limb reaction speed	*F.O. 8x10+10*	**-0.498***	0.25	16	0.050
Dominant upper limb reaction speed	*VamEval – VO_2max*	0.088	0.01	16	0.745

We note that out of the 9 associations, the highest coefficient is that of the acceptable to moderate negative correlation between dominant upper limb reaction velocity and lactate anaerobic fatigue factor (r = -0.498, p = 0.050).

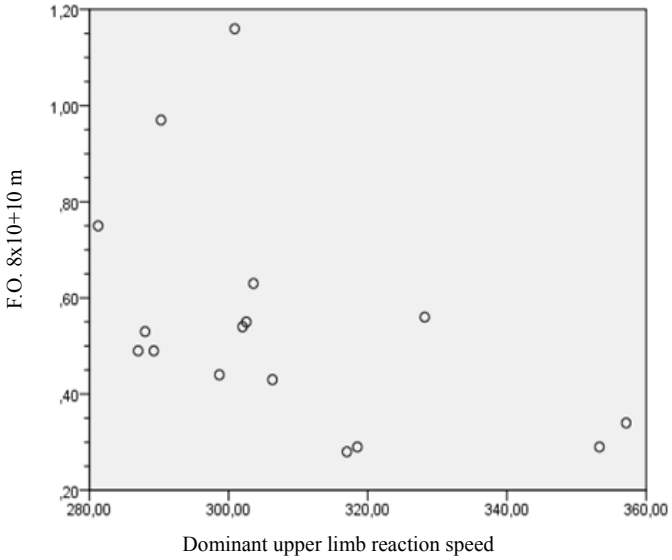

Figure 2. Pearson correlation graph between fatigue factor and reaction speed of the dominant upper limb

Referring to the distribution of values in the graph in **Figure 2**, an inversely proportional relationship can be distinguished, due to the acceptable negative correlation, towards moderate.

Thus, the increase of one parameter causes the decrease of the other, which is unusual for the given significance. We refer to the fact that both reaction speed and fatigue factor have values inversely proportional to performance. According to the correlation relation, it would mean that an athlete with an increased fatigue factor would have a poorer reaction speed, which is contrary to a logic of quick analysis.

It is necessary to keep in mind that this correlation is only valid for 25% of the cases and would require further investigation on other groups of athletes.

On the basis of the data in **Table 8**, we observe the association of the indices of the reaction speed of the non-dominant part of the basketball players with the values of the physical tests.

Table 8. Pearson correlation (r) between reaction speed of the non-dominant upper limb and physical parameters

Parameter 1	Parameter 2	Pearson correlation coefficient (r)	Coefficient of determination (R^2)	Number of subjects (N)	p
Non-dominant upper limb reaction speed	*Free Jump (cm)*	0.359	0.13	19	0.132
Non-dominant upper limb reaction speed	*4 jumps – FPEP*	0.348	0.12	19	0.145
Non-dominant upper limb reaction speed	*Illinois (s)*	-0.001	0.00	19	0.998
Non-dominant upper limb reaction speed	*Lane (s)*	-0.215	0.05	19	0.377
Non-dominant upper limb reaction speed	*Random Visual Stimulus Hexagon Agility (s)*	-0.160	0.03	16	0.554
Non-dominant upper limb reaction speed	*8x10+10 (s)*	-0.316	0.10	16	0.234
Non-dominant upper limb reaction speed	*8x10+10 (%)*	-0.205	0.04	16	0.446
Non-dominant upper limb reaction speed	*F.O. 8x10+10*	-0.191	0.04	16	0.478
Non-dominant upper limb reaction speed	*VamEval – VO_2max*	-0.031	0.00	16	0.909

As in the case of the link between dynamic visual memory and physical parameters, the correlations found between the reaction speed of the non-dominant upper limb with the 9 physical parameters are overall low, the p level being statistically insignificant.

DISCUSSIONS

Our research involved two associations between effort and cognitive ability, one of which was unusual. Regular, high-frequency basketball training has considerable effect on working memory and cognitive flexibility in boys

aged 6-8 years (Xu et al., 2022). Likewise, in another study, three weeks of massive basketball training increased the efficiency of executive functions and developed motor performance, as determined by the agility T-test and Yo-YoIR1 test, in young players (Silvestri et al., 2023). Also, the implementation of training sessions with FitLight, a system similar to BlazePod, favored cognitive ability.

Specialists, such as Policastro et. al (2018), correlated the coordination ability of basketball players (ages 7-10 years) with cognitive abilities. They administered the Corsi test to 70 basketball players, which is similar to dynamic visual memory testing, the difference between the two is rendered by the typology of the deployment (Corsi presents a faithful repetition of a sequence of squares reached performed by the assessor, while the present test was conducted through a digital application). They found a correlation between children's motor skills with the ability to memorize a sequence and its repetition ($R^2 = 0.06$), showing that the lowest values obtained on the motor test were recorded by the same subjects who also performed poorly on the Corsi test. Whereas, among the players in our study, no correlations were found between the agility tests, which are based on coordination, and the cognitive tests, simple visual, dynamic and numerical memory.

Among students (10-15 years old) in Rio de Janeiro, regression showed that physical tests (Touch test disc (TTD), upper and lower limb explosive strength, agility) were the best predictors of executive functions ($p < 0.001$). Hand-eye motor coordination was found to be the most significant predictor of cognitive outcomes, being more influential than academic skills. Significant associations were observed between the hearts and flowers task (HFT) and agility ($p < 0.001$) and touch test disk ($p < 0.001$) (Fernandes et al., 2024).

Matlák et al. (2022) aimed to determine the relationship between agility and cognitive functions among 12.3±0.4-year-old soccer players, they observed a high significant correlation ($p < 0.05$) between the time of time recorded on the agility test. Zhu et al. (2022) studied the links between nutritional status, cognitive functions and physical fitness also in preadolescents (mean age = 10.8 years), they concluded that subjects with poor nutritional status, if they improve their cardiorespiratory fitness and agility, they can improve executive functions. In contrast, in our athletes, no correlations were found between cognitive ability, as measured by memory tests, and agility, as measured by three tests (Lane, Illinois and Random Visual Stimulus Hexagon Agility Test).

Preschoolers who performed better on the physical tests (PREFIT battery: handgrip strength, standing long jump, speed/agility (4 x 10 m) and cardiorespiratory fitness) showed significantly higher scores on visual-spatial working memory ($p < 0.001$), phonological memory ($p < 0.001$), inhibition ($p < 0.001$) and cognitive shifting ($p < 0.001$) (García-Alonso et al., 2025).

Several experts have demonstrated a strong link between agility and the degree of cognitive and brain development in preadolescents and adolescents (Mora-Gonzalez et al., 2019, Hu et al., 2022). The complex situations that adolescents are exposed to while performing physical activity favor the development of agility and cardiorespiratory fitness, which in turn improve functional activity and cognitive efficiency (Shi & Feng, 2022).

Bazalo et al. (2024) studied the relationship between explosive strength, speed/agility, and fluid reasoning in 129 children, and they found significant associations between physical fitness at these ages and fluid intelligence. Physical fitness could have a positive impact on children's cognitive health.

With regard to the relationship between reaction speed and VO_2max, according to the study by Maghsoudipour et al. (2018), a significant correlation was found, resulting in a $p < 0.05$. The researchers included athletes in the study, whose VO_2max was assessed using the Queen Step Test, and reaction speed was determined using the psychomotor vigilance test (PVT). Our study showed a negative correlation between the reaction speed of the dominant upper limb and the fatigue factor ($r = -0.498$, $R^2 = 0.22$, $p = 0.050$), as measured by the anaerobic lactate test, which is curious. Others have found positive associations between physical condition, tested by ergometry on a PWC-130 bicycle, and some cognitive functions, such as selective attention, verbal memory, working memory, logical reasoning, and interference processing (Gajewski et al., 2023). Aerobic fitness showed a significant but negative association with the dorsal attention network (DAN) (Abbasi et al., 2025), whereas in our research no association was found between aerobic and cognitive capacity, but this may be because we associated another function, namely memory.

In the case of climbers, significant links were observed between their performance and working memory, with high-performance athletes performing much better than lower-level athletes (Garrido-Palomino et al., 2024). Even among boxers, associations were found between their specific work capacity (determined by maximum speed punches in 8 seconds) and the speed of verbal information memorization. Furthermore, a higher level of this working capacity is ensured by the activation of verbal intelligence, logical and operational thinking (Korobeynikov et al., 2022). Among soccer players, the performance of skills acquired in speed dribbling, passing, and shooting at the goal showed a significant positive correlation with the sensorimotor network (SMN) and the attention network (Abbasi et al., 2025).

Using BlazePod technology in their research, as we did in the present study, Hsieh et al. (2025) found a significant correlation between response inhibition measures in the laboratory and on the field. Furthermore, only the

go/no-go decision-making ability determined on the field correlated with overall performance on the field.

Li et al. (2020) concluded that physical activity influenced working memory and inhibition and had a moderate effect on cognitive flexibility. Malambo et al. (2024) consider that physical activities involving coordination appear to be significantly associated with conceptual thinking among preschoolers.

Gross motor coordination is correlated with cognitive control, with Liu et al. (2022) demonstrating this relationship with executive functions in preadolescents. Musálek et al. (2024) argue that physical activities focused on improving fine motor control and strength/agility can help improve children's cognitive abilities.

Practitioners and specialists in the field emphasize the interdependent relationship between the cognitive and motor systems, noting a directly proportional relationship between their levels. The complexity of physical tasks has an acute effect on the inhibition of basketball players (Gutiérrez-Capote et al., 2024). Zaichenko Y. (2023) emphasize the importance of the athlete's ability to manipulate physical, technical, mental, and tactical abilities in order to achieve the proposed goal and win in sports.

CONCLUSIONS

This research aimed to determine the degree of association between the ability to sustain prolonged, high-intensity effort and the cognitive processes of young basketball players. To this end, the correlation between anaerobic lactacid effort capacity and mental abilities was analyzed, along with other components of physical effort potential.

The association between effort capacity and the cognitive level of the players is partially demonstrated, as correlations were found only between numerical memory and the Lane agility test ($p = 0.041$) and the reaction speed of the dominant upper limb with the fatigue factor reported by the anaerobic lactacid capacity test ($p = 0.05$). The analysis of the data leads us to believe that an athlete with a high effort capacity does not necessarily have a commensurate cognitive capacity, based on our study group. To confirm this hypothesis, we believe that a larger number of basketball players is needed.

Given the correlation coefficients found in the associations between upper limb reaction speed and physical parameters, especially those related to agility, we recommend the implementation of specific reaction speed exercises in player training.

Due to the characteristics of dynamic sports, the assessment of practitioners' cognitive abilities is necessary to determine the factors that need to be trained or improved, as well as to manipulate them in order to improve sports performance and efficiency.

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The Benefits of Dry-Land Training for Swimmers: A Systematic Review

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ABSTRACT. Introduction: In competitive swimming, dry-land training has routinely become an important aspect of the training programme for swimmers. In contrast, traditional swimming training remains the main method emphasised, focusing heavily on the development of endurance and speed, which are characteristic of the sport. **Aim:** The aim of this study is to conduct a systematic review to observe the effects that strength training can have on a swimmer's training cycle, specifically whether there is a positive correlation between it and swimming performance. **Research methods:** Using the Prisma platform methodology, 354 articles published between 2013 and 2024 were retrieved from the PubMed, ScienceDirect, Medicine & Science in Sport & Exercise, American Physiological Society databases, of which a sample of 50 articles were used after meeting the criteria. **Results:** From this review, they suggested that the inclusion of physical training in the training programme of swimmers can have a positive effect on performance over different distances by improving force transmission in the biomechanics of swimming style. **Conclusions:** The swimmers' dry-land training focused on the development of abdominal muscular endurance, along with strength and power as the most important qualities. The training included specific core strengthening exercises as well as weightlifting sessions. This approach had a positive impact on the swimmers, preparing them for their respective trials and successful competitions.

Keywords: *swimmers, dry-land training, swimming performance, strength training.*

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INTRODUCTION

The importance of strength training for swimming performance has been discussed since the early 20th century. It is particularly associated with Robert Kiphuth, who was probably one of the first swimming coaches in the 1920s and 1930s to introduce out-of-pool (land-based) training in an attempt to develop swimming-specific musculature (Wirth et al., 2022).

Swimming as a competitive sport is popular worldwide and has been part of the Olympic programme since the first modern Olympic Games in 1896. Today, competitive swimming comprises 16 Olympic pool events ranging from 50 to 1500 metres and lasting from approximately 21 seconds to 15 minutes (Fone and Tillaar, 2022). Swimming is one of the most popular competitive sports in the world, requiring a combination of motor skills such as strength, speed and endurance to achieve peak performance due to the wide range of distances and intensities in swimming events (Mavroudi et al., 2023; Pérez-Olea et al., 2018). These qualities are supported by a combination of energy systems (lactacid, alactacid and aerobic). The swimmer's speed is also important and is determined by water resistance and the propulsive force of the movement. When swimming, the head, hips and heels should be in approximately the same horizontal line (Storck, 2017).

Swimming performance can be divided into four key phases: start, freestyle, turns and finish (Thng et al., 2019). The time spent on the turns accounts for between 19-20% of the total race time in 100 m events, rising to 36% in the 1500 m freestyle in long-distance events. This influence is obviously higher in short course events, with values between 44-45% in the 100 m breaststroke (Hermosilla et al., 2021). Therefore, coaches have started to prescribe land-based fitness training to develop motor skills.

L. Rodriguez Gonzalez et al. (2022), in a study of physical training in competitive swimming, argue that the motor quality that currently receives the most attention in swimming is endurance, at the expense of other skills. One aspect that is often neglected in preparation for the sport is strength, a physical quality that has numerous physiological and sporting benefits (González et al., 2022). In the context of strength training for swimmers, when talking about the development of athletic fitness, we can distinguish between two types: strength-speed and speed-strength.

As mentioned earlier, strength development is an important factor in swimming performance. Muscle strength can be measured in a number of ways, but to measure maximum muscle strength, a one-repetition maximum test is usually performed, and to measure muscular endurance, a test is used in which subjects perform as many repetitions of an exercise as possible, with a time of

30 seconds typically used (Hasan et al., 2016; Coyne et al., 2015). Muscles are made up of muscle fibres and are divided into two groups, slow-twitch and fast-twitch fibres. Muscle fibres are specifically trained for a particular type of activity, either speed or endurance.

In fact, the development of strength should be promoted from young athletes (10-11 years of age by starting the development of lumbo-pelvic stability and the biomechanics of technical elements) in order to support the development of motor skills, to improve fitness and performance, but also to improve health indicators and quality of life, and one of the most important aspects is the reduction of injuries.

The human neuromuscular system is capable of developing high forces in a short period of time. Approximately 1.50 ms is required to achieve high force levels [>70% of maximum voluntary force (MVF)] during a single joint explosive concentric voluntary contraction (Del Vecchio et al., 2018). Force is often measured at specific time intervals from contraction onset or characterised by the slope of the joint time-motion curve [i.e. rate of force development (RTD)] during the first 2.00 ms of force generation (Del Vecchio et al., 2018). Over the last few decades, there has been a growing interest in strength development, particularly for improving athletic performance.

There is ample evidence in the literature of the effectiveness of dry-land training in improving swimming performance. In the research by Dr Dnyanesh Patil & al. (2013), as expected by the authors, specialised core strength development training, which also included an area-specific functional strength test, led to significant improvements in a 50m crawl swimming event.

The purpose of this systematic review is to analyse the existing literature to synthesise studies conducted by other sport science authors that have evaluated the effects of physical training on swimmer performance. The main hypotheses include: are there additional benefits of combining strength training with swimming compared to traditional swimming training; what types of exercises are more effective in monitoring progress. This review will provide a comprehensive understanding of the current state of knowledge in this area and may identify gaps or needs for future research.

MATERIALS AND METHODS

Considering the main aspects of the problem, a systematic review of the scientific literature was carried out. The PRISMA statement was taken into account in the selection of the articles to be reviewed in order to properly structure this systematic review (Page et al., 2021) and for this aspect we find all the data in **Figure 1**.

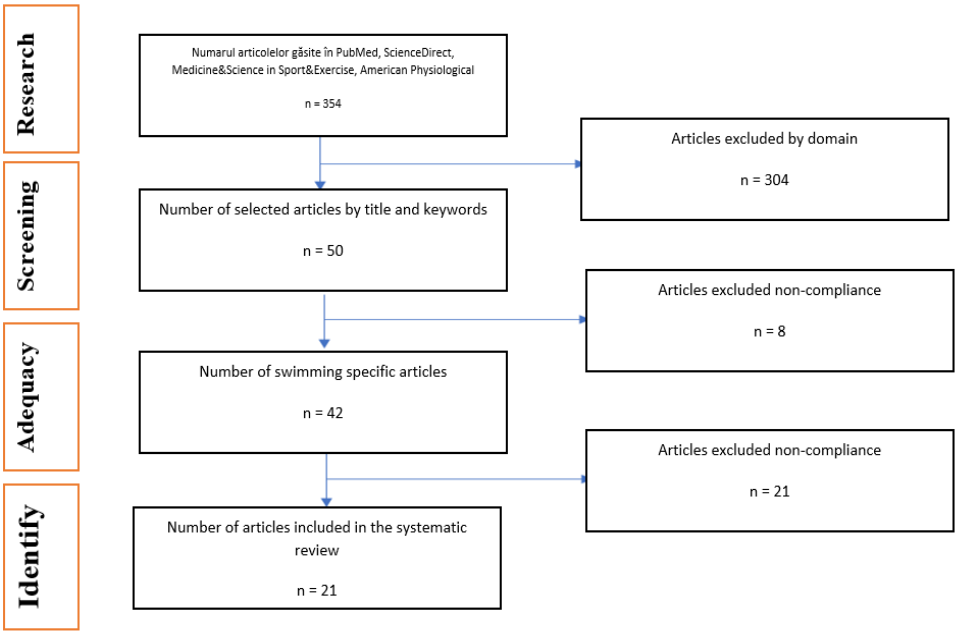

Fig. 1. Representation of the item selection process

1. Research strategy

Articles for this review were searched between January and March 2024 using the PubMed, ScienceDirect, Medicine&Science in Sport&Exercise and American Physiological Society databases, including only articles published between 2013 and 2024. The search terms used were “swimming”, “dry-land”, “strength training” and “velocity”.

The first search returned 354 articles. This was followed by a selection of articles based on keywords and titles, resulting in 50 articles. The matching process was then applied to include only swimming articles, leaving 42 articles. **Figure 1** shows the entire selection process. In this collection, the titles and abstracts of each article were read and only those that met the following criteria were selected:

- Articles written in English and not older than 2013;
- Contain the words “swimming”, “strength training”, “speed and power”, “dry-land” in the title, keywords or abstract;
- The sample consists of amateur, semi-professional and/or professional swimmers;

- The intervention in the study is focused exclusively on improving swimming performance through strength training as part of a programme that also includes in-water training;
- The results contribute to knowledge in the field.

2. Eligibility criteria

The following inclusion criteria were used to extract information: (a) year of publication; (b) study sample; (c) methodology; (d) study; (e) objective(s); (f) instruments; (g) outcomes.

Exclusion criteria were as follows: (a) swimmers from different sport-specific branches: triathlon, aquathlon, open water swimming, frozen water swimming; (b) Paralympians; (c) studies older than 2013.

Data were extracted from eligible articles: author, year of publication, sample size and athlete characteristics (age, gender, weight) in **Table 1** and **Figure 2**.

Table 1. Study and sample data

Authors	Participants
Lopes & colab. (2020)	n = 20 (n = 14 male and n = 6 female) swimmers, age: 20.55 ± 1.76 years, body mass: 68.86 ± 7.69 kg, height: 1.77 ± 0.06 m, 100 m crawl: 71.08 ± 6.71 m, 50 m crawl: 31.70 ± 2.45 s, two groups: experimental (EG: 11) and control (CG: 9).
Sadowski & colab. (2020)	n = 26; age 15.7 ± 0.5 years, height 174.6 ± 6.6 cm, weight 68.4 ± 8.2 kg. Two groups: experimental (E) (n = 12, age 15.8 ± 0.4 years, height 175.7 ± 5.9 cm, weight 67.8 ± 7.9 kg) and control (T) (n = 14, age 15.6 ± 0.6 years, height 173.4 ± 7.1 cm, weight 69.1 ± 8.4 kg).
Gatta & colab. (2015)	n = 20, Masters, males, were allocated to the strength training (ST, n = 10) and swimming training (SW, n = 10) groups. Age (years) 38.7±8.6 32.0±6.9 Body mass (kg) 77.2±8.6 74.9±9.2 Height (cm) 176.2±4.4 176.4±5.8 BMI (kg/m2) 24.8±2.4 24.1±2
Karpiński & colab. (2020)	n = 16, male (21.6 ± 2.2 years). Two groups: experimental (EG, n = 8) and control (CG, n = 8).
Sammoud & colab. (2019)	n = 26, males, two groups: experimental PJT (PJT; n = 14; age = 10.3 ± 0.4 years) and control CG (n = 12; age = 10.5 ± 0.4 years).
Amaro & colab. (2017)	n = 21, males, age 12.7 ± 0.7 years, three groups: control (n = 7) and experimental GR1 and GR2 (n = 7 for each group).
Amara & colab. (2023)	n = 22, males, specialised in butterflies, two groups: experimental (EG, n = 11; age: 14.1 ± 0.30 years; height: 170 ± 9.8 cm; body mass: 68.7 ± 4.3 kg) and control (CG, n = 11; age: 14.5 ± 0.32 years; height: 171 ± 8.4 cm; body mass = 68.1 ± 3.8 kg).

Authors	Participants
JI Mu-Yeop & colab. (2021)	n = 30, two groups: basic training (n = 15; age 13.00±0.88; BMI 19.47±1.13) and traditional training (n = 15; age 13.06±0.88; BMI 19.76±1.85) (CTG and WTG, respectively).
Amara & colab. (2021)	n = 22, males, two groups: experimental (CRTG: n = 11, age = 16.5 ± 0.30 years; height: 174 ± 9.80 cm; body mass = 72.7 ± 5.30 kg) and control (CG: n = 11, age = 16.1 ± 0.32 years; height: 175 ± 9.70 cm; body mass 73.6 ± 5.25 kg).
Pérez-Olea & colab. (2018)	n = 12, males, age 19 ± 3 years, 180 ± 6 cm, 75 ± 10 kg, 15 ± 3% fat mass.
Junior E.B. & colab. (2016)	n = 21, males, three groups: n = 7 swimmers who trained with an elastic band in the water (RW); n = 7 traditional strength programme (ST); and n = 7 control group (CG).
Keiner & colab. (2019)	n = 14, males, age 16-20 years; weight 70.21 ± 4.88 kg; height 1.81 ± 0.05 m.
Patel & colab. (2019)	n = 60, young swimmers (age not specified), two groups: experimental (strength + swimming) and control (swimming only).
Morais & colab. (2016)	n = 27; n = 12 boys, age 13.55 ± 0.72 and n = 15 girls, age 13.16 ± 0.93), divided into 3 groups according to anthropometric and performance measurements (fast, average, poor).
Thng & colab. (2020)	n = 72; n = 38 boys, age 21.0 ± 3.2, height 1.83 ± 0.08 m, body weight 76.7 ± 10.2 kg and n = 24 girls, age 19.2 ± 4.1, height 1.73 ± 0.06 m, body weight 64.8 ± 8.4 kg).
Garcia-Ramos & colab. (2016)	n = 15, boys, age 17.1 ± 0.8 years, height 181.2 ± 6.5 cm, weight 74.1 ± 8.0 kg.
Kanelov and Gotsi (2024)	n = 16, n = 8 females (age 16.63 ± 0.52 years, weight 62.76 ± 3.41 kg, height 165.8 ± 4.20 cm, arm span 175.8 ± 6.36 cm and body fat 16.20 ± 1.4%) and n = 8 males (age 16. 38 ± 0.52 years, weight 65.40 ± 3.36 kg, height 172.1 ± 2.90 cm, arm span 181.3 ± 2.61 cm and body fat 12.6% ± 2.03).
Khiyami & colab. (2022)	n = 18, male, two groups: experimental n = 9, age: 13 ± 2 years, height: 158.8 ± 17.3 cm, weight: 48.3 ± 14.2 kg, swimming experience 2.8 ± 0.4 years and control n = 9, age: 13.11 ± 2.6 years, height: 160.4 ± 11.9 cm, weight: 49.1 ± 11.3 kg, swimming experience 2.9 ± 0.7 years.
Morais & colab. (2018)	n = 27, n=11 boys: 13.5 ± 0.75 years, 54.12 ± 7.81 kg weight, 165.22 ± 8.45 cm height; n=16 girls: 13.2 ± 0.92 years, 51.64 ± 7.22 kg weight, 159.96 ± 6.42 cm height.
Popovici and Suciu (2017)	n = 24, female, age 13-14 years, completed three tests over 3 years in 2012, 2013 and 2014.
Storck (2017)	n = 13, females n=4, age 18±1.41 years; males n=9, age 18±1.11 years.

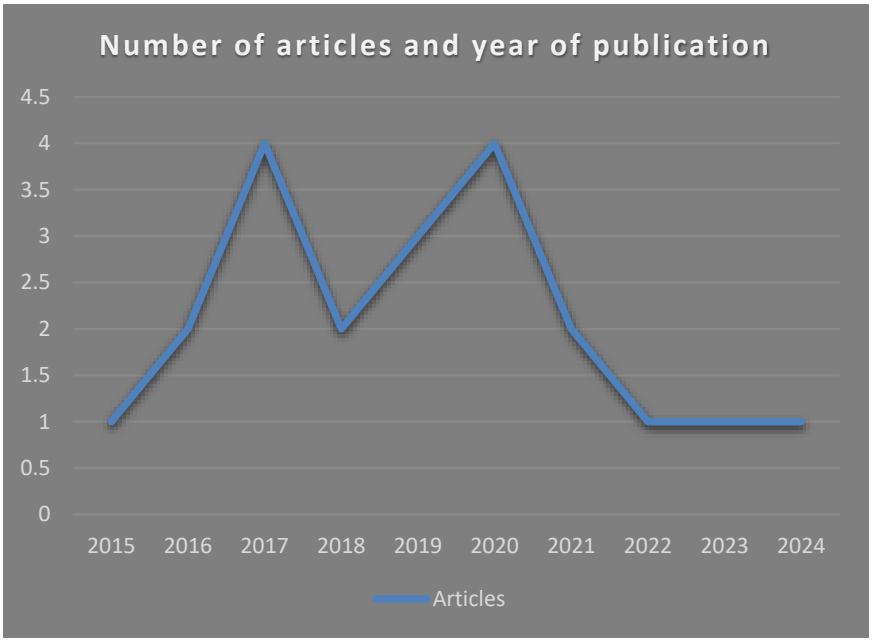

Fig. 2. Presentation of the theme according to the year of publication

RESULTS

Of the 50 studies (publication year 2013-2024) in the PubMed, ScienceDirect, Medicine&Science in Sport&Exercise and American Physiological Society databases, 42 were selected as swimming-specific and 21 were included according to the knowledge criteria based on the results. The aim of the 21 studies was to demonstrate the benefits of land-based training for swimmers.

It can be seen that the importance of this aspect of athletic performance is increasing year by year, as evidenced by the number of studies conducted on this topic in **Table 2**.

Table 2. Swimming performance results after integrating dry-land training

Study	Objectives	Methods	Results
Lopes & colab. (2020)	To evaluate the effect of eight weeks of combined swimming and resistance training on swimming performance.	In water evaluation: 50 m freestyle 100 m freestyle Strength evaluation: 1RM Squat	Experimental training improved performance in the 50 m (29.65→ 28.47 s, p = 0.013) and 100 m freestyle (67.04→64.13 s,

Study	Objectives	Methods	Results
		1RM Bench press	p = 0.023), as well as in the squat (70.30→ 79.95 kg, p = 0.022) and bench press (74.55→85.67 kg, p = 0.001).
Sadowski & colab. (2020)	To compare the effects of specific land-based strength training using an ergometer with traditional land-based strength training over a 12-week period.	Assessment of 25m swimming performance.	Transfer rates were significantly higher in the experimental group than in the control group, resulting in a significant increase in swimming speed (by 4.32%, p<0.001; ES (mean effect size) =1.23 and 2.78%, p<0.003, ES=0.31, respectively).
Gatta & colab. (2015)	To test a training method, Cometti, based on a mixed phase "on dry land with loading followed by a series of fast swims", over a period of 6 weeks.	It was used a accelormeter Maximum-Mechanical-External-Power for evaluation, over a distance of 15m of crawl swimming.	The strength training (ST) group had increases in power (+5.73%), strength (+11.70%) and a slight decrease in speed (-4.99%), while the swimming only (SW) group had decreases in power (-7.31%), strength (-4.16%) and speed (-3.45%).
Karpiński & colab. (2020)	Evaluate a 6-week training programme designed to strengthen the core muscles.	- 50 m freestyle - Distance to enter the water - Entry speed (m/s) - Reaction time - Flight phase - Time 5m after turning - Average swimming speed 5m after return	The experimental group significantly improved the 50 m freestyle time (25.24→24.94 s, p = 0.01), the 5 m time after the turn (0.43→ 0.34 s, p = 0.001) and the average speed after the turn (11.77→ 15.34 m/s, p = 0.001).
Sammoud & colab. (2019)	Comparison of the effects of an 8-week plyometric training programme combined with swimming and swimming training on	- 15m, 25m, 50m crawl - 25m water start without pushing off the wall - 25m kick stroke with start in water without pushing off the wall - CMJ	The experimental group showed significant improvements in both the counter movement jump (CMJ: 19.7→21.7 cm) and the long jump (134.3→148.4 cm), as

Study	Objectives	Methods	Results
	muscle strength indicators.	- Long jump	well as in water performance, reducing the times for the 25 m crawl (18.2→17.52 s) and the 50 m crawl (40.0→39.1 s).
Amaro & colab. (2017)	Evaluation of 3 training regimens in which the control group underwent 10 weeks of swimming only training, GR1 underwent a 6-week strength development programme plus a 4-week swimming only training programme, and GR2 underwent a 6-week explosiveness programme plus a 4-week swimming only training programme.	- 50 m Freestyle - Power during an accelerometer sprint (participants perform 10 seconds of moderate effort followed by 30 seconds of maximal effort) - CMJ - 1kg medicine ball throw (speed and distance measured)	GR2 showed the greatest improvement, with a significant reduction in 50 m freestyle time (33.43 to 31.65 s, p = 0.003) and improved CMJ (29.70 to 31.91 cm, p = 0.018) and medicine ball throw (4.07 to 5.18 m, p = 0.0001) performance, whereas GR1 showed progress in CMJ, but no significant change in swimming, and the control group (CG) showed no relevant improvement.
Amara & colab. (2023)	Evaluation of the effect of 8 weeks of HIIT training combined with maximal training.	1RM Bench pressontal 1RM Leg extension 100 m Butterfly	The experimental group showed significant improvements in 1RM bench press (45.18 kg, p = 0.001), 1RM leg extension (48.73 kg, p = 0.001) and 100 m butterfly (61.85 s, p = 0.001), whereas the control group did not show significant improvements.
JI Mu-Yeop & colab. (2021)	To investigate the effect of adapting land-based abdominal muscle training on swimming performance and fitness.	- 1 RM Deadlift - 1 RM Pullover - Maximum and average power produced on a cycle ergometer (within 30 seconds) - Plank - Throw medicine ball (2kg) forward from supine position with knees bent at 90° (FAPT)	The CTG group showed significant improvements, increasing 1RM deadlift, 1RM pullover, max power from, plank from, FAPT and SAPT.

Study	Objectives	Methods	Results
		- Throw medicine ball (2kg) diagonally from supine position with knees bent at 90° (SAPT)	
Amara & colab. (2021)	The effect of a training programme aimed at developing strength, both on land and in the water, simultaneously, over a period of 9 weeks.	- 1 RM Bench press - 25m crawl - 50m crawl	The experimental group showed significant improvements in 1RM bench press (50.36±2.94 kg, p=0.001), 25 m crawl (12.24±0.55 s, p=0.002) and 50 m crawl (26.17±0.92 s, p=0.009).
Pérez-Olea & colab. (2018)	The main aim of this study was to analyse whether performance in common land based exercises such as pull-up and counter movement jump (CMJ) could predict swimming performance.	- Two high jump tests were carried out: 1. Five jumps were performed with a 1 minute rest between jumps, the highest and lowest were eliminated and the 3 were averaged (CMJ H). 2. 30 jumps were performed with a 2-second rest between them, and all were averaged (CMJ MH). - There were also two tests for the upper body, including chin-ups: 1. 5 pull-ups with a 1 minute rest, recording the speed of execution, eliminating the fast-est and the slowest, averaging the 3 (PUv), the absolute and relative force (PU AF, PU RF), the absolute and relative power (PU AP, (PU RP) and the peak speed (PU PV). 2. After 15 minutes, the par-ticipants performed the maximum repetitions (PUF) - 50 m freestyle (50 F) - 50 m kick with water start	Regarding the upper body fatigue endurance indices, a strong correlation was found between 50m crawl and PUF V (0.57 ± 0.15 m-s -1) and PUF VL (26.4 ± 6.7%), with no significant correlations between CMJ H (36. 8 ± 4.4 cm), CMJ MH (30.1 ± 3.4 cm) with 50 F or with 50 L. However, a strong correlation (r = 0.78; 90% CI = 0.45 to 0.92; R 2 = 0.60; p = 0.03) was found between 50 F and 50 L (40.59 ± 5.18 s).
Junior E.B. & colab. (2016)	The aim of this study was to compare the effects on swimming performance of a traditional strength training programme, a	- 25m crawl - 50m crawl	The resistance band group showed the greatest improvement in the 25 m crawl and the weight training group had a slight

Study	Objectives	Methods	Results
	programme using an in-water resistance band, and in-water only training (no additional strength training aids).		improvement., and in 30 crawl those groups had slight improvements.
Keiner & colab. (2019)	The aim of this study was to determine the relationship between strength and various specific indices of swimming performance, also analysing start and turn performance.	- 1 RM Squat; - 1 RM Bench press; - Counter movement jump (CMJ); - Squat jumps (with weight)	Maximum force, particularly in the upper body, significantly influences swimming performance, including starts and turns. Therefore, strength training should be an essential part of a swimmer's training programme.
Patel & colab. (2019)	The aim of this study was to compare the effects of 6 weeks of strength training between two groups.	1. Arm frequency using the formula: SR= 60X 3/t SR (SR=arm frequency, t SR=time of 3 arm cycles). 2. 50m kick with water start 3. Core test: - plak 60 sec - Raise left arm for 15 sec - Raise right arm for 15 sec - Raise left leg for 15 sec - Raise right leg for 15 sec - Raise right arm and left leg for 15 sec - Raise left arm and right leg for 15 sec - plank for 30 sec	Significant improvements were observed in the experimental group in terms of arm frequency, 50 m kick time and core test results, indicating the effectiveness of the intervention ($p = 0.0001$), whereas the control group showed no progress and some even regressed.
Morais & colab. (2016)	The objectives of the study were carried out over a whole season in three groups: G1- the effect of a physical training programme combined with swimming training G2- Effect of swimming training programmes G3- Effect of classical periodisation	- Squat jump (SJ) - Counter movement jump (CMJ) - Medicine ball throwing velocity (VT) - 100m crawl (PERF)	G1 performed consistently better than the other groups across all three stages (M1–M3), achieving superior results in jump performance (SJ and CMJ), velocity (VT) and swimming time (PERF). Despite a slight decline in some parameters at M3, G1 remained the top-performing group. In contrast, G2 and, in

Study	Objectives	Methods	Results
			particular, G3 showed limited progress.
Thng & colab. (2020)	The primary objective was to determine lower body strength as a predictor of swimming start and the secondary objective was to observe gender differences in these predictors.	TEST – Squat jump: - A warm-up is performed - with the hands on the hips, the participants perform a triple-joint flexion for 3 seconds, followed by the propulsion part. - Participants are asked to perform 3 jumping squats with 30 seconds rest in between. - The highest jump squat is recorded. Test start swim 5m, 15m: All 72 participants (crawl n=50, butterfly n=12, breaststroke n=10) perform the 5m start, and for the 15m breaststroke is excluded due to the requirement to perform a single underwater kick.	Lower body strength is a strong predictor of swim start performance, with higher correlations at 15 metres for both males and females ($R^2 > 0.80$, $p < 0.001$).
Garcia-Ramos & colab. (2016)	a) To analyse the evolution of the genuflexion during the jump and the start of the swim. b) To correlate the height of the jump and the start between the pre- and post-training periods. c) To correlate the percentage change in the genuflexion and the percentage change in the start after the training camp	- start performance: 5m, 10m, 15m - Squat Jump with and without weight (maximum load equal to body weight)	After testing, significant improvements in performance were observed: Squat jump increased and start performance times were reduced, e.g. for 5 m ($p = 0.01$).
Kanelov and Gotsi (2024)	To analyse the effect, positive or negative, of the application of combined strength training in speed and plyometrics - medicine ball throwing (MBP).	- Half-squat against the stopwatch (HS); - High jump (VJ); - 50m crawl	Improvements were seen in the medicine ball throw, high jump and 50 m crawl times for boys and girls. The boys also performed better in the half-squat test, indicating an increase in overall strength and performance.

Study	Objectives	Methods	Results
Khiyami & colab. (2022)	Evaluation of swimming performance following a program aimed at developing abdominal strength.	- 50m crawl - Muscle tension on the external oblique (EO) - Muscle tension on the erector spinae (ES) - Muscular tension on the latissimus dorsi (LD)	The experimental group showed significant improvements in 50 m crawl times and reductions in muscle tension, indicating enhanced performance and better muscle condition compared o the control group ($p \leq 0.05$).
Morais & colab. (2018)	The aim of this study was to determine the interaction between dry-land training, arm entry biomechanics and swimming performance over a 34-week period.	- Medicine ball throw (1 kg and 0.72 m circumference - 100m crawl	Participants demonstrated significant improvements in swimming velocity and 100 m crawl time, indicating enhanced physical and technical capabilities. These results demonstrate the effectiveness of the training programme in enhancing swimming performance ($p < 0.001$).
Popovici and Suciu (2017)	The aim of this study was to test the neuromuscular coordination and control of movement to a given force in swimmers.	- 50m butterfly Biometer Isokinetic Trainer test (30 sec): - Average force (N) - Average power (W) - Average speed (m/s)	Significant improvements in swimming performance and strength were observed from 2012 to 2014. These improvements were evidenced by faster 50 m butterfly times and increased force and power in the isokinetic test. This confirms the effectiveness of the training programme.
Natalie Storck (2017)	The aim of this study was to evaluate the correlation between bench press, pull-ups and 400m freestyle in elite swimmers.	1RM bench press. - Pull-ups, maximum repetitions for 30 seconds. - 400m freestyle (V4 speed test), starting from the water and blood lactate level close to 4 mmol/l.	Men demonstrated greater strength and speed than women. Moderate negative correlations between strength measures and V4 speed suggest that greater strength is linked to faster performance.

DISCUSSION

The purpose of this review was to examine the effects of dry-land programmes on swimming performance, and recent studies in competitive swimming highlight the importance of specific training to improve athlete performance. Optimisation of performance in short distance events is associated with higher levels of maximal upper body strength. It also emphasises the importance of developing lower body strength and power to improve start and return performance in swimming. Correct technique and biomechanics are also critical factors in determining swimming efficiency, and specific training can make a significant contribution to injury prevention and improved athlete performance.

Analysis of the included studies shows that land-based strength training has a significant positive effect on performance, such as the 50m and 100m breaststroke events. For example, the study by Lopes et al (2020) showed a significant time reduction in the 50m event for the experimental group (29.65 ± 2.94 s to 28.47 ± 2.25 s; $p = 0.013$) and a similar improvement in the 100m (67.04 ± 8.06 s to 64.13 ± 6.46 s; $p = 0.023$). In addition, the increase in muscular strength, as assessed by tests such as 1RM in squats and bench press, was significant within the experimental groups, highlighting the effectiveness of these methods. Gatta et al (2015) also showed that the group that combined strength training with intense swimming sessions achieved significant increases in muscle strength and power, in contrast to the group that focused on swimming alone.

Probably the strongest correlation between strength training (bench press and pull-ups) and swimming performance (400 m freestyle) was demonstrated by Natalie Storck (2017). The correlation between maximum number of repetitions in bench press and performance in 400m freestyle was moderate. The correlation between the number of repetitions in the 30-second pull-up and performance in the 400-metre freestyle was strong (Storck, 2017).

Over the course of a competitive year, the body and musculature of athletes adapt to dry-land training, increasing both muscular strength and the hypertrophy effect, and these variables depend on the frequency, volume and type of training (interval, set or continuous).

In competitive swimming, optimising performance in short-distance events depends on a higher level of maximal upper body strength. Indeed, dry-land training has been found to be very important in improving maximal strength in competitive swimmers. Water resistance training has also been reported in several studies (Arsoniadis et al., 2022).

Sofiene Amara et al, in their study (2021) focusing on upper body strength development in adolescent swimmers, argue that this is consistent with the principle of training specificity, which states that training-related adaptations

are greater when training characteristics (e.g. exercise type, contraction mode and movement speed) are matched to the activity being trained and tested. Study results were improved by 3.22-7.26% at a load of 60-80% of 1RM (Amara et al., 2021). Furthermore, the study by Amara et al (2023) confirms that combined HIIT and maximal strength training can significantly reduce times in the 100m butterfly event (64.13 ± 1.41 s reduced to 61.85 ± 1.22 s; p = 0.001), suggesting that explosive strength directly contributes to performance.

Most studies focus on increasing upper body strength, but improving lower body performance is also an important factor in determining swimming performance. Morouço et al (2015) showed that the relative contribution of leg movement was 29.7% for male and 33.4% for female swimmers. However, lower body strength and power are two very important variables that determine start and return performance in swimming (Amara et al., 2022). The extensor muscle group (mainly the quadriceps) of the lower limbs contributes predominantly to the swim turn from the moment the swimmer's foot makes contact with the wall to the momentum (Jones et al., 2018).

Sammoud et al. (2019) showed that the development of the long and high jump, adapted in a swimmer's training, has a positive impact on swimming performance, namely the times of 15, 25, 50 m breaststroke and 25 m standing breaststroke. For the same index involving the start, namely 15 m, Michael Keiner et al. (2019) showed that 1 RM squat and 1 RM bench press accounted for 50% of the performance over this distance, and the lower body momentum from the technical elements: high jump and jump squat, accounted for 30-42% of the 5 m start performance in the craul process.

Core exercises are an integral part of many strength training programmes, as greater stability of the abdominal girdle can provide a foundation for greater strength production in the upper and lower body (Tsoltos et al., 2023).

Roshani S. Patel et al (2019) come up with a very plausible hypothesis in which they explain that a well-developed body in terms of strength can have a much more efficient transfer in the process of water traction through a strong core. If the core muscles are weak, energy expenditure is much higher, especially during leg movements.

In addition to developing muscular endurance, body mass index, flexibility and prevention, a physical training programme has been shown to increase stroke frequency, improve swimming efficiency and improve the hydrodynamic momentum at the moment the stroke enters the water (Morais et al., 2016; Morais et al., 2018).

It is interesting to note that many athletes and coaches do not accept the use of strength training to improve swimming technique and timing. In general, however, it is clear that the stronger the athlete, the better their performance in addition to their swimming ability (Junior E.B. et al., 2016).

The percentage of injuries to professional swimmers is determined by injuries to the hip (37%), knee (28%), ankle and foot (19%), with the remainder being upper limb and trunk injuries (Patel et al., 2019). Brian J. Krabrak along with his collaborators in a study (2013) specified the investigation of other authors regarding the association between dry-land training and injuries in American college swimmers, and dry-land training contributed to 38%-44% of the injuries/pain experienced by the athletes. In conclusion, as the title of the study suggests (Comparison of Dry-Land Training Programs Between Age Groups of Swimmers), each athlete should follow a personalised programme according to their age and level of training or competition.

FUTURE CONSIDERATIONS

Based on the design of dry-land training, we can provide physiological adaptation to further improvements. Some authors have described the effects on the energy systems, which are at the centre of several scientific teams, and there is a temptation to maintain this in the coming years, as is common in other sports. However, to the best of my knowledge, there has not been an update on the progress of strength training by assessing the lactate threshold during work and optimising sessions so that athletes are in good physical condition throughout the training period, providing a good transition between strength training and swimming so as not to overload.

Sebastian Keller et al (2023) studied 19 adolescent swimmers (age 14.8 ± 1.3 years, n = 7 boys, n = 12 girls), 716 FINA points, for neuromuscular development related to swimming performance and metabolic changes over a 12-month period. They were tested 3 times: T1- before the start of training, T2- during the competition period and T3- at the end of the season. Some of the results were significant, an improvement in strength and VO2 max had a positive effect on swimming performance, and another variable of interest was the positive correlation between the improvement in upper body strength and the anaerobic lactate threshold (LT2) during training.

CONCLUSIONS

Core endurance, strength, and power were the most targeted physical performance factors. Bench press and squats were the most commonly prescribed exercises, along with core strengthening to improve lumbo-pelvic stability in swimmers.

The evidence summarised in this systematic review supports the hypothesis that dry-land training contributes to improved performance in swimmers, especially when combined with specific training in the water. These findings emphasise the importance of incorporating strength training into swimmers training programmes.

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Exploring the Relationship between Body Image and Self-Confidence Dimensions among females Sport Students

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ABSTRACT. This study explored the relationship between body image and dimensions of self-confidence among female sports students at University of Setif 2. Using a descriptive correlational approach, this study utilized a sample of 88 female students specializing in Physical Education and sports sciences. Data were collected using a body image scale and a self-confidence dimensions scale. Statistical analysis was conducted using the SPSS V 26 software. The results revealed strong and statistically significant positive correlations between body image and linguistic fluency, independence, and physiological and psychological dimensions. These findings underscore the importance of positive body image in enhancing various aspects of self-confidence among female sports students. Based on these results, it is recommended that universities implement programs to promote positive body image and self-confidence among sports students, incorporate media literacy education to counter negative influences, and provide targeted support for students struggling with body image issues.

Keywords: *body image, self-confidence, female athletes, sport students.*

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INTRODUCTION

Body image is a crucial psychological concept that, exerts substantial influence on an individual's self-perception and self-confidence. The widespread impact of media portrayals and social pressure often leads to distorted ideas about how bodies should look, which worsens body dissatisfaction across all demographic groups. Studies have shown that exposure to idealized body images in the media can lead to body dissatisfaction (Möri et al., 2022). The widespread use of social media among adolescents and young adults can lead to increased body dissatisfaction (Jiotsa et al., 2021). This issue has become particularly prominent among sports students, especially in recent years, due to the widespread proliferation of social media and the active engagement of this demographic with influencers on these social media platforms (Colak et al., 2023). This could be a source of both pride and anxiety. These students are not only subject to constant physical evaluations and comparisons but also face a culture that often prioritizes specific physical aesthetics, creating a challenging environment for maintaining positive self-confidence. Social comparison, specifically upward social comparison with peers and social media influencers, serves as a mediator in the relationship between social media usage and body dissatisfaction (Pedalino & Camerini, 2022). Addition, some studies have proposed solutions to address this issue, such as mindfulness-based interventions that help reduce negative body focus. Balciuniene et al. (2022) highlighted that mindfulness-based physical activity interventions have the potential to enhance positive body image and decrease unhealthy exercise behaviors among female university students. Media literacy is instrumental in promoting a critical understanding of body image in media. Studies suggest that interventions incorporating positive body content can effectively improve mood and body appreciation among young people (Fioravanti et al., 2023).

However, students in sports science programs face the pressure to meet specific physical standards and demonstrate athletic competence, potentially leading to heightened self-consciousness and, in some cases, body dissatisfaction. The dual pressures of academic performance and athletic excellence result in varying levels of self-confidence across academic, social, and physical domains. While some students may develop psychological resilience and the ability to enhance self-efficacy (Colak et al., 2023; Sheng et al., 2024), others may experience diminished self-confidence because of dissatisfaction with their appearance. According to Aysha et al. (2024), body dissatisfaction positively predicts body-related social anxiety and negatively predicts self-esteem. Moreover, studies have shown a negative relationship between body dissatisfaction and academic performance (Zhao et al., 2024), potentially because of the impact of anxiety

and stress on focus and academic achievement. Previous research indicates that individuals with negative self-perceptions regarding their weight are more prone to mental health issues (Robinson et al., 2020), and oral or indirect encouragement to strive for physical perfection can cause people to doubt themselves, have bad thoughts, and feel less competent, even though their studies require them to do well in physical areas. This can further contribute to feelings of inadequacy and body dissatisfaction, as noted by Vasconcelos-Raposo et al. (2024), who also noted that negative thoughts can significantly undermine athletes' self-confidence.

Despite the significance of this issue, there remains a lack of in-depth research specifically exploring how body image impacts the dimensions of self-esteem among this student population within the context of the University of Setif 2. It is necessary to move beyond general assumptions and study this unique dynamic to understand how these individuals internalize cultural standards and develop positive or negative attitudes toward their bodies, which affect their academic and athletic performance, social interactions, and overall psychological well-being. This precise understanding is important for schools, and may affect how people grow and perform in this crucial area. This population is subject to distinct pressures related to physical appearance and athletic prowess, rendering it an ideal setting for examining the interaction between body image and the dimensions of self-confidence. This study has led to the formulation of the following key research questions:

What is the level of body image and self-confidence among female sports students?

Is there a relationship between body image and dimensions of self-confidence among female sports students?

MATERIAL AND METHODS

Participants

The sample consisted of all the female sports students. They are studying for the academic year 2024-2025 at the University of Mohamed Lamine Debaghine Setif 2, totaling 88 participants; the mean age was approximately 21 years. Of these, 55 specialize in sports training, while 33 on physical education. This purposive approach ensured that the study represented the entire population of interest, providing detailed insight into the dynamics of body image and self-confidence among female sports students**.** All research procedures involving human participants were conducted in accordance with the ethical standards of the Declaration of Helsinki. The study protocol was reviewed and approved by the University of Mohamed Lamine Debaghine Setif 2.

Study procedure

After reviewing the theoretical literature and previous studies, tools were selected to measure both self-confidence and body image perception in female students. Three experts reviewed the two scales and approved them after making the appropriate modifications and adjustments. Subsequently, validity and reliability were calculated using a pilot sample of 15 students who were not part of the main study sample. This process ensured the suitability of the tools used. The two scales are distributed between December 1 and December 20, 2024.

Instruments

The Body Image Scale

Hamzawi's (2016) Body Image Scale comprises 22 items designed to assess three domains of body image: physical body image (13 items), composite body image (11 items), and social body image (13 items). Participants responded using a three-point Likert scale (often, sometimes, never) ranging from zero to three points. Positively worded items were scored (2, 1, 0), whereas negatively worded items were scored (0, 1, 2).

Self-Confidence Scale

The Self-Confidence scale of Nasir Bay et al. (2018), consists of 18 items designed to assess self-confidence across four dimensions: linguistic fluency (5 items), autonomy (4 items), physiological dimension (4 items), and psychological dimension (5 items). Participants responded using a five-point Likert scale (always, often, sometimes, rarely, never) ranging from 1 to 5 points. Positive statements were scored as (5, 4, 3, 2, 1), whereas negative statements were scored as (1, 2, 3, 4, 5).

Psychology proprieties

Validity

The correlation coefficient between the score of each dimension and the total score of the scales was calculated as shown in the following table:

Table 1. Correlation Coefficient between dimensions and Total Score of the Body Image Scale and the Self-Confidence

	Dimension	Items	Correlation
The Self-Confidence	linguistic fluency	5	0.889**
	Autonomy	4	0.763**
	Physiological	4	0.745**
	psychological	5	0.884**
The Body Image	physical body image	13	0.856**
	composite body image	11	0.879**
	social body image	13	0.951**

The significant correlation coefficients between the dimensions and the total score of the scales indicated the validity of the self-confidence and body image measures. These correlations suggest that the scales effectively capture the underlying constructs they are designed to measure, thereby supporting their construct validity.

Reability

The reliability of the scales was assessed using Cronbach's alpha, which yielded a coefficient of 0.901. This high value indicated that the scales exhibited strong internal consistency, thereby supporting their reliability.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 26. The reliability of the two scales (self-confidence and body image) was assessed by calculating Cronbach's alpha coefficients for each dimension and overall scale. Additionally, correlation coefficients were determined to ensure the validity of the scales, in addition to assessing the level of body image and self-confidence. The mean and standard deviation of the total scores for both scales were computed. Correlation coefficients were employed to examine the relationship between body image evaluation and the dimensions of self-confidence.

RESULTS

To determine the level of body image appreciation and self-confidence, the mean and standard deviation were calculated for the total score on both scales for the sample participants, as shown in the following table.

Table 2. Level of recognition of body image and self-confidence among female students

	N	Mean	Standard Deviation	Decision
Self-confident	**88**	**76.74**	**13.888**	**High**
Body image	**88**	**39.35**	**6.796**	**High**

This table presents the level of recognition of body image and self-confidence among female students. The mean score for self-confidence was 76.74 with a standard deviation of 13.888, indicating a high level of self-confidence. Similarly, the mean score for body image was 39.35 with a standard deviation of 6.796, suggesting a high level of body image recognition. These findings suggest that female students generally have positive perceptions of themselves, which could contribute to their personal and social abilities.

Table 3. The Relationship between body image and dimensions of self-confidence among Female Students

	N	Mean	Standard Deviation	R	Sig
fluency among	**88**	21.43	3.826	0.891**	**0.00**
Autonomy	**88**	17.48	2.849	0.841**	**0.00**
physiological dimension	**88**	16,51	3.370	0.853**	**0.00**
psychological dimension	**88**	21.32	3.843	0.888**	**0.00**

Table 3 shows the relationship between body image and several dimensions of self-confidence among female students. Strong positive correlations were found between body image and linguistic fluency (R = 0.891), autonomy (R = 0.841), the physiological dimension (R = 0.853), and the psychological dimension (R = 0.888). All correlations were statistically significant at the $p < 0.001$ level. These results indicate that body image plays a crucial role in enhancing self-confidence, linguistic abilities, independence, and physical and psychological well-being.

DISCUSSION

This study aimed to explore the relationship between body image and dimensions of self-confidence among female sports students at University of Setif 2. Employing a descriptive correlational approach, the results of Table 2 align with previous research that emphasizes self-confidence as a crucial indicator of academic success, particularly among female students specializing in sports.

A study by Sadaf Latif et al. (2025) indicated that sports activities significantly enhance student confidence levels. Additionally, there is a positive and significant relationship between self-confidence and sports behavior (Toy, 2023). Engaging in sports activities has also been shown to improve the body image of female students. Results from a study by Ayesha et al. (2024) revealed that athletic female students have a lower body mass index, improved body shape, and a more positive perception of their body image compared to their non-athletic peers. In addition, participation in physical activity was associated with higher levels of self-esteem among university students, suggesting a direct link between engaging in sports and positive body image. A study by Doymaz et al. (2024) highlighted positive correlations between physical activity and self-esteem as well as between body image and self-efficacy among university students. In addition to enhancing self-confidence through physical activity, cultural and social factors also play a significant role in shaping students' perceptions of body image and increasing self-confidence. A study by Cipriani et al. (2022) noted that socio-cognitive and cultural factors influence children's perceptions, thoughts, beliefs, and attitudes toward their bodies. The proliferation of social media has significantly impacted the body image and self-confidence of female students. Social media can aid in designing effective interventions to promote a positive body image and psychological well-being (Rahman & Mehnaz, 2024). Perangin-Angin and Chandra (2022) emphasized that family support accounts for 46% of body image formation, which, in turn, contributes to increased self-confidence (Rosida Hijrianti & Taqiyah, 2024)

Table 3 highlights the significant relationship between body image and linguistic abilities among female sports students, emphasizing the crucial role of body image in enhancing self-confidence. This aligns with previous research indicating that positive body image boosts self-confidence, which in turn facilitates the fluent and clear expression of thoughts and feelings(Ouyang et al., 2020). Conversely, negative body image can lead to anxiety and stress, hindering self-confidence and negatively impacting communication styles, as supported by Du et al. (2023), who found that low self-esteem and heightened anxiety impede clear expressions. Moreover, positive body perceptions encourage interactive engagement with peers, enhancing communication skills and fostering fluent and spontaneous interactions (Yani & Basuki, 2023). Participation in sports activities within universities and fitness clubs enhances self-confidence and; positively influences body image and linguistic ability. Sports promotes positive communication among peers and elevates self-esteem, contributing to linguistic proficiency (Erkmen Hadi & Denktaş, 2023). Negative body image often results in heightened social anxiety, diminishing the ability to communicate effectively,

and exacerbating social anxiety (Xia et al., 2023). This is consistent with the finding of Jin et al. (2022), who found that negative body image increases social anxiety and negatively affects peer interactions.

In addition, Table 3 shows a statistically significant positive correlation between body image and independence, consistent with research highlighting the role of body image in psychological and social well-being (Singh & Manju, 2022). A positive body image enhances confidence and independence in decision-making (Rosida Hijrianti & Taqiyah, 2024), while a negative body image poses health risks (Batista et al., 2021). Engagement in sports activities can enhance both body image and independence, thereby creating a positive feedback loop. A supportive sports environment empowers students to improve their body satisfaction and decision-making abilities (Jankauskiene et al., 2022). Consistent yoga practice fosters mental balance, promotes health behaviors, and positive psychological traits, which increase self-efficacy and emotional intelligence 2) (Mishra, 2022), thereby enhancing independence (ÇetiN et al., 2021). Other factors such as social media and social support influence the relationship between body image and autonomy. Social media often promotes unattainable beauty ideals, leading to body dissatisfaction that affects decision making (Campbell Phillips & Proshad Halder, 2019). Social support plays a significant role; Vani et al. (2022) found that body image and peer support enhance self-acceptance and independence.

In addition, the study revealed a strong positive correlation between body image and physiological dimension among female sports students, aligning with Kriaučionienė et al. (2024), who linked positive body image to better health outcomes. Physical exercise enhances body awareness and improves body image, leading to healthier behaviors(Li & Fang, 2024; Patten et al., 2021). Intervention programs should focus on promoting a positive body image among female sports students to improve their physiological health and well-being. Studies, such as Kieselbach et al. (2024), highlight the importance of enhancing physical capabilities to improve body image. Physical activity interventions contribute to a reduction in body weight and fat percentage (Alnuaimi et al., 2023).

These results agree with those of previous studies that illustrated the role of body image in mental health. Positive body perceptions are associated with higher self-esteem and psychological well-being (Alamdarloo et al., 2019; Taniady & Murti, 2024). Sports participation acts as a mediator between body image and psychological well-being by enhancing mood and reducing stress (Zhang et al., 2024), thus serving as a protective factor against negative body image (Balčiūnienė et al., 2021). Support from family, peers, and coaches enhances psychological well-being by promoting by self-esteem promotion (Scott et al., 2020). However, social media and cultural factors significantly influence body

image and, psychological well-being (Heather et al., 2021; Lôbo et al., 2020). Although our findings align with many studies, they diverge from those of Karna and Sivaraman (2023), possibly due to cultural differences in how body image is perceived. In some societies, cultural values such as modesty play a significant role in shaping female students' body perceptions.

CONCLUSION

This study highlighted the significant relationship between body image and various dimensions of self-confidence among female sports students. The findings revealed strong positive correlations between body image and linguistic fluency, autonomy, and physiological and psychological dimensions. These results emphasize the importance of body image in enhancing self-confidence, particularly among students engaged in sports. This study underscores the role of cultural and social factors in shaping body image perceptions and self-confidence, including social media and family support. Future research should focus on developing targeted interventions to promote a positive body image and enhance self-confidence among this population, considering the unique pressures and challenges they face in their academic and athletic pursuits.

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Study on Stress Management in Sport Organizations

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ABSTRACT. Organizational stress significantly influences athletic performance, especially in high-stakes sports environments. This study investigates perceived stress among high-performance basketball athletes, both foreign and Romanian, male and female, aged 18–30, affiliated with national and international clubs. **Objectives:** The primary objective of this research was to assess athletes' perceived stress using the Perceived Stress Scale (PSS-14) and to classify stress levels into low, moderate, and high categories. **Materials and Methods:** The study employed a quantitative design, distributing the PSS-14 via Google Forms to a sample of 50 athletes. The scale consists of 14 items measuring emotional and cognitive stress experiences over the past month, scored on a five-point Likert scale. Data were collected securely and anonymously, with results processed using descriptive statistics and visualized through individual-level and item-based graphs. **Results:** The findings indicated that most athletes experience moderate levels of stress. Item-specific responses revealed the highest stress associated with the inability to control important things, feelings of anger, and difficulties coping. Differences between the first and second group of 25 athletes showed minor fluctuations in item responses. **Conclusions:** These findings highlight the prevalence of moderate perceived stress among performance basketball players. Addressing psychological stress through targeted interventions—such as resilience training, mental skills development, and psychosocial support—may enhance individual well-being and athletic performance. Regular monitoring using validated tools like PSS-14 can inform personalized strategies within sports organizations.

Keywords: *perceived stress, basketball, performance athletes, sports psychology, mental health, PSS-14.*

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REZUMAT. ***Studiu privind managementul stresului în cadrul organizațiilor sportive.*** Această cercetare a vizat evaluarea nivelului de stres perceput în rândul sportivilor de performanță practicanți ai baschetului, activând atât în cadrul organizațiilor sportive din România, cât și din străinătate. Studiul a fost fundamentat pe aplicarea Scalei Percepute de Stres – PSS-14 (Cohen & Williamson, 1988), un instrument validat științific, recunoscut pentru eficiența sa în măsurarea stresului cotidian. **Obiective:** Obiectivul principal al lucrării a fost identificarea nivelului de stres în rândul baschetbaliștilor de performanță, diferențierea acestuia pe trei paliere (scăzut, mediu și ridicat), precum și analiza factorilor potențial asociați cu manifestarea acestuia în mediul competițional. **Materiale și Metode:** Cercetarea a fost desfășurată la data de 26 mai 2023, pe un eșantion de 50 de sportivi (bărbați și femei, cu vârste între 18–30 de ani), prin completarea online a chestionarului PSS-14, utilizând platforma Google Forms. Rezultatele au fost centralizate și interpretate cu ajutorul unei baze de date Excel, iar analiza a fost realizată prin metode descriptive. **Rezultate:** 66% dintre sportivi au prezentat un nivel mediu de stres perceput, 22% un nivel ridicat, iar doar 12% un nivel scăzut. Cele mai ridicate scoruri s-au înregistrat la itemii privind lipsa controlului și suprasolicitarea, în timp ce itemii pozitivi (autoeficacitate și capacitate de adaptare) au obținut scoruri sub 40% din totalul posibil. Nu s-au constatat diferențe semnificative între sexe, însă sportivii străini au raportat cu 8% mai multe simptome de stres ridicat decât cei autohtoni. Aceste rezultate subliniază necesitatea implementării unor strategii adaptative eficiente pentru menținerea performanței sportive. Analiza grafică a evidențiat variații notabile între itemi, indicând prezența unor factori specifici de stres, cum ar fi incertitudinea |competițională, presiunea performanței, relațiile interpersonale sau solicitările cognitive și afective. Rezultatele sugerează necesitatea intervențiilor de tip preventiv și al sprijinului psihologic în cadrul organizațiilor sportive, pentru a menține echilibrul psiho-emoțional al sportivilor. **Concluzii:** Studiul subliniază importanța monitorizării sistematice a stresului la sportivii de performanță și implementarea unor strategii adecvate de gestionare psihologică a acestuia. Intervențiile personalizate și susținerea din partea echipei tehnice pot contribui semnificativ la reducerea impactului stresului și la optimizarea performanței sportive.

Cuvinte-cheie: *stres perceput, sportivi de performanță, organizații sportive, sănătate mintală, mecanisme de adaptare psihologică*

INTRODUCTION

Today, stress is a type of change that causes physical, emotional or psychological pressure. Stress is each individual's body's response to anything that requires attention or action. Everyone experiences stress to some degree, in different environments and in different areas. Stress affects both the brain and the body. A little stress is good for people to perform and protect themselves,

but too much stress, coupled with other aspects of the individual, can overwhelm them and lead to a fight, flight, flight response or, at worst, death. However, how each individual responds to stress makes a big difference, in terms of each individual's overall well-being (Sonnentag & Frese, 2012).

A systematic review by Nuetzel (2023) highlighted the complexity of coping strategies employed by elite athletes, underscoring the necessity for tailored mental skills training to mitigate stress-related mental health issues. Further exploring the psychological dimensions, Shipherd et al. (2024) found a significant negative correlation between stress mindset and burnout in college athletes, suggesting that athletes who perceive stress as a challenge rather than a threat experience lower levels of burnout. Complementing this, Yu et al. (2025) demonstrated that psychological capital —comprising hope, self-efficacy, resilience, and optimism— negatively predicts athlete burnout, with coping strategies mediating this relationship and perceived stress moderating it. Moreover, a study revealed that psychological stress impairs performance even among Olympic athletes, emphasizing the critical need for effective stress management interventions at all levels of competition. These contemporary findings reinforce the imperative for sports organizations to implement comprehensive stress management programs that address both the psychological and physiological aspects of athlete well-being.

One of the types of psychological stress frequently mentioned today is organizational stress. This refers to stress caused by stressors encountered in the workplace, in the organization where the individual works. Organizational stress, a prevalent form of psychological stress, arises from various workplace factors that challenge employees' mental and emotional well-being. Recent studies have identified key stressors such as interpersonal conflicts, inadequate communication, and unsupportive work environments. For instance, a 2023 study by the American Institute of Stress found that 80% of employees experience productivity anxiety leading to decreased well-being and job satisfaction (American Institute of Stress, 2023). Additionally, the 2024 Mind the Workplace report by Mental Health America highlighted that poor organizational culture and lack of psychological safety contribute significantly to employee stress levels (Mental Health America, 2024). These findings underscore the critical need for organizations to address structural and interpersonal factors to effectively reduce stress and promote a healthier work environment.

When examining organizational stress, it is essential to consider the multifaceted structure of the organization and the various dimensions in which stress manifests. According to Moise (2006), stress within an organization can be categorized into four primary types: group stress, individual stress, organizational stress, and interpersonal stress.

- Group stress arises from the relational dynamics and interactions among team members working collaboratively within an organizational setting.
- Individual stress pertains to the psychological strain experienced personally by an employee in response to workplace demands or conditions.
- Organizational stress reflects the broader interplay between employees and their work environment, influenced by structural, social, and procedural aspects of the organization.
- Interpersonal stress emerges from relational tensions, communication barriers, and social conflicts between individuals, often rooted in ineffective or strained interpersonal interactions (Moise, 2006).

In a sports organization, there are several stressors that act on performing athletes and induce anxiety, mental tension, increased activation, self-defensive reactions against the background of a strong desire to assert the responsibility felt, the uncertain end of success or failure. Athletes operating within professional sports organizations face a diverse range of stressors that can significantly impact their psychological well-being and athletic performance. These include physical demands such as rigorous training, frequent travel, and fatigue, as well as psychological challenges like the fear of underperformance, high expectations from stakeholders, and injury-related anxiety. According to Rice et al. (2016), common stressors among elite athletes include injury, organizational instability, and fatigue, which are frequently associated with elevated levels of anxiety and performance decrements.

Moreover, transitional periods in an athlete's career, particularly the shift from junior to senior levels, are marked by increased stress due to intensified competition and the uncertainty surrounding professional advancement (Stambulova & Wylleman, 2019). Beyond institutional pressures, athletes also encounter growing psychosocial stressors, notably from media scrutiny and online commentary. Recent findings indicate that persistent exposure to critical discourse on social media platforms contributes to elevated mental fatigue, anxiety, and a perceived loss of control over one's public image (Sporting Bounce, 2025).

Taken together, these stressors underscore the critical importance of comprehensive psychological support systems within sports organizations. Addressing both internal (organizational) and external (social and media) stressors can enhance athlete resilience and foster sustainable performance trajectories.

A systematic scoping review by Bentzen et al. (2023) highlights that elite-level coaches often experience significant mental health challenges, including stress and burnout, due to the demanding nature of their roles and the high expectations placed upon them. The study emphasizes the need for targeted mental health support and interventions to address these issues effectively. Moreover,

a longitudinal study conducted by Altfeld et al. (2015) reveals that full-time coaches experience increased emotional stress and decreased recovery over the course of a season, particularly when their perceived success diminishes.

Considering these findings, it is imperative for sports organizations to implement comprehensive strategies that address the multifaceted nature of coaching stress. Such strategies may include providing mental health resources, fostering supportive organizational cultures, and ensuring that coaches have access to adequate recovery opportunities. By proactively addressing these issues, organizations can enhance coaches' well-being and, by extension, the performance and development of the athletes they mentor.

PURPOSE OF THE STUDY

This study explores the extent and nature of organizational stress experienced by high-performance basketball players, encompassing both local and international athletes, male and female. We used a structured questionnaire, which seeks to evaluate how individuals respond to stressors within the competitive sports environment. The aim of this research is to gain deeper insight into the organizational factors contributing to stress in elite basketball settings, with the goal of informing future practices in stress management and performance optimization in sports organizations.

MATERIAL & METHODS

To explore the level of organizational stress among high-performance basketball athletes, in this study we utilized the Perceived Stress Scale – 14 (PSS-14), a widely used instrument developed by Cohen, Kamarck, and Mermelstein (1983). The PSS-14 is designed to assess the frequency of stress-related thoughts and emotions over the previous month and is recognized for its reliability in measuring perceived stress across diverse populations. The research was carried out on May 26, 2023, the sample consisted of 50 athletes (28 male and 22 female) currently active in professional basketball teams in Romania and international sports organizations (Hungary). The participants' ages ranged from 18 to 30 years, reflecting the typical demographic of competitive senior and U21 young basketball player categories.

The mean age of the male athletes was 23.5 years (SD = 3.20), while the female athletes reported a mean age of 22.67 years (SD = 2.69). This distribution

ensured a balanced representation across early and mid-career stages within the sport, suitable for assessing stress levels and job satisfaction in high-performance environments and international sports organizations.

Table 1. Participants of the study

No.	Male initials	Age	Female initials	Age
1	D.C.	22	A.M.	21
2	T.B.	25	M.R.	23
3	I.N.-P.	24	E.S.	20
4	V.P.	26	C.A.	22
5	L.D.	21	S.I.	24
6	R.F.	23	D.M.	25
7	G.T.	20	F.E.	22
8	B.-N.L.	19	T.C.	23
9	A.C.	27	M.L.-E.	19
10	N.S.	28	A.Z.	26
11	P.R.-A.	22	D.P.	21
12	H.V.	23	I.C.	27
13	R.T.	24	B.T.	24
14	O.D.-L.	29	A.F.	28
15	V.I.-C.	19	L.C.	22
16	C.N.	26	D.A.	20
17	S.M.	30	I.F.	18
18	G.S.	18	N.C.	23
19	E.M.	20	A.P.	24
20	R.D.	22	R.M.	25
21	C.T.	23	L.M.	19
22	V.L.	24	T. A. M.	29
23	T.N.	25		
24	S.V.	23		
25	G.C.	26		
26	M.T.	28		
27	O.C.	21		
28	D.T.	20		

The participants voluntarily completed the questionnaire, which was distributed digitally through the Google Forms platform. The PSS-14 consists of 14 items, each addressing how often respondents experienced specific thoughts and feelings related to stress.

Participants indicated their responses using a 5-point Likert scale, ranging from 0 ("never") to 4 ("very often"). Instructions emphasized the importance of responding intuitively, without overanalyzing, to capture an accurate reflection of their recent experiences. To determine each participant's perceived stress level over the past month, the total score was calculated by summing the responses to all 14 items on the PSS-14 scale (Cohen & Williamson, 1988).

For negatively worded items (e.g., items 1, 2, 3, 8, 11, 12, 14), the circled values were used directly. In contrast, for positively worded items (e.g., items 4, 5, 6, 7, 9, 10, 13), scores were reversed by subtracting the participant's response from 4. Based on the total score, perceived stress was categorized as low (0–18), moderate (19–36), or high (37–56).

To assess perceived stress levels, the study employed the Perceived Stress Scale – PSS-14 (Cohen et al.), a widely validated psychological instrument used in occupational and sports contexts. The questionnaire was administered individually under standardized conditions, in the presence of a research facilitator, with no time constraints. The analysis focused on three main stress dimensions: cognitive, emotional, and behavioral. Notably, items Q1, Q2, and Q3 were identified as particularly relevant, indicating high levels of cognitive stress among athletes. These items reflected athletes' perceived unpredictability of events, lack of control over important aspects of life, and difficulties coping with competitive demands. Data were processed and analyzed using SPSS v.26. Descriptive statistics (means, standard deviations) were calculated to characterize the overall distribution of responses. To assess statistically significant differences between groups (e.g., by gender), independent-samples t-tests were conducted. Additionally pie charts were used to visually illustrate response trends across the stress dimensions.

The statistical significance threshold was set at $p < 0.05$, with results at or below this level considered indicative of meaningful differences or associations. To align with contemporary approaches in social research, the methodology integrated digital technologies in accordance with best practices outlined by Neacşu, Manasia, and Chicioreanu (2016), facilitating efficient data collection and broader participant accessibility. The use of an anonymous survey format also reinforced ethical standards and encouraged honest self-reporting from athletes who might otherwise hesitate to disclose personal experiences related to psychological stress.

RESULTS

To gain a more nuanced understanding of how performance athletes experience psychological stress, this study categorizes the 14 items of the Perceived Stress Scale (PSS-14) according to three core psychological domains:

cognitive, emotional, and behavioral responses to stress. This approach aligns with recent advancements in stress research, such as the integrative cognitive-affective stress model developed by Uphill, Sly, and Swain (2016), which suggests that individuals' appraisal of stress and their emotional and behavioral responses significantly influence performance and well-being. Furthermore, this classification facilitates the application of athlete-specific interventions by targeting the predominant stress domain in each case. Recent literature in sport psychology emphasizes that stress in high-performance contexts manifests through differentiated yet interlinked mechanisms:

- Cognitive stress reflects athletes' perception of unpredictability, overload, or lack of control over events (e.g., thoughts of helplessness, inability to manage tasks).
- Emotional stress involves affective responses such as irritability, anxiety, and feelings of being upset.
- Behavioral stress responses represent how athletes manage time, take control, and engage in actions to cope with stress, often reflecting either adaptive or maladaptive strategies.

This classification enhances the interpretative clarity of the PSS-14 results and is consistent with integrative frameworks proposed by Connor-Smith et al. (2000) and Gaudreau & Blondin (2004), which advocate for the analysis of stress by mapping cognitive appraisal, emotional valence, and behavioral regulation.

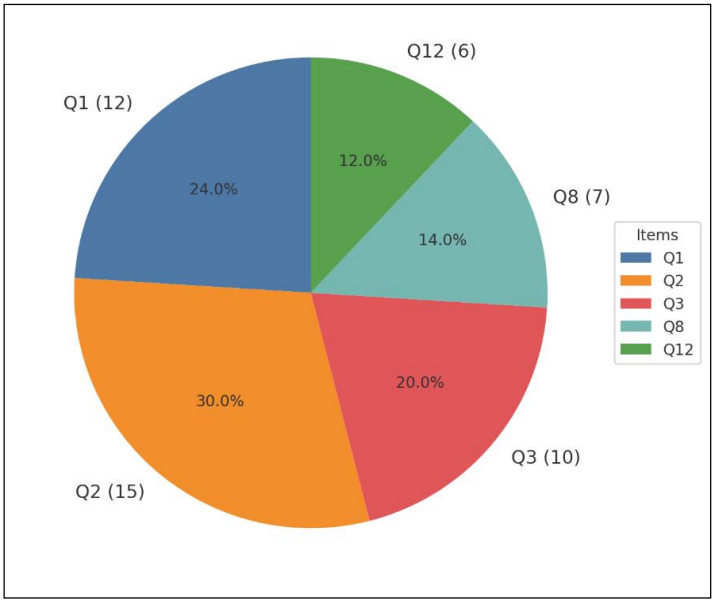

Fig. 1. Cognitive stress PSS-14 item distribution

Fig. 1. illustrates the relative distribution of responses across five PSS-14 items associated with cognitive stress: Q1, Q2, Q3, Q8, and Q12. These items reflect an individual's perceived control, unpredictability, and difficulty managing daily demands. The highest proportion of responses was recorded for item Q2 ("felt unable to control the important things"), followed by Q1 and Q3, suggesting that loss of control and unexpected events are dominant cognitive stressors among the participants. The lower shares attributed to Q8 and Q12 indicate that while task-related overwhelm exists, it may be less prevalent than general perceptions of control loss.

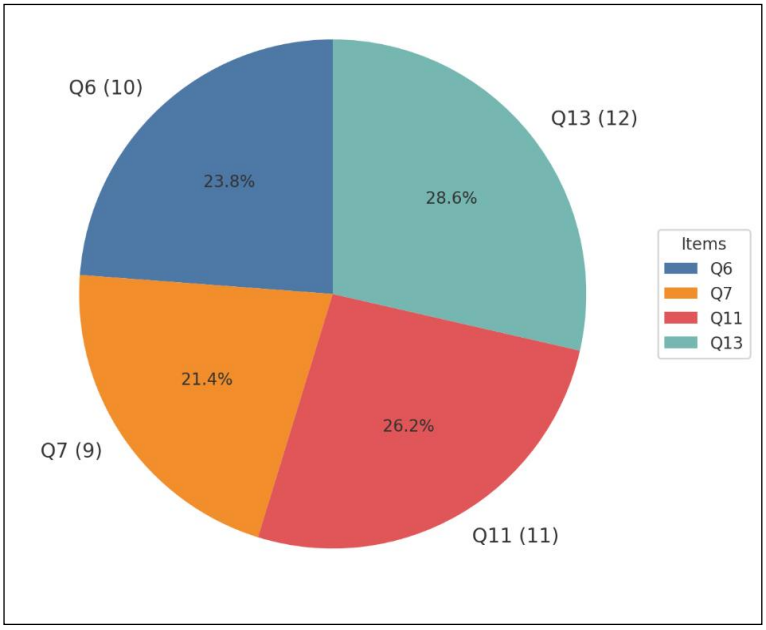

Fig. 2. Emotional stress PSS-14 item distribution

According to Fig. 2., the chart presents data on the emotional dimensions of stress using four key PSS-14 items: Q6, Q7, Q11, and Q13. These items capture feelings such as anger, helplessness, emotional overload, and a lack of confidence. Item Q13 ("felt difficulties were piling up too high to overcome") represents the largest segment, highlighting emotional overwhelm as a significant stressor. Q11 and Q6 show moderate frequencies, while Q7, which addresses perceived positive outcomes, appears least endorsed, possibly reflecting reduced emotional resilience.

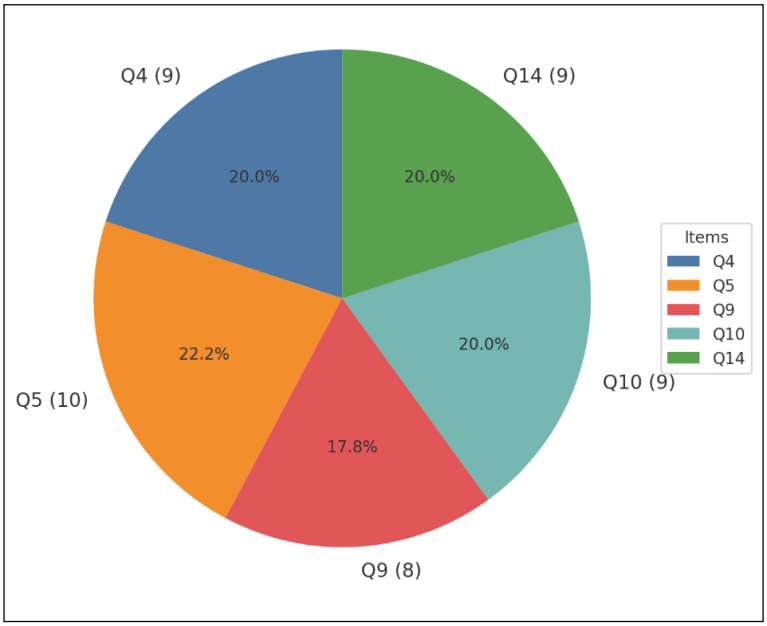

Fig. 3. Behavioral stress PSS-14 item distribution

Findings in this category depict the behavioral coping dimension through items Q4, Q5, Q9, Q10, and Q14, which assess self-efficacy, time management, and the ability to control one's reactions and environment. The chart reveals a relatively even distribution among these five items, suggesting that no single behavioral mechanism is disproportionately impaired, but moderate levels of difficulty are present across self-regulatory actions. Slight peaks in Q5 and Q10 may suggest that feeling on top of tasks and time control are areas where athletes report more strain.

DISCUSSIONS

In the domain of emotional stress, the highest scores were observed for Item Q13 ("felt difficulties were piling up too high to overcome") and Item Q11 ("angered because things were out of your control"). These responses suggest a prominent emotional burden associated with performance pressures and perceived helplessness. Emotional exhaustion is a known predictor of burnout in elite athletes (Gustafsson et al., 2017), and interventions such as mindfulness-based stress reduction or emotion regulation training may be particularly beneficial.

The analysis of behavioral stress responses was relatively balanced across the relevant PSS-14 items, indicating that while no single coping behavior is overwhelmingly impaired, athletes nonetheless experience consistent behavioral strain. Items such as Q10 ("angered because things were out of control") and Q14 ("could not overcome piled-up difficulties") showed modest peaks, emphasizing the importance of enhancing athletes' time management and self-regulatory capacities. These findings support research by Rice et al. (2016), who argued that behavioral coping strategies are crucial for sustaining performance and psychological well-being in sports contexts.

Overall, the distribution of stress levels across the full sample revealed that a significant number of athletes fall into the moderate stress category, while a non-negligible portion experience high stress. This underlines the urgent need for targeted psychological support within sports organizations, particularly during transitional phases such as post-season recovery or injury rehabilitation. The graphs developed in this study enabled a detailed visualization of stress manifestations across different domains, facilitating data interpretation. Future research should consider incorporating longitudinal methods and qualitative interviews to further explore the causes and consequences of stress in performance athletes.

Overall, the distribution of stress levels across the full sample revealed that a significant number of athletes fall into the moderate stress category, while a non-negligible portion experience high stress. Approximately 62% of the participants reported moderate stress, 26% exhibited high stress levels, and only 12% fell within the low stress range. This underlines the urgent need for targeted psychological support within sports organizations, particularly during transitional phases such as post-season recovery or injury rehabilitation.

Furthermore, a preliminary correlation analysis indicated a positive relationship between emotional stress scores and high overall PSS-14 scores ($r = 0.67$, $p < 0.01$), suggesting that emotional burden is a key driver of overall perceived stress. Similarly, a moderate correlation was found between cognitive stress items and behavioral coping difficulties ($r = 0.53$, $p < 0.05$), indicating interconnectedness between thought processes and coping behaviors.

By understanding and addressing the multidimensional nature of stress in elite basketball athletes, sports organizations can design more effective support systems that not only enhance performance but also safeguard the psychological health of their athletes. Statistical analyses were performed using SPSS v.26. Descriptive statistics (mean, standard deviation, minimum, and maximum) were calculated for the overall sample. Additionally, to determine whether stress levels differed significantly between genders, an independent-samples t-test (Welch's t-test) was conducted. The significance level was set at $p < 0.05$ for all analyses.

Table 2. Data statistical analisys

Statistics	PSS-14 score
Mean	26.38
Standard Deviation	2.20
Minimum	21
Maximum	30

The scores indicate a moderate level of perceived stress across the athlete population, with limited variability, suggesting a generally uniform experience of organizational stressors in competitive basketball environments. To assess gender-based differences in perceived stress, an independent-samples t-test was conducted comparing the male and female subgroups:

CONCLUSIONS

The results of this study highlighted a predominance of moderate stress among athletes, with emotional and cognitive stress emerging as particularly impactful. Emotional burdens related to uncertainty, pressure to perform, and lack of control were strongly correlated with elevated overall stress levels, suggesting a pressing need for mental health and coping strategy interventions within sports organizations. The findings also demonstrate the interconnection between cognitive stress and behavioral coping difficulties, underscoring the complexity of stress responses in competitive environments.

While some athletes manage stress effectively, a substantial group struggles with emotional overload and inadequate coping mechanisms, placing them at risk for burnout or performance decline. To promote athlete well-being and performance sustainability, sports organizations should implement comprehensive stress management programs. These should include psychological support, emotional regulation strategies, and resilience-building interventions tailored to the needs of athletes. Strengthening mental health resources can contribute significantly to both individual athlete development and the long-term success of sports institutions.

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The Role of the Educational Manager in High Schools in Cluj-Napoca as Centres of Excellence in the Local Community

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ABSTRACT. The Role of the Educational Manager in High Schools in Cluj-Napoca as Centers of Excellence in the Local Community. Educational management oversees the education system to ensure an effective learning environment by planning, organizing, coordinating, and controlling activities such as leading staff, managing resources, implementing policies, and engaging with the community. Educational leaders develop strategies to enhance programs and services, aiming to produce competent graduates ready for the workforce and significant societal roles, thereby improving the overall education system. **Objective:** This study explores high schools' vision and mission, the educational manager's role in shaping future competencies, and the strengths each institution promotes. It also examines the importance of parental involvement in education. The findings provide insights into strategic educational leadership and its impact on student development and institutional excellence. **Materials and Methods:** This study involved 10 directors (educational managers) selected from a total of 26 high schools in Cluj-Napoca. The data collection method chosen was structured interviews conducted based on a personal data processing agreement. The study was conducted from February to April 2023. **Results:** Highlighting the role of high schools as centers of excellence in the local community, this investigation can contribute to strengthening the connection between educational institutions and the surrounding community. It can promote collaboration, parental involvement,

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and community engagement in supporting and developing high schools. The results and conclusions of the investigation can provide valuable information for the development of educational policies at the local or regional level. They can serve as a foundation for the development of strategies and measures to support the development of high schools as centers of excellence and improve the quality of education. **Conclusion:** This investigation contributes to the field of education research by providing new knowledge and understanding of the role of the educational manager in high schools in Cluj-Napoca. It can inspire and stimulate further research and studies in the field of educational management and excellence in education.

Keywords: *management, leadership, community, key competences, future of education.*

REZUMAT. ***Rolul managerului educațional în liceele din Cluj-Napoca ca centre de excelență în comunitatea locală.*** Managementul educațional supraveghează sistemul educațional pentru a asigura un mediu de învățare eficient prin planificarea, organizarea, coordonarea și controlul activităților precum conducerea personalului, gestionarea resurselor, implementarea politicilor și implicarea comunității. Liderii educaționali dezvoltă strategii pentru a îmbunătăți programele și serviciile, având ca scop formarea de absolvenți competenți, pregătiți pentru forța de muncă și roluri semnificative în societate, îmbunătățind astfel sistemul educațional în ansamblu. **Obiective:** Acest studiu investighează rolul managerului educațional în liceele din Cluj-Napoca pentru a le integra ca centre de excelență în comunitatea locală. **Materiale și metode:** Acest studiu a implicat 10 manageri educaționali selectați dintr-un total de 26 de licee din Cluj-Napoca. Metoda de colectare a datelor aleasă a fost interviurile structurate, desfășurate pe baza unui acord de prelucrare a datelor personale. Studiul a fost realizat în perioada februarie-aprilie 2023. **Rezultate:** Prin evidențierea rolului liceelor ca centre de excelență în comunitatea locală, această investigație poate contribui la întărirea legăturii dintre instituțiile educaționale și comunitatea înconjurătoare. Poate promova colaborarea, implicarea părinților și angajamentul comunității în sprijinirea și dezvoltarea liceelor. Rezultatele și concluziile investigației pot oferi informații valoroase pentru dezvoltarea politicilor educaționale la nivel local sau regional. Ele pot servi drept bază pentru dezvoltarea strategiilor și măsurilor de sprijinire a dezvoltării liceelor ca centre de excelență și pentru îmbunătățirea calității educației. **Concluzie:** Această investigație contribuie la domeniul cercetării în educație, oferind noi cunoștințe și înțelegere a rolului managerului educațional în liceele din Cluj-Napoca. Poate inspira și stimula cercetări și studii ulterioare în domeniul managementului educațional și al excelenței în educație.

Cuvinte-cheie: *management, leadership, comunitate, competențe cheie, viitorul educației.*

INTRODUCTION

Education is a comprehensive and structured process aimed at fostering the intellectual, moral, and physical development of individuals and communities (Ţoca, 2002). Within this framework, educational management plays a fundamental role in ensuring an effective and efficient learning environment. It encompasses essential functions such as planning, organizing, coordinating, and overseeing the activities within the educational system, including teacher supervision, financial and material resource management, and the development and implementation of educational policies (Kerr, 2003). According to Fayol (2016) and Popa et al. (2013), the four core functions of management-planning, organizing, directing, and controlling—are integral to optimizing the educational process.

Closely linked to educational management is educational leadership, which emphasizes the ability to inspire and influence the education system in achieving its objectives (Sallis, 2002). Effective educational leaders play a key role in establishing a compelling vision, fostering a climate of trust, providing meaning, and facilitating success among both educators and students (Amanchukwu et al., 2015). Through their leadership, they motivate and guide stakeholders, ensuring that institutional goals align with students' needs and societal expectations.

The primary beneficiaries of public education are students and young people. As stated by the Ministry of National Education (2019), schools have the mission of ensuring that future adults acquire functional literacy across various disciplines, ethical values, character formation, and a commitment to a healthy lifestyle. Additionally, educational institutions support families and communities in the learning process, contributing to social well-being and preparing students for professional and societal integration.

A key factor in delivering high-quality education is the framework of key competencies for lifelong learning, as outlined in the EU Council Recommendation (2018). These eight fundamental competencies include literacy, multilingual skills, scientific and mathematical reasoning, digital proficiency, personal and social abilities, civic engagement, entrepreneurship, and cultural awareness. The goal of the education system is to develop these competencies at a functional level by the end of high school and at an advanced level in post-secondary education (Monitorul Oficial, 2021).

By equipping students with these essential skills, educational institutions enhance their capacity to navigate complex and dynamic societal challenges. Education will increasingly focus on personalized learning, tailoring the educational experience to meet the unique needs and learning styles of each student (ACT Government Education, 2019). The advancement of digital technologies, artificial

intelligence, and online platforms will be pivotal in implementing this approach, enabling the creation of customized learning materials, performance analysis, and personalized recommendations (Valamis, 2023). However, the successful implementation of personalized learning will largely depend on the adequate training of educators in using advanced educational technologies (Sridhar, 2021).

The Ministry of Education of the Australian Capital Territory (ACT Government Education, 2019) has outlined a ten-year strategy for the future of education, emphasizing a student-centered approach. This strategy includes increased investment in teacher professional development, the strengthening of learning communities, and the optimization of organizational structures within educational institutions. By focusing on these aspects, the strategy aims to enhance student engagement and learning outcomes, ensuring that education remains adaptive to emerging trends and societal needs.

In conclusion, educational management and leadership are critical to ensuring the quality and effectiveness of the teaching and learning process. By integrating strategic planning, institutional oversight, and inspirational leadership, these elements shape the educational experience and institutional success. Future education will center on personalized learning models and the adoption of advanced digital technologies, with a primary focus on individual student needs and the development of key competencies required for successful socio-professional integration. These advancements will require continuous investment in teacher training, adaptive learning strategies, and institutional innovation to ensure that education remains relevant and effective in a rapidly evolving global landscape.

STUDY OBJECTIVES

- First objective was to identify and analyze the vision and mission of high schools.
- Secondly, the study aimed to examine the educational manager's approach regarding the competencies required for future generations.
- Third objective of this research was to find out the strengths promoted by each high school.
- Fourth objective seeked to determine the significance attributed by the educational manager to the role of parents in the future of education.

MATERIAL AND METHODS

The study involved 10 directors (educational managers) from 26 high schools in Cluj-Napoca, representing a diverse range of educational institutions. These directors hold authoritative positions and extensive responsibilities in decision-making, policy implementation, ensuring educational quality, and developing staff and students. The experience of the subjects is a minimum teaching time of five years in at least pre-university institutions. The research aimed to understand the challenges, strategies, and experiences of these school directors. Specific objectives included identifying school visions and missions, examining approaches to developing competencies for future generations, analyzing promoted strengths, and determining perceived importance of parental roles in education.

Regarding methods, the theoretical component involved a literature review, while the empirical component utilized qualitative interviews conducted from February to April 2023 with consent for data processing. Researchers employed observation of daily activities, in-depth interviews, and document analysis for data collection. Additionally, statistical-mathematical methods were used to process and analyze the collected data, including techniques like sampling, measurement, data centralization and processing, and graphical representation.

Table 1. High schools involved in the study

Liceul cu Program Sportiv Cluj-Napoca
Liceul de Informatică „Tiberiu Popoviciu” Cluj-Napoca
Liceul Tehnologic UCECOM „Spiru Haret” Cluj-Napoca
Liceul Teologic Adventist Maranatha Cluj-Napoca
Liceul Teologic Baptist „Emanuel” Cluj-Napoca
Liceul Teoretic „Brassai Samuel” Cluj-Napoca
Liceul Teoretic „Apáczai Csere János” Din Cluj-Napoca
Liceul Teoretic Creştin Pro Deo Cluj-Napoca
Liceul Teoretic Eugen Pora Cluj-Napoca
Liceul Waldorf Cluj-Napoca

Table 2. Questions used to interview the educational managers from high schools

Question 1	What is the vision and mission of the high school you lead?
Question 2	How has your school aimed to compensate for what the pre-university education system is currently unable to provide?
Question 3	In your opinion, what competencies do future generations need? What can your high school do to develop these skills?
Question 4	What are the development priorities for the next academic year regarding academic, curricular, and extracurricular activities?
Question 5	What makes your high school unique, and why should parents choose it for their children?
Question 6	What should be the role of parents in the future of education?
Question 7	How do you anticipate pre-university education in 2043?

RESULTS

Question1: More than half of the respondents emphasize the promotion of Christian values, integrating students within family, church, and society while fostering ethical and moral development. Another key aspect is the formation of responsible citizens with strong character, adaptability, and leadership skills. Additionally, respondents highlight the importance of a learning community and diversity, ensuring a safe and inclusive environment for student growth. There is also a strong focus on academic excellence and personal development, encouraging individuality, creativity, and high achievement. One respondent specifically mentions the promotion of sports values, shaping students into responsible citizens, athletes, and professionals.

Question 2: Schools have implemented various strategies to address gaps in the pre-university education system. A key focus is continuous teacher training, ensuring educators are well-prepared for evolving student needs. Additionally, extracurricular and volunteer activities provide valuable learning experiences beyond the classroom, fostering both academic and personal growth. The digitalization of education enhances resource accessibility and personalized learning, while career guidance and counseling support students in setting goals and preparing for professional pathways. Initiatives like the Future Authoring program, developed by Dr. Jordan B. Peterson (University of Psychology in Toronto), highlight the benefits of self-reflection and goal setting in reducing uncertainty about the future. Schools also emphasize collaboration with external stakeholders such as federations, associations, and NGOs to expand educational opportunities. Some institutions adopt Waldorf-inspired scheduling, integrating rhythmic activities, cognitive learning, and storytelling to create a holistic and engaging learning environment that balances theoretical, artistic, and practical development.

Question 3: Responses indicate that social competence is considered the most essential skill for future generations, with 40% of respondents emphasizing the need for strong interaction, collaboration, empathy, and conflict resolution abilities, which schools foster through extracurricular activities and non-formal education. Digital competence, highlighted by 30% of responses, underscores the importance of integrating digital literacy programs to ensure students develop responsible and effective technology use. Literacy competence, noted by 20% of respondents, remains fundamental, with schools promoting reading, writing, and communication skills through creative writing, debates, and public speaking. Another 20% of respondents stress the importance of organizational competence, focusing on time management, task prioritization, and resource allocation to enhance academic and professional efficiency. The remaining 10% recognize the significance of critical thinking, artistic creativity, and information analysis, which schools support through projects, artistic initiatives, and learning programs.

Question 4: Schools have outlined several key development priorities for the next academic year. Human resource development remains a primary focus, with emphasis on teacher training and professional development to enhance the quality of education. Infrastructure improvement is also a priority, aiming to modernize facilities and expand school capacity to accommodate growing student populations. Expanding extracurricular programs is another major goal, ensuring students have diverse opportunities for personal and academic growth. Additionally, national and international mobility programs are encouraged to broaden students' perspectives through exchange programs and study trips. Schools are also working towards educational accreditation expansion, securing certifications that provide students with recognized qualifications. Health education initiatives are being introduced or strengthened to promote student well-being. To bridge the gap between education and industry, collaboration with universities and the private sector is being pursued, creating real-world learning experiences. Lastly, decentralized decision-making is being prioritized, allowing schools greater autonomy in implementing clear, measurable educational strategies tailored to their needs.

Question 5: Responses highlight key aspects that make high schools in Cluj-Napoca unique and attractive to parents. Many emphasize Christian-based education, fostering ethical values, and ensuring a safe learning environment. Several schools stand out through national and European partnerships, offering cultural exchanges and diverse learning experiences. Other defining elements include effective communication with stakeholders, international collaborations, and academic excellence. Some schools specialize in IT education, partnering with industry leaders, while others emphasize community building, personalized teaching, and sports opportunities.

Question 6: Responses highlight the crucial role of parents in the future of education, with 50% of respondents emphasizing the need for active collaboration between parents and schools to support students' learning and development. An additional 20% stress the importance of emotional and motivational support, helping students build confidence, resilience, and motivation in their academic journey. Another 20% focus on the need for parents to understand and respect the school's role, fostering effective communication and cooperation with educators. The remaining 10% underline the role of parents in career guidance, assisting children in making informed decisions about their professional paths and preparing for future opportunities.

Question 7: Responses highlight key expectations for pre-university education in 2043, emphasizing the growing role of technology, personalization, and institutional autonomy. Technology integration (30%) is a primary focus, with predictions of AI-driven learning, digital platforms, and adaptive teaching tools enhancing student engagement and accessibility. Personalized learning models (25%) are expected to replace standardized education, adapting to individual interests and needs through data-driven instruction. Greater school autonomy (20%) is seen as essential, allowing institutions to implement flexible curricula and localized decision-making. Teachers' roles (15%) are projected to shift towards mentorship and facilitation, guiding students through self-directed learning rather than traditional instruction. The remaining 10% of responses highlight concerns about societal changes affecting education, emphasizing the need for schools to prioritize critical thinking, real-world competencies, and ethical values to prepare students for an uncertain future.

Presenting the vision and mission of their institutions, the ten educational managers provided 28 responses. Of these, 11 responses focused on preparation for community and society, including perspectives such as „building a community of students who can serve as role models in society" or „educating students to appreciate the environment and the people around them". These were followed in frequency by five responses emphasizing individual student development. Other responses, mentioned less frequently, referred to promoting Christian values, creating a safe learning environment, and preparing students for change and future demands.

Regarding the competencies required for future generations, social competence had the highest frequency, appearing in 8 out of the 24 responses provided by educational managers. Digital competence was highlighted by four managers, while other competencies such as literacy, artistic competence, and organizational skills were mentioned more often.

The key strengths promoted by each high school vary widely. However, three educational managers emphasized the importance of national and international partnerships, while two managers highlighted the safety and security of school environment. The following table presents the advantages of each manager mentioned particularly.

Table 3. Advantages of high schools from the educational managers perception

Educational managers answers	
Extracurricular activities for easier social integration	United school community
Christian education	Partnerships with industry firms
IT-related activities	Correction of undesirable behaviors
Safe and secure environment	Teaching adapted to the specific needs and developmental stages of children
Qualifications offered	Regional and national trips
Learning environment	Academic achievements
Sports championships and training camps	Practical applicability
International/National and European partnerships	Comprehensive child development across all necessary areas
Effective communication	Development of teamwork skills

DISCUSSIONS

The research has provided valuable insights into the vision and mission of high schools in Cluj-Napoca, demonstrating their commitment to delivering quality education, holistic student development, and preparation for the challenges of the future. Schools emphasize values such as academic excellence, responsible citizenship, diversity, and personal growth, with some also integrating Christian principles as a foundation for character formation. This finding is consistent with Sridhar (2021), who argues that personalized learning is becoming a core element in modern educational systems. Additionally, the responses suggest a strong desire for these institutions to act as centers of excellence within the local community, not only by fostering intellectual development but also by providing students' social and emotional well-being.

One of the primary objectives of this study was to analyze the approach of educational managers regarding the competencies required for future generations. The findings highlight the increasing importance of transferable skills, critical thinking, creativity, collaboration, and adaptability in an era of rapid technological

and societal change. Educational managers recognize that these competencies are essential for students' successful integration into the workforce, encouraging a learning environment that goes beyond traditional academic knowledge to include practical problem-solving g learning skills, similar to findings outlined in Monitorul Oficial (2021).

Furthermore, the research examined how high schools compensate for gaps in the current pre-university education system. Several key strategies emerged, including continuous teacher training, extracurricular and volunteer activities, digitalization, career guidance, and partnerships with external organizations such as municipal authorities, and higher education institutions. Schools aim to offer a more dynamic and interactive learning experience that aligns with students' real-world needs and aspirations. Additionally, innovative pedagogical approaches, such as those inspired by Waldorf education, reflect an effort to create a well-rounded curriculum that balances intellectual, artistic, and practical development.

The unique strengths of each high school also play a significant role in shaping their identity. These strengths often include modern infrastructure, diverse learning opportunities, and a strong extracurricular framework that provides students with essential experiences beyond the classroom, in line with Fayol (2016) on the management of educational organizations. The ability of schools to effectively promote and develop these strengths has a direct impact on their ability to attract and retain students, contributing to their overall reputation as institutions of excellence.

A crucial aspect highlighted in the research is the role of parents in the future of education. The findings emphasize that educational success is a shared responsibility, requiring close collaboration between schools and families. Educational managers strongly encourage open communication and a transparent relationship between parents and the school, ensuring a coordinated approach to student development, similar to ACT Government (2019).

Looking toward the future, pre-university education in 2043 is expected to undergo significant transformations, with a shift toward technology-driven, personalized, and competency-based learning models. Educational managers perceive an increase in school autonomy, enabling institutions to tailor their curricula to better meet the needs of their students and communities. Additionally, the role of teachers is anticipated to evolve into that of mentors and facilitators, guiding students in a more interactive and flexible learning environment. Alongside these developments, the status and remuneration of teachers are also expected to improve, ensuring that the education system continues to attract highly qualified professionals who can prepare students for the demands of the future job market.

The study's findings provide valuable insights into shaping educational policies at the local and regional levels. By identifying both the strengths and challenges within the current system, this research serves as a foundation for developing strategies that support high schools as centers of excellence. Furthermore, the study contributes to the broader field of educational management, offering an in-depth understanding of the role of school leadership in driving institutional success. The results can inspire further research on best practices in educational leadership, innovative learning methodologies, and the integration of technology into teaching and learning.

CONCLUSIONS

In conclusion, this research highlights the crucial role of educational managers in shaping the future of high schools in Cluj-Napoca. Through strategic planning and a strong commitment to excellence, these leaders play a pivotal role in defining a clear vision and mission, fostering essential competencies for future generations, leveraging each school's unique strengths, and promoting active parental involvement. Their holistic and forward-thinking approach ensures that students receive a high-quality education that prepares them for both professional success and personal fulfillment. By continuously adapting to emerging educational trends and societal needs, these institutions can maintain their status as leading educational centers within the community.

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Correlations Between Body Composition Indicators and Performance in Sprint and Agility Tests Among Handball Referees

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ABSTRACT. Introduction: Refereeing plays a decisive role in the development of handball games, as referees enforce the rules of the game and facilitate the functioning of the other components, essential to success. To remain consistently prepared, referees must maintain optimal physical condition to support both essential and complementary motor abilities. **Objectives:** This study aimed to investigate the correlations and regression models between body composition variables and performance in sprint and agility tests among handball referees. **Methods:** A sample of 12 referees underwent anthropometric assessments using bioelectrical impedance analysis (Tanita MC-580) to explore the correlations between body composition and performance in sprint and agility tests. Statistical analyses included correlation and regression tests to identify significant predictors. **Results:** The findings indicate a positive correlation between sprint speed and agility, and a negative correlation between sprint speed and bone mass. **Conclusions:** Despite the limited sample size, the findings suggest that fat-free mass (FFM) and fat mass (FM) influence referees' physical performance. Further research on larger samples is recommended to validate these results.

Keywords: *handball, referee, anthropometry, speed, agility.*

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INTRODUCTION

Handball is a professional and Olympic sport played by two teams of seven players (six field players and one goalkeeper) on a 40 × 20 m court (García-Sánchez et al., 2023). The game engages both aerobic and anaerobic thresholds, and an athlete's height and body composition may influence referees' physical performance. Handball involves periods of intense physiological exertion as well as phases of low activity (Lijewski et al., 2021; Hermassi et al., 2021). It is a full-body sport that demands high levels of speed, muscular strength, and flexibility (Haksever et al., 2020; Rios et al., 2023).

Modern handball is continuously evolving through player interactions and environmental influences (Espoz-Lazo & Hinojosa-Torres, 2025). Consequently, contemporary handball performance depends on various factors such as reaction time, movement time, decision-making ability, and body composition (Śliż et al., 2025; Arnaoutis et al., 2024).

Handball referees, as well as those in other sports (Sant'Anna et al., 2021), have multiple responsibilities during a match, which are significantly easier to fulfill when they are physically fit and not hindered by physical limitations (Belcic et al., 2022). In addition to the athletic aspect, physical preparedness enhances a referee's authority—an essential component for officiating, maintaining match control, and making difficult decisions with greater confidence and assertiveness (Belcic et al., 2022; Webb et al., 2024). Referees carry the critical responsibility of enforcing the rules of the game (Mazaheri et al., 2016).

Body composition is an important factor among referees. The structure of body mass provides insight into the content of the various components that make up the human body (Aniśko et al., 2024). Although no significant correlations have been found between refereeing quality and body composition (BMI and body fat percentage) (Belcic et al., 2022), it remains highly relevant, as it can influence referees' physical performance (Bustos-Viviescas et al., 2020).

The World Health Organization (WHO) encourages the use of Body Mass Index (BMI), as it is a simple and easy-to-calculate indicator. BMI is the most commonly used method for detecting excess weight and severe overweight (Galeas et al., 2017).

Also known as the Quetelet Index, BMI represents the ratio of body weight to height squared. It is used to determine the degree of obesity and is considered a cost-effective and quick method of assessment (Díaz, 2015, pp. 16–17; Alvarez, 2023, p. 16; Guamialamá-Martínez et al., 2018). However, BMI may not be entirely accurate for athletes, as results can vary due to their greater muscle mass.

The optimal range for adults, regardless of gender, is between 18.5 (minimum value) and 24.9 kg/m^2 (maximum acceptable value) (Guamialamá-Martínez et al., 2018). To better clarify optimal values in this study, we also calculated BF (Body Fat Mass) and FFM (Fat-Free Mass) to enhance the interpretation of the results obtained.

FFM represents the estimated mass of all molecules in the body that are not fat. It includes all non-lipid components, such as phospholipids from cell membranes and nervous tissue (Heymsfield et al., 2024).

Excess adipose tissue inhibits muscle activation, thereby limiting performance on the field. A leaner body produces greater power and sustains physical activity more efficiently (Lijewski et al., 2019). Body fat percentage is a more suitable indicator for performance evaluation in handball, and its results may be considered more relevant than BMI values (Hermassi et al., 2021).

I consider the analysis of body composition in handball referees essential for assessing bioimpedance levels in comparison with international-level referees, and for classifying the performance level of our referees relative to elite referees from other countries. The Tanita MC-580 analyzer provides a detailed assessment of numerous parameters, including body weight, BMI, body fat mass (BF), body fat percentage (BF%), bone mass (BM), muscle quality, muscle score, visceral fat, total body water percentage, basal metabolic rate (BMR), daily caloric intake, metabolic age, physique rating, and bone mass. Additionally, it offers a segmental analysis of fat percentage and muscle mass for each arm, leg, and trunk.

The Tanita body fat analyzer is an innovative device for estimating body fat based on the principles of bioelectrical impedance. Unlike other impedance systems that use surface electrodes, this device requires subjects to stand barefoot on a metal platform containing integrated electrodes, allowing impedance to be measured through the feet and the lower torso (Jebb et al., 2007).

STUDY OBJECTIVE

The primary objective of this study was to analyze the relationships between body composition indicators and performance in sprint and agility tests among a sample of handball referees. Using correlation and multiple regression methods, the study aimed to identify significant predictors of physical performance in order to better understand the impact of body characteristics on the specific physical demands of handball refereeing.

MATERIALS AND METHODS

To assess body composition parameters, the study included 12 handball referees - 10 males and 2 females - with a mean age of 25.67 ± 8.16 years and an average refereeing experience of 5.75 ± 5.69 years.

On October 30, 2024, at the Tomeşti Sports Hall in Iaşi County, Romania, motor and anthropometric testing were conducted during the evening hours between 7:00 PM and 10:00 PM. The sports hall was heated to an optimal temperature, similar to match conditions. Referees were instructed to refrain from engaging in any physical activity for 24 hours prior to testing, and on the day of testing, they abstained from their typical daily activities (e.g., going to work). Approval for testing was obtained from the Romanian Handball Federation and the Iaşi County Handball Association. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. All participants provided informed consent prior to participation.

For the sprint tests, distances relevant to handball gameplay were used - 10 meters and 30 meters - while agility was assessed using the 505-agility test. Using the Tanita MC-580 device, we measured BMI, visceral fat percentage, muscle mass percentage relative to body weight, bone index, and fat-free mass. Motor testing was conducted with the aid of Witty SEM by Microgate. This device, paired with a "smart indicator," is recommended for the accuracy and reliability of the results it provides.

The measurement procedure with the Tanita analyzer involved positioning the subjects on the platform in a perfectly upright and still posture for approximately 45 seconds, during which the device scanned and recorded all body composition data. For motor performance testing, using the Microgate system, subjects were positioned behind a starting line, in front of two laser gates equipped with light and motion sensors, connected at a 5-meter distance. These sensors acted as timing gates at the start line, at 10-meters, and at 30-meters. The subjects started at their own discretion - without a pre-set signal - when they felt ready, and were instructed to sprint through the three gates at maximum speed. For the agility test, the laser gates were arranged differently. Subjects ran at a self-selected pace to the first gate, sprinted 5 meters, executed a quick turnaround, and sprinted back another 5 meters. The Microgate system recorded the elapsed time between the initial crossing and the return through the starting gate. Each subject was allowed two attempts, and the best recorded time was selected for analysis. Table 1 presents the participants' age, height, gender, and weight.

Table 1. Anthropometric data of the subjects

Age	Weight	Gender	Height
25.67 ± 8.16	87.83 kg ± 15.84 kg	The sample consisted of 12 participants: 10 males and 2 females.	178.42 cm ± 6.19 cm

Based on the Pearson correlation analysis, we identified several significant relationships between certain motor and anthropometric variables over the 10-meter distance. However, simple correlations do not allow for the simultaneous evaluation of the combined effect of multiple factors. Therefore, to determine which anthropometric variables have an independently significant influence on 10-meter sprint performance, we applied multiple linear regression analysis. This approach provides a more comprehensive understanding of the factors influencing motor performance.

The normality of data distribution was tested using the Shapiro - Wilk test. The results indicated that all variables followed a normal distribution ($p > 0.05$), allowing for the use of parametric tests in the statistical analysis. The level of statistical significance was set at $p < 0.05$.

RESULTS

Table 2 presents the results obtained in the speed tests, specifically the 10-meter and 30-meter sprints performed by the subjects. Only the best performance time for each referee was recorded and reported.

Table 2. Referees' Results in the 10 Meter and 30 Meter Sprint Tests

Speed 10 m	Speed 30 m
1.83 m/s ± 0.15 m/s	4.64 m/s ± 0.43 m/s

Table 3 shows the referees' results in the agility tests, specifically the 505 agility test. As with the sprint tests, each referee had two attempts, and the best time was recorded in the table.

Table 3. Referees' Results in the Agility Test – 505 Agility Test

Agility 505 – Test
Subjects = 2.55 s ± 0.17 s

Table 4 presents the values for Body Mass Index (BMI), the percentage of muscle mass relative to body weight, and the percentage of fat-free mass.

Table 4. Results for BMI, FFM, and MM

BMI (Body Mass Index)	**FFM (Fat-Free Mass)**	**MM (Muscle Mass)**
27.53 kg/m^2 ± 4.64 kg/m^2	65.6 kg ± 10.12 kg	62.34 kg ± 9.65 kg

Table 5 presents the subjects' results for visceral fat levels and bone mass index.

Table 5. Results for Visceral Fat Level and Bone Mass Index

Visceral Fat (level)	**Bone Mass**
6.83 ± 3.90	3.26 kg ± 0.48 kg

Table 6 presents the final measurements recorded for our subjects: fat mass and skeletal muscle mass.

Table 6. Referees' Results for Fat Mass (FM) and Skeletal Muscle Mass (SMM)

FM (Fat Mass)	**SMM (Skeletal Muscle Mass)**
22.25 kg ± 6.75 kg = 25.01% ± 3.63%	37.87 kg ± 7.31 kg = 44.32% ± 5.18%

The 10-meter sprint test was significantly and positively correlated with the 505 agility test ($r = 0.683$, $p = 0.014$), indicating that participants with higher sprint speed tended to demonstrate better agility performance.

Additionally, a significant negative correlation was observed between bone mass (BM) and the 10-meter sprint test, indicating that lower bone mass may be associated with greater speed over short distances. Although variables such as skeletal muscle mass and fat-free mass showed negative correlation trends with the motor tests, these values did not reach statistical significance. Table 7 presents the significant correlations observed in our study.

Table 7. Significant correlations between speed, agility and bone mass

Correlated variables	Correlation coefficient (r)	Statistical significance (p)	Correlation type
Speed 10 m - Agility test 505	0.683	0,014	Significantly positive
Speed 10 m - Bone mass	-0,578	0,049	Significantly negative

Linear Regression Results for the 10-Meter Sprint Test

Fat-Free Mass (FFM) and Fat Mass (FM)

Multiple linear regression analysis demonstrated that both fat-free mass (FFM) and fat mass (FM) are significant predictors of 10-meter sprint performance. The negative coefficient for FFM clearly indicates that an increase in fat-free mass is associated with a reduction in 10-meter sprint time, meaning it enhances maximum speed. Conversely, fat mass was shown to be positively associated with sprint time, suggesting that higher fat mass contributes to slower sprint performance over this distance.

Table 8. Linear Regression Analysis of FFM, FM, and BM on 10-Meter Sprint Performance

Predictor	Unstandardized Coefficient (B)	Standard Error (SE)	Standardized Coefficient (Beta)	t	p	VIF
Constant	2.392	0.224	-	10.695	<0.001	-
FFM	-0.018	0.006	-1.215	-3.184	0.011	2.795
FM	0.028	0.011	0.922	2.416	0.039	2.795

$R^2 = 0.531$, $F(2,9) = 5.094$, $p = 0.033$

Height, Weight, and BMI

Regarding the participants' weight, height, and BMI, the analysis revealed a positive and significant effect of weight on sprint performance (coefficient B = 0.264, p = 0.011), indicating that greater body weight was associated with higher sprint speed. In contrast, both height and BMI showed a negative effect on sprint performance (B = -0.249, p = 0.010 and B = -0.825, p = 0.010, respectively), suggesting that taller stature or a higher BMI were associated with slower sprint speeds over the 10-meter distance.

MM and SMM

According to the results, neither muscle mass (MM) nor skeletal muscle mass (SMM) had a significant effect on sprint speed, as indicated by p-values greater than 0.05. Additionally, the collinearity indicators (VIF) were below the critical threshold, indicating no major multicollinearity issues among the explanatory variables.

BM

Visceral fat was analyzed separately from the other body composition variables, as it was measured in discrete levels rather than percentages or kilograms, making it incompatible for direct inclusion in regression models alongside continuous variables.

Bone mass was also treated independently, since it showed a significant and strong correlation with 10-meter sprint speed in the Pearson correlation analysis, thereby justifying the investigation of its standalone effect on sprint performance.

Bone mass appears to be an important factor in 10-meter sprint performance. As bone mass increases, the time required to complete the sprint tends to increase (see Table 9).

Table 9. Linear Regression of Bone Mass (BM) on 10 Meter Sprint Performance

Predictor	Unstandardized Coefficient (B)	Standard Error (SE)	Standardized Coefficient (Beta)	t	p	VIF
Constant	2.418	0.264	-	9.162	<0.001	-
BM	-0.179	0.080	-0.578	2.237	0.049	1.000

R^2 = 0.334, F (1,10) = 5.006, p = 0.049

Visceral Fat

The results from the multiple regression analysis suggest that visceral fat is not a major predictor of 10-meter sprint performance. Other variables appear to play a more significant role in determining sprint ability. While visceral fat is often linked to metabolic risk factors, it does not seem to have a relevant impact on short-distance sprint performance.

Linear Regression Results for the 30-Meter Sprint Test

FFM and FM

The results indicate the very weak influence of both fat-free mass (FFM) and fat mass (FM) on 30-meter sprint performance. Although FFM showed a near-significant coefficient ($p = 0.054$), suggesting that greater fat-free mass tends to reduce sprint time, the results are not sufficiently strong to be considered statistically relevant.

Height, Weight, and BMI

Regarding the 30-meter sprint performance, relevant findings were identified. Height showed a negative influence within our sample, indicating that taller participants performed worse in the 30-meter sprint test ($B = -0.952$, $p = 0.006$). Similarly to the 10-meter sprint, a higher BMI was also associated with poorer performance. A surprising result in our study was that referees with greater body weight achieved better sprint outcomes. This may be explained by their higher proportion of muscle mass ($B = 1.011$, $p = 0.006$).

MM and SMM

As with the 10-meter sprint, the multiple regression model for 30-meter sprint speed showed that both muscle mass (MM) and skeletal muscle mass (SMM) were not significant predictors. In their measured form, neither variable directly influenced sprint capacity in this sample.

BM

The negative coefficient for bone mass ($B = – 0.431$) suggests that higher bone mass is associated with lower sprint times over 30 meters (i.e., greater speed). However, this effect was not statistically significant ($p = 0.196$).

Visceral Fat

The coefficient for visceral fat was also negative (B = –0.010), indicating a very weak and non-significant relationship between visceral fat levels and 30-meter sprint performance.

Linear Regression Results for the Agility Test – 505-Agility Test

FFM and FM

Table 10 provides a significant representation of the predictors FFM and FM. Our model shows that approximately 43.7% of the variation in agility test performance is explained by these variables, indicating a moderate to strong relationship between body composition and agility test scores.

Table 10. Linear Regression of FMM and FM on 505-Agility test

Variable	Coefficient B	Standard Error	Standardized Beta	t	p
(Const.)	2,988	0,288	—	10,382	0,000
FFM	–0,019	0,007	–1,079	–2,581	0,030
FM	0,036	0,015	1,007	2,407	0,039

Participants with greater muscle mass tended to achieve better (lower) times, indicating superior agility. Fat mass (FM) had a positive and statistically significant influence on performance time (p = 0.039), suggesting that a higher proportion of body fat is associated with poorer agility performance.

Height, Weight, and BMI

None of the predictors showed a statistically significant contribution. The negative coefficient for BMI suggests a trend indicating that performance may be poorer with higher BMI; however, this result is not statistically meaningful in this sample.

MM and SMM

In this sample and under these conditions, muscle mass (MM) and skeletal muscle mass (SMM) do not appear to be relevant predictors of performance in the 505-agility test. The results indicate no significant findings.

BM

According to the data obtained, bone mass does not significantly influence performance in the agility test.

Visceral Fat

Visceral fat does not have a significant effect on performance in the 505-agility test ($R = 0.09$, $p = 0.78$), explaining only 0.8% of the variance. The regression coefficient is non-significant (–0.004), indicating no meaningful relationship between the two variables.

DISCUSSION

Although our methodology included correlation and regression analyses, the results will be discussed in relation to the existing body of literature, which generally explores the relationship between body composition and physical performance.

Our findings show that the regression analyses identified weight, height, and BMI as the most significant predictors of 30-meter sprint performance, explaining 66.7% of the variation in results. The positive coefficient for weight indicates that, within this sample, heavier participants achieved better sprint times—possibly due to greater muscle mass.

FFM and FM showed moderate influence on agility test performance and the 10-meter sprint. Although recent studies suggest that handball referees do not spend much time in the anaerobic zone, it is important to note that the most critical decisions are often made at that level of exertion (Belcic, 2022; Babity, 2022). Hermassi (2021) emphasizes that body fat percentage is a more accurate metric for assessing handball performance than BMI. He analyzes the impact of body fat on agility testing and concludes that higher fat mass increases the predictive power of regression models in athletes.

Our results indicate that higher muscle mass contributes positively to improved sprint and agility times, while fat mass has a detrimental effect. In the 10-meter test, bone mass (BM) was negatively correlated with performance: the lower the bone mass in kilograms, the better the sprint performance. This suggests that less skeletal mass may reduce inertia during acceleration and improve short-distance speed.

The sprint performance findings in our sample are consistent with those reported in recent studies. Šegota (2024) analyzed 32 referees from Croatia and reported average sprint speeds at various distances. The average time for international referees was 1.80 ± 0.12 seconds, and for national referees, 1.94 ±

0.15 seconds. These are comparable to our findings, with our sample showing an average of 1.83 ± 0.15 seconds.

The referees' average body weight (87.83 kg ± 16.49 kg) was consistent with findings in other studies. FFM (20.45 ± 2.84 kg/m^2) and body fat (22.25 kg ± 7.05 kg) were also similar to values reported by other researchers (Babity, 2022; Belcic, 2022; Fernandes da Silva, 2010; Martínez-Rodríguez, 2024).

A significant correlation was observed between the 10-meter sprint and the 505 agility test, indicating a strong link between the two motor qualities. Referees who performed well in the sprint also achieved better agility scores. Additionally, a significant negative correlation was found between 10-meter sprint speed and bone mass, suggesting that higher bone mass may increase inertia and negatively affect short-distance acceleration.

One of the main limitations of this study is the small sample size, which may affect the statistical power and generalizability of the findings. To confirm and expand upon these results, further research is needed with a larger and more diverse sample. Nevertheless, this topic remains important and relevant for future research, given its potential contribution to understanding the relationship between body composition and physical performance in handball referees.

CONCLUSIONS

The results of this study highlighted the influence of body composition on motor performance in both agility and sprint tests over various distances. The most important predictors were fat-free mass (FFM) and fat mass (FM), both of which influenced motor performance variables.

A significant negative correlation was also observed between 10-meter sprint speed and bone mass (BM), suggesting that lower bone mass may positively affect sprint capacity. These findings suggest that higher levels of muscle mass may enhance sprint performance in handball referees, as referees with greater muscle mass tended to achieve better sprint performance, likely due to increased muscle development.

While the small sample size limits the generalizability of the results, the study provides a strong rationale for further research with a larger and more diverse sample. As the first study of its kind in Romania, it underscores the need to explore the role of referees in greater detail, given their potential impact on performance and decision-making in high-intensity moments of handball matches.

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Artificial Intelligence in Tennis. A Social Perspective

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ABSTRACT. Introduction: Artificial Intelligence (AI) is increasingly influencing professional sports, including tennis, by supporting technical analysis, training optimization, and decision-making processes. Understanding how different groups perceive AI in the sports context is essential for its effective integration. **Objective:** The study aims to explore and compare the social representations of artificial intelligence in tennis among athletes and non-athletes. **Methods:** The research employed the word association technique (Vergès, 2001) and the social representation indicator (Havârneanu, 2001). The sample included 60 participants, divided equally into two groups: 30 athletes and 30 non-athletes. The analysis focused on the frequency and order of appearance of words associated with AI in a sports context. **Results:** Distinct differences emerged between the two groups. Athletes primarily associated AI with advanced technology that enhances performance and efficiency, while aspects such as injury prevention or ethical concerns were less prominent. Non-athletes emphasized "equipment and infrastructure," reflecting a more concrete and device-oriented perception of AI in sports. **Conclusions:** The study highlights divergent perceptions of AI between athletes and non-athletes, which may influence how AI-based technologies are accepted and implemented in tennis. Understanding these differences is crucial for tailoring AI applications to meet the expectations and needs of various stakeholders in sports.

Keywords: *artificial intelligence, tennis, social representation.*

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INTRODUCTION

Artificial intelligence (AI)

Artificial Intelligence is an advanced domain within computer science dedicated to the development of systems capable of replicating cognitive processes specific to human intelligence, such as learning, reasoning, perception, planning, and decision-making. These systems rely on sophisticated algorithms and computational models that enable machines to analyze large volumes of data, identify patterns, make predictions, and act autonomously or semi-autonomously.

According to Morandín-Ahuerma (2022), artificial intelligence is defined as "the ability of a machine or computer system to simulate and perform tasks that would normally require human intelligence, such as logical reasoning, learning, and problem-solving."

Additionally, as noted by Apoorva et al. (2018), artificial intelligence is a field within computer science focused on developing computational models designed to solve problems of complexity comparable to those addressed by human intelligence, including processes such as reasoning, planning, and perception.

Artificial intelligence in sport

In the realm of sports, artificial intelligence has become a cornerstone tool with a significant impact on transforming training, competition, and decision-making processes. AI applications are diverse and encompass performance analysis, technique and tactic evaluation, game strategy optimization, injury prevention, physiological monitoring, and even the automation of officiating decisions.

According to a bibliometric analysis by Sampaio et al. (2024), the use of artificial intelligence in tennis is continually expanding, covering areas such as biomechanical movement analysis, match outcome prediction, assessment of technical-tactical performance, physiological parameter monitoring and also the analysis of competitive economics.

Types of devices used in tennis

Artificial intelligence has brought significant innovations to professional tennis through the integration of devices that optimize training, assessment, and game strategy.

Among the most widely used technologies are video systems with automated feedback, which analyze technical executions in real time and accelerate learning (Lin et al., 2020), as well as smart rackets such as the Babolat Pure Drive,

which enhance shot accuracy and efficiency by integrating sensors and advanced materials (Ozdemir, 2019). Additionally, posture estimation technology and wearable devices allow for the monitoring of biomechanics and physical condition, contributing to personalized training and injury prevention (Chatterjee et al., 2021; Wang et al., 2024).

Another area includes smart ball launchers and tactical-technical analysis platforms that provide automated training and decision-making support for coaches by adjusting drills and analyzing match data (Abid et al., 2023; Yin, 2021). Furthermore, wearable devices track physiological parameters and support injury prevention by enabling training intensity adjustments (Wang et al., 2024).

Overall, these technologies demonstrate a transformative potential for athletic practice, supported by empirical research. However, their implementation requires a balanced approach that considers technical limitations and ethical implications.

The value of artificial intelligence in tennis

Artificial intelligence has a significant impact on professional tennis, particularly by enhancing technical and tactical analysis.

An important contribution in this area comes from Chatterjee et al. (2021), who demonstrated the effectiveness of posture estimation technology through computer vision. This allows for the automatic identification of players' body positions and the classification of strokes, thereby helping to detect biomechanical imbalances and enabling timely, precise corrections.

However, these advantages come with certain limitations. Excessive reliance on technology may reduce the athlete's ability to self-correct and develop intuitive skills, while high costs can restrict access to such tools (Wang et al., 2024; Abid et al., 2023). Additionally, the accuracy of visual recognition algorithms depends on external conditions such as lighting or game speed (Wu et al., 2023), and the integration of these technologies into the sports education process requires a clearly defined methodological framework (Lin et al., 2020).

Artificial intelligence offers considerable benefits in improving training efficiency and refining sport-specific technique in tennis, but it also involves risks that call for a critical and balanced approach. The effectiveness of these systems depends on their contextualized integration, economic accessibility, and the capacity of coaches and athletes to use them reflectively and adaptively.

The associative technique in the current context

Using the associative technique from social psychology, this section explores how artificial intelligence shapes perceptions of technique in tennis.

The associative technique involves forming stable mental connections between stimuli and responses. In sports, this process is manifested through repeated pairings between a specific technical execution and the feedback received. Artificial intelligence-based devices amplify this association by providing immediate, accurate, and personalized feedback. Associativity thus functions as a cross-cutting principle that helps explain the effectiveness of AI-based interventions in tennis.

Smart devices not only record and analyze data but also facilitate the development of cognitive networks that link action, feedback, and adjustment (key components in motor learning and technical refinement). In this regard, artificial intelligence becomes a catalyst for associative learning, transforming each execution into an opportunity for cognitive and motor reinforcement.

HYPOTHESIS

Research question

In the context of the accelerated digitalization of sports, analyzing perceptions of artificial intelligence in tennis has become a timely and relevant topic with both theoretical and practical implications. As AI is increasingly used in training, evaluation, and technical optimization, it becomes essential to understand how different user groups, namely athletes and non-athletes, perceive these technologies. This understanding can support the development of effective implementation strategies that are tailored to users' real needs.

Accordingly, the *research question centers on identifying the social representations held by athletes and non-athletes regarding the use of artificial intelligence in tennis, and potentially, the differences in their cognitive association patterns between the two groups*.

It is hypothesized that athletes and non-athletes differ significantly in their social representations and perceptions of artificial intelligence in tennis, both in terms of the content of their cognitive associations and the depth of their engagement with the technology.

MATERIALS AND METHODS

Methodology

To explore perceptions of artificial intelligence in tennis from a social perspective, a qualitative research design with an exploratory component was used. The study included a total of 60 participants, selected based on variability in sports experience, ranging from 0 to 18 years.

The group of active athletes consisted of 30 participants aged between 16 and 25 years, including 17 male and 13 female athletes. The group of non-athletes was composed of 30 participants aged between 18 and 30 years, evenly split between 15 male and 15 female individuals. This diversity in participant profiles was considered essential to capture potential differences in perception and symbolic associations between the two categories.

The study variables included independent variables: namely, the status of being an athlete or non-athlete; and the dependent variable, which was the social representation of artificial intelligence in tennis.

Instrument

The research employed a questionnaire based on the word association technique (Vergès, 2001) and an alternative method for determining the structure and organization of the elements within a social representation, as proposed by Professor C. Havârneanu (2001). The first technique relied on the frequency of mentions and the average order of appearance, while the second technique used the frequency of occurrence and the average importance rankings. The formula used for the latter is:

Social Representation Indicator (SR) =
frequency of mentions × mean rank scores

The use of the Social Representation Indicator (SR) has proven essential in revealing not only the salience but also the structural positioning of elements within participants' cognitive frameworks regarding artificial intelligence in tennis, in this case. By combining frequency of mentions with perceived importance, the SR index allows for a more nuanced understanding of how deeply rooted certain concepts are within the shared social knowledge of both athletes and non-athletes. This indicator does more than highlight popular associations. It identifies the core components of the social representation, distinguishing central, stable beliefs from more peripheral, flexible ones. Such insight is important when aiming to design targeted communication strategies or technology implementation policies that resonate with users' actual cognitive structures.

The data collection process involved the physical distribution of the questionnaire to each participant, who completed it individually in the presence of the researcher. This ensured clarity of the instructions and adherence to standardization conditions. Upon completion, the questionnaires were collected to ensure the integrity of the data.

Questionnaire 1. ***Questions related to identifying the social representation of artificial intelligence in tennis***

I. What comes to mind when you think of artificial intelligence in tennis? Please list 5 representative words or ideas.
II. Rank these words or ideas in order of importance (from 1 = most important to 5 = least important).

Procedure

The data analysis was carried out in two stages. In the first phase, the responses were thematically coded by identifying semantic recurrences, symbolic variations, and metaphorical uses. Subsequently, the frequencies and rankings of each word/association were extracted, forming the basis for constructing the structural framework proposed by Vergès (2001), including the delineation of the central core and peripheral zones.

RESULTS

Associative Technique

Following the application of the word association technique, content analysis enabled the identification of 96 distinct terms, grouped together with their semantic synonyms and equivalent expressions. These terms were then categorized into thematic groups based on the similarity of their meanings and usage context. The classification process was conducted separately for the two participant groups: athletes (see Appendix 1); and non-athletes (see Appendix 2). The following thematic categories emerged for each of these groups:

Table 1. Categories, Frequencies, and Mean Ranks (Mean Rank of Appearance and Mean Rank of Importance), Social Representation Indicator – Specific to Athletes
Athletes – N = 30

No.	Category	Frequency	Rank of appearance	Rank of importance	Social representation indicator (RS)
1	Advanced technology	56	2.5	2.625	143.5
2	Training	18	3.66	3.61	65.43
3	Social and ethical aspects	14	3.78	3.51	51.03
4	Tactics	15	3.2	3.4	49.5
5	Injury prevention and physical monitoring	15	3.6	3	49.5
6	Video analysis	12	2.41	2.91	31.92
7	Officiating	7	3	3.28	21.98
8	Equipment and infrastructure	6	2.66	3.33	17.97
9	Feed-back	7	1.85	1.71	12.46

Table 2. Categories, Frequencies, and Mean Ranks (Mean Rank of Appearance and Mean Rank of Importance), Social Representation Indicator – Specific to Non-Athletes Non-Athletes – N = 30

No.	Category	Frequency	Rank of appearance	Rank of importance	Social representation indicator (RS)
1	Training	35	3.25	2.48	100.3
2	Advanced technology	17	3.52	3.7	61.3
3	Officiating	15	3.33	3.66	52.4
4	Tactics	20	2.6	2.5	51
5	Video analysis	18	2.66	2.94	50.4
6	Equipment and infrastructure	17	2.47	2.7	43.9
7	Social and ethical aspects	13	2.61	3.15	37.4
8	Injury prevention and physical monitoring	9	3.55	2.66	27.9
9	Feed-back	6	2.66	3.33	17.9

The application of the technique developed by P. Vergès (2001) allowed for the identification of both the central core and the peripheral system of the social representation of artificial intelligence in the context of tennis, differentiated for the two categories of independent variables: athletes and non-athletes.

The analysis was based on two main indicators: the frequency with which an element was mentioned and its rank of appearance within the individual lists. In constructing the analytical quadrant, frequency was represented on the vertical axis, while order of appearance was plotted on the horizontal axis. A convenient threshold was established to distinguish elements with both high frequency and low rank of appearance (indicating high cognitive salience) from other categories of terms.

Thus, the upper left quadrant was interpreted as representing the central core of the social representation (the most stable and widely shared elements), while the lower right quadrant included peripheral elements, characterized by low frequency and high order of appearance, and therefore reflecting more contextual or individualized components of the representation.

Data analysis reveals clear differences between athletes and non-athletes in how artificial intelligence is socially represented in the context of tennis. These differences suggest that AI is understood and valued differently depending on one's direct experience with sport and their orientation toward technological phenomena.

In the case of athletes (Table 3), the central core of the representation is occupied by the category "Advanced Technology," which has a significant frequency (56) and a low mean rank of appearance (2.5). This reflects a dominant

perception that AI is primarily a performance tool, associated with efficiency, innovation, and precision in athletic practice. This category is situated in a strong consensus zone, being considered essential for the advancement of professional sports.

Table 3. Tabular Matrix for Athletes

		Rank of appearance	
		≤2,5	**>2,5**
Frequency	≥28	Advanced technology (56)	Training (18)
	<28	Video analysis (12)	Social and ethical aspects (14)
		Feedback (7)	Tactics (15)
			Injury prevention and physical monitoring (15)
			Officiating (7)
			Equipment and infrastructure (6)

At the opposite end, in the peripheral quadrant, we find categories such as "Training," "Tactics," "Social and Ethical Aspects," "Injury Prevention and Physical Monitoring," "Equipment and Infrastructure," and "Officiating." Although these elements appear in athletes' discourse, they do so with lower frequency and in less prominent positions, suggesting a secondary role in the structure of the representation. These elements seem to be perceived more as complementary or contextual functions, rather than defining characteristics of AI in tennis.

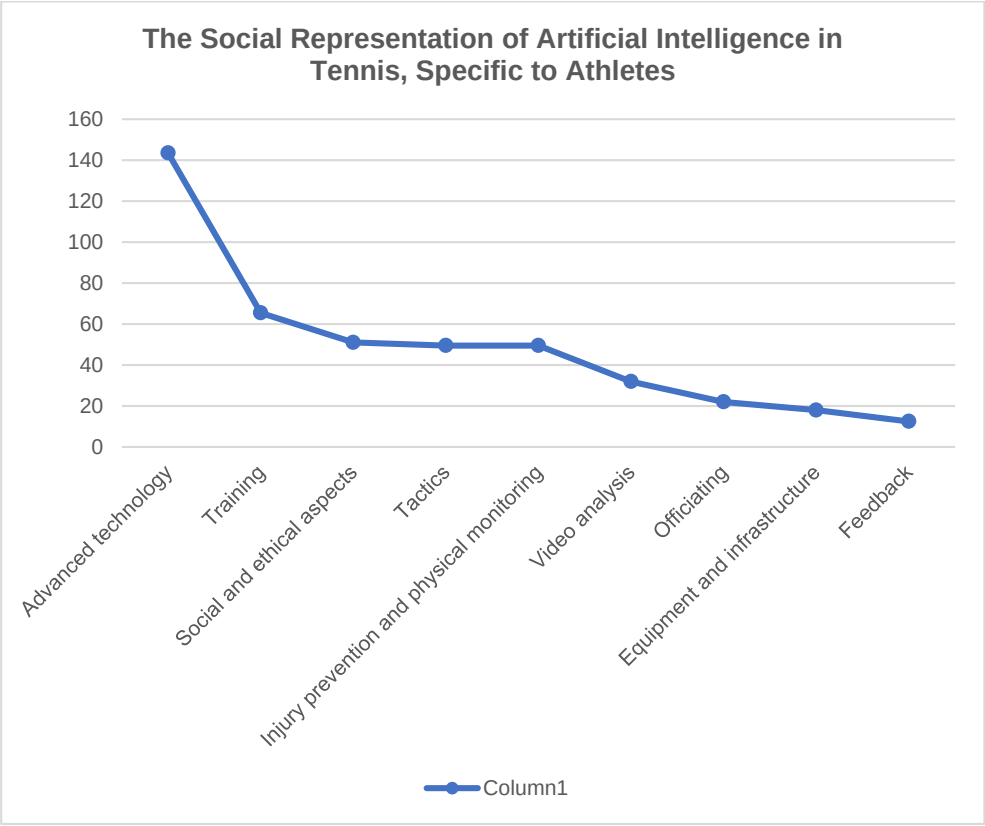
For non-athletes (Table 4), the configuration of AI's social representation is distinct, with a central core dominated by the category "Equipment and Infrastructure." This is the only category that meets both a high frequency (17) and a low mean rank of appearance (2.47). The result suggests that, for non-athletes, artificial intelligence is primarily perceived as an extension of tangible technology (e.g., sporting infrastructure, smart equipment, and logistical support).

Table 4. Tabular Matrix for Non-Athletes

		Rank of appearance	
		≤2,5	**>2,5**
Frequency	≥17	Equipment and infrastructure (17)	Training (35)
			Advanced technology (17)
			Tactics (20)
			Video analysis (18)
	<17		Officiating (15)
			Social and ethical aspects (13)
			Injury prevention and physical monitoring (9)
			Feedback (6)

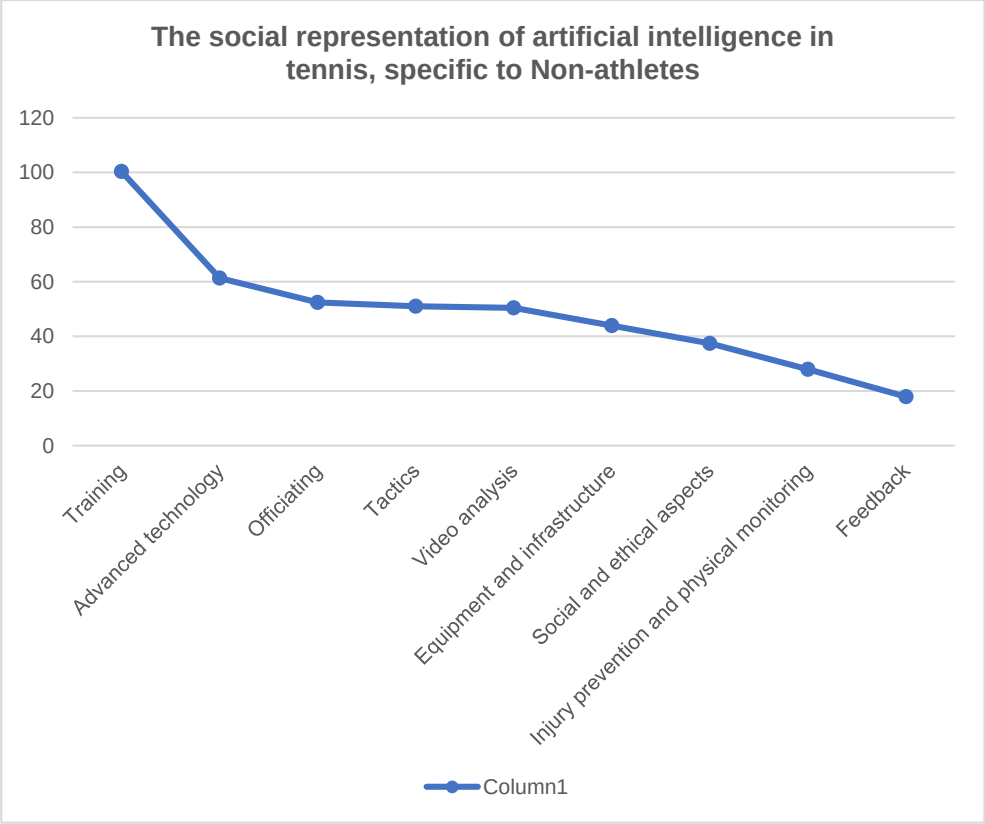
Other categories such as "Training," "Advanced Technology," "Tactics," and "Video Analysis," while frequently cited, appear with higher cognitive positioning ranks and are thus included in the peripheral system. These indicate sustained interest in the functionalities of AI in sport, though not yet integrated into a collective consensus. Their perception remains relevant but more individualized and situational.

In the lower peripheral zone, categories such as "Feedback," "Injury Prevention," and "Social and Ethical Aspects" are found, which appear rarely and in delayed positions. This positioning indicates that non-athletes do not associate these elements with a central role in AI-assisted sports practice but rather perceive them as less relevant or visible within their experience.



The Social Representation Indicator Technique (Havârneanu, 2001)

Figure 1. The social representation of artificial intelligence in tennis - Athletes



The Social Representation Indicator Technique (Havârneanu, 2001)

Figure 2. The social representation of artificial intelligence in tennis – Non-athletes

Therefore, the social representation of artificial intelligence in tennis among non-athlete's centers on technical and infrastructural dimensions, suggesting a more external and mechanical perception of the technology. Compared to athletes, who perceive AI in terms of performance and practical efficiency, non-athletes construct a more concrete and object-focused representation, anchored in what can be directly seen and used.

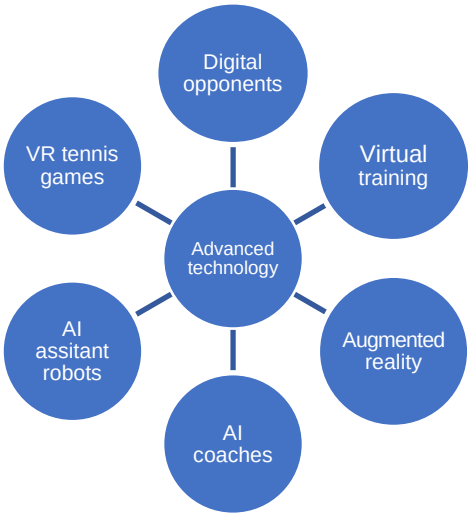


Figure 3. The social representation of artificial intelligence in tennis - Athletes

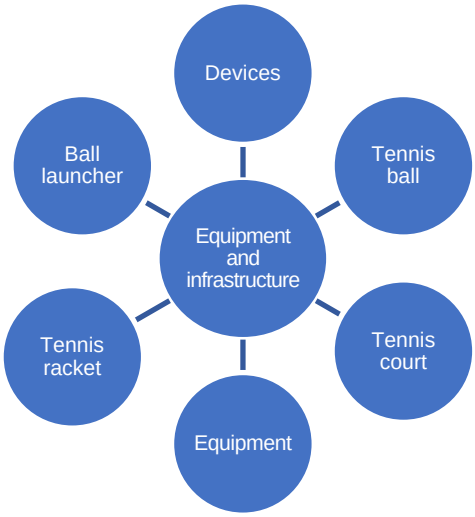


Figure 4. The social representation of artificial intelligence in tennis – Non-athletes

DISCUSSION

The results reveal substantial differences in the social representation of artificial intelligence in tennis between athletes and non-athletes. These differences are nuanced and reflect the distinct experiential positioning of each group toward technological phenomena.

For athletes, AI is primarily associated with "advanced technology," indicating a representation focused on functionality, efficiency, and performance optimization. This aligns with the academic literature, which emphasizes AI's role in personalized training, real-time biomechanical feedback, and automated movement analysis (Ma, 2020). Furthermore, the integration of AI into sports equipment such as smart rackets or ball-tracking cameras is perceived as a natural extension of professional training (Ozdemir, 2019).

Athletes appear to assign a secondary role to categories like "ethical aspects," "feedback," or "injury prevention." While these dimensions are present in their discourse, they are not central. This outcome can be interpreted in light of Moscovici's theory of social representations, which posits that direct experience influences the cognitive salience of elements. Thus, what is directly useful in enhancing performance gains greater prominence in their representation.

In the case of non-athletes, the core of the representation is occupied by the category "equipment and infrastructure," suggesting a concrete and visual understanding of AI as a collection of tangible technologies (courts, rackets, balls, sensors, automated interfaces). Although terms like "training" or "advanced technology" are frequently mentioned, their higher rank of appearance indicates lower cognitive salience.

This perception is consistent with research showing that individuals without direct experience in sport relate to AI in terms of general technological potential rather than specific functionality (Lv et al., 2021). Moreover, the concerns of non-athletes regarding elements such as "feedback," "injury prevention," or "ethics" remain peripheral, indicating a more fragmented and less integrated representation.

CONCLUSIONS

The study revealed significant differences in the social representation of artificial intelligence in tennis between athletes and non-athletes. For athletes, AI is predominantly perceived as a technological tool for optimizing performance, whereas non-athletes primarily associate it with equipment and infrastructure. These findings confirm the influence of direct experience on the structure of social representations and highlight the need to tailor the implementation of AI technologies according to the profile of their users.

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Annex 1
Mentions by Athletes

No.	Category	Mentions
1	Advanced technology	Advanced technology, correction algorithms, AI coach, opponent simulation, technology, technological progress, computer vision, 3D visualization, augmented coaching, augmented reality, AI assistant robots, training with cutting-edge machines
2	Training	Training personalization, execution consistency, technical rigor, personalized training
3	Social and ethical aspects	Impact on employment, enhancing fan experience, reduction of human effort, trust, time-saving
4	Tactics	Tactical optimization, tactical prediction, game forecasts, personalized tactics, gameplay strategies, score prediction, tactics
5	Injury prevention and physical monitoring	Posture correction, physiological parameter control, physical wear reduction, injury protection, correlation of physiological indicators
6	Video analysis	Video analysis, stroke analysis, service analysis, video cameras for motion capture, shot timing via video cameras
7	Officiating	Automated decisions, automatic umpiring, error detection/automatic officiating
8	Equipment and infrastructure	Smart racket, equipment development, equipment optimization, equipment management
9	Feedback	Instant feedback, immediate correction, precise feedback, voice feedback

Annex 2
Mentions by Non-Athletes

No.	Category	Mentions
1	Training	Helps with training, personalized training, practice, speed, better speed and reactions, performance improvement
2	Advanced technology	Simulates a playing partner, tennis games on PC/mobile, smart ball, smart racket, sensor-equipped court
3	Officiating	Umpire assistance, referee decision-making, error correction by referees, automated umpiring decisions, officiating
4	Tactics	Teaches new tactics, strategy, prediction, game tactics, tactical foresight, strategies, tactical analysis
5	Video analysis	Video analysis, ball tracking, stroke analysis, video assistance, video recognition
6	Equipment and infrastructure	Ball launcher, stopwatch, rackets, court, ball, equipment, equipment management
7	Social and ethical aspects	Inspiration, motivation, confidence building, game improvement, reassurance
8	Injury prevention and physical monitoring	Injury prevention, real-time biometric monitoring, nutrition
9	Feedback	Precision, accuracy

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Considerations Regarding the Parents' opinions About the Physical Education Lesson in the Secondary Schools of Reșița

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ABSTRACT. Parents' attitudes towards physical education lessons can have a significant impact on children and their participation in physical education lessons. If parents show disinterest or have a negative attitude towards the lesson and the physical education teacher, children may receive a signal that this activity is not important, causing them to be reluctant to engage in physical education lessons, to avoid these activities, to engage in sedentary activities, which can contribute to increasing the risk of obesity and other conditions. The purpose of our research is to find out the opinions of the parents of secondary school students regarding the lesson of physical education and sports. We used the questionnaire-based survey method and the graphic method. Questionnaires were applied to the parents of students from educational institutions in the municipality of Reșita. The answers showed that parents are aware of the importance of physical education and sports classes alongside other school subjects, sports making children happier, more motivated in terms of choosing a sport to practice in their free time.

Keywords*: physical education, sport, lesson, attitude, motivation.*

INTRODUCTION

Social contemporary phenomenon, with its roots in the Ancient Greece, sport represents a source of well-being and social connections, an educational and self-improvement instrument, the physical activity having multiple benefits on the human body, regardless of age.

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If we talk about children, it must be said that parents are responsible for their formation, because they are their life models (Raudsepp, 2006) on all levels. Parents have a significant influence concerning the physical activity of their children (Hein, 2015), they are considered important responsible people for its promotion (Erkelenz et al., 2014) and for the behaviour which aims the physical activity of their children (Jago et al., 2009; Kettner et al., 2012). The research indicates the fact that parents who were physically active in the past and who are still active have assessed more the importance of physical activity than the inactive parents and these assessments did not take into account the parents' education or their studies Cercet (Hein, 2015).

Besides this, the physical education teachers have a significant influence in promoting the physical activities by physical education lessons done according to the present curricular documents in force. By their roles: didactic, motivational, assessment, cognitive diagnosis, regulator of social relations in the classroom as a group and the role of partner in the affective interaction (Jeremić et al., 2018), the physical education teacher also contributes to the qualitative involvement of students in the physical education classes (Cox & Williams, 2008).

The subject *Physical education and sport* is stipulated in the education curriculum with a budget of two hours per week, during every school year in the Romanian secondary school education. Generally, the physical education lessons in Romania follow similar principles and objectives to the educational systems from other countries. These include the development of motor skills, promoting an active and healthy lifestyle, learning and application of specific rules and techniques specific for sports and the promotion of cooperation and team spirit (Almond et al., 2019), by warm up and stretching exercises, athletics, gymnastics, ball games, individual and team sports, dancing or other recreative activities. The curriculum of physical education can vary according to the country and education level. Sometimes, there is special attention given to certain sports or activities and sometimes they follow the promotion of a large range of physical activities (Hardman & Marshall, 2017).

The structure and content of the lessons can vary according to the education level, school program and the preferences of the physical education teachers (McKenzie & Kahan, 2017). In the education system, the physical education plays an important role in the students' physical, mental and social development being considered an important part of the school program and it is a compulsory subject in most of the countries (National Association for Sport and Physical Education, 2015). The purposes of physical education in the educational system are manifold. Among them we can count the development of the motor skills and aptitudes, the improvement of the general physical condition, the promotion of an active and healthy lifestyle, as well as the development of the cognitive, emotional and social capacities (World Health

Organization, 2018), the development of some physical capacities, of physical aptitudes and motor skills by physical and sport activities (Standage et al., 2012). The physical education class offers the students the opportunity to be engaged in varied physical activities by means of which the students learn to work in a team, to develop the communication skills and to improve the self-esteem (McKenzie & Kahan, 2017).

The physical education plays an important part in the human development and is beneficial for the physical and mental health, for a better social, emotional, spiritual and academic life. With physical activity, children can improve their physical capacity, body posture and eventually they can increase their self-esteem. If they are helped, the students can develop good habits from an early age. Running, jogging, weight training, food and sleep are only a few skills that can help them in the future (Pop, 2021).

MATERIALS AND METHODS

Procedure

This research used a descriptive, cross-sectional and observational design. Having in view the achievement of this research objectives, we have used quantitative and qualitative methods. The qualitative data facilitated the explanations which were stated based on the initial quantitative results (Creswell & Plano Clark, 2018). As quantitative methods we have used the inquiry based questionnaire, in order to find the parents' perception of the secondary school students in Reșița, and the graphical method in order to represent the answers received. In order to find the answers to the research question: „What is the parents' perception of the students in the secondary school referring to the physical education and sport lesson?" we have done, on the Google forms platform, a questionnaire with eight questions. At the end of the questionnaire, respondents' consent to have their answers processed is stated, mentioning that the research is anonymous, all the information are confidential and the communication of the results obtained is done by statistical processing and examples which do not allow the identification of the people whom we solicited the information from. The questionnaire was built around three themes: a. the importance of the physical education discipline in relation to other subjects in the curriculum (one item: "The importance of PE in relation to other subjects"); b. the importance of the physical education discipline in terms of physical, mental health and academic activity (three items: "The importance of PE for

physical health", "The importance of PE for mental health", "The importance of PE for improving academic performance"); c. the role of the teacher in adapting the contents of the physical education lesson, diversifying activities, student safety and in terms of positive personal example (four items: "The importance of adapting content in the PE lesson", "The importance of diversity of activities in the PE lesson", "The importance of the positive example of the PE teacher", "The importance of student safety in the PE lesson").

Subjects/Participants

The participants in this questionnaire were parents of the students in the secondary school from 10 education institutions in Reșița (three colleges, two high-schools and five secondary schools), which schools more than 2000 students in the 89 classes in the secondary school cycle. We sent to them a questionnaire with eight items, created with the help of the Likert scale with five answer options (1 – very unimportant, 5 – very important). The inquiry was achieved during the period April-May 2023.

Contacting parents was carried out with the support of physical education teachers from the mentioned schools and the homeroom teachers of the students in the middle school cycle, who distributed the link on the class group (created for efficient communication between school and family), after we obtained, in advance, the verbal agreement of the management of the educational institution in order to distribute the link with this questionnaire.

Table 1. The participants incidence

No. crt.	Educational unit	No. total classes	No. total students
1.	"Traian Lalescu" National College Reşiţa	11	271
2.	"Diaconovici-Tietz" National College Reşiţa	11	194
3.	"Mircea Eliade" National College Reşiţa	12	247
4.	"Sabin Păuţa" Art High School Reşiţa	7	151
5.	Baptist Theological High School Reşiţa	4	78
6.	Gymnasium School No. 2	8	198
7.	"Mihai Peia" Gymnasium School Reşiţa	6	121
8.	Gymnasium School No. 7	11	306
9.	Gymnasium School No. 8	9	218
10.	Gymnasium School No. 9	10	242
	TOTAL	**89**	**2026**

RESULTS

412 filled in questionnaires were handed in, which constitutes a representative sample for the town of Reşiţa.

Table 2. The number of responses to the questionnaire questions

Themes	Item / Appreciation	Very unimportant	Little important	To some extent	Important	Very important
1. The importance of PE in relation to other subjects	The importance of PE in relation to other subjects	2	21	100	203	86
			5 %	24.2 %	49.2 %	20.8 %
2. The importance of PE for physical and mental health, for improving academic performance	The importance of PE for physical health	0	2	53	217	140
				12.8 %	52.6 %	33.9
	The importance of PE for mental health	8	16	39	272	77
		0.2 %	3.8 %	9.4 %	66 %	18.6 %
	The importance of PE for improving academic performance	8	21	84	213	86
		0.2 %	5 %	20.3 %	51.7 %	20.8 %
3. The role of the PE teacher	The importance of adapting content in the PE lesson	7	13	33	198	161
		1.6 %	3.1 %	8 %	48 %	39 %
	The importance of diversity of activities in the PE lesson	0	47	129	217	19
			11.4 %	31.3 %	52.6 %	4.6 %
	The importance of the positive example of the PE teacher	0	7	18	179	208
			1.6 %	4.3 %	43.4 %	50.4 %
	The importance of student safety in the PE lesson	0	0	26	218	168
				6.3 %	52.9 %	40.7 %

The answers show that the parents are aware of the importance of the physical education lesson achieved in schools and they have expectations connected to the aspects they were questioned about by means of the questionnaire.

Thus, over 69% of the respondent parents agree that the subject physical education is a very important one for the students, not being with anything less than all the subjects contained in the school curriculum.

The answers show that parents are aware of the importance of the physical education lesson held in school and have expectations regarding the

aspects that were brought to their attention through the questions of the administered questionnaire. Thus, over 70% of the parent respondents believe that the physical education (PE) subject is extremely important for students, being in no way inferior to other subjects included in the curriculum. At the same time, 87% of the parents consider that the physical education lesson is important and very important for the physical health of children, 85% of the respondents consider it important for the mental, social and emotional health of children, the other percentages representing responses from parents convinced that only to a certain extent can one speak of such importance of the physical education lesson.

Parents overwhelmingly agree, 72.5%, that physical education is of great importance for improving students' academic performance, while 20% believe that this is true to some extent. However, they are interested in the diversity of activities during physical education lessons, with 57% considering it important and very important for students. The positive examples of the physical education teachers are appreciated as being important and very important by 94% of the parents. Over 90% of parent respondents highlighted the importance of the safety of their children and students in general during physical education lessons.

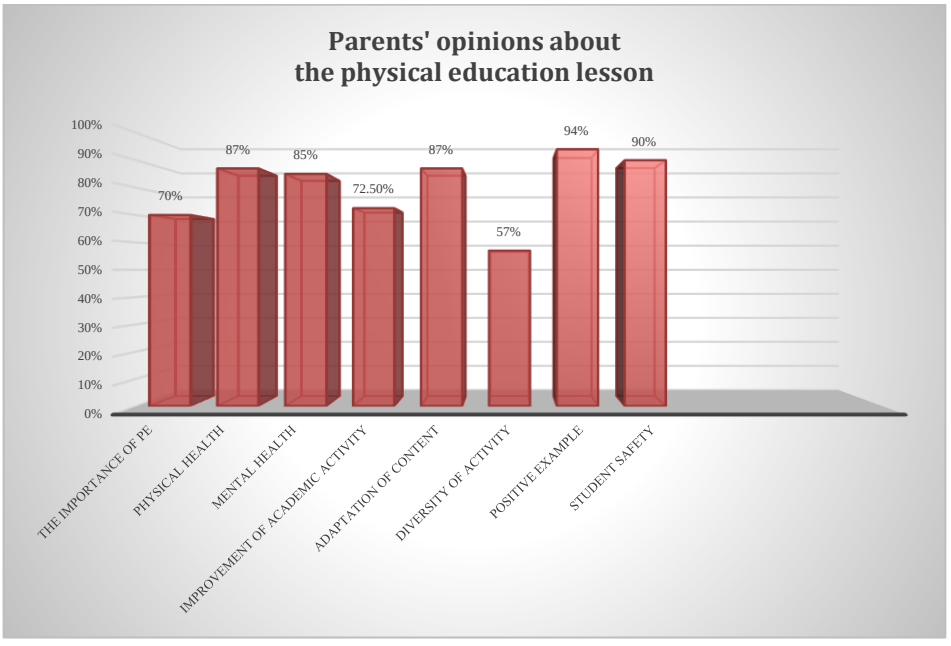

Fig. 1. Parents' opinions about the physical education lesson

DISCUSSIONS

It is a reality that today's children are both physically inactive (Venetsanou et al., 2020; Voukia et al., 2018), and heavily exposed to screens (Sigmundová et al., 2018). Sedentary behavior caused by watching television, using computers/ smartphones and video games (Ussher et al., 2007) is associated with various negative health consequences (Prentice-Dunn & Prentice-Dunn, 2012). Therefore, schools have the mission to ensure sufficient physical literacy (Castelli et al., 2014) and to help students maintain their health-related physical fitness. In this sense, there are parents in whose eyes schoolwork only targets a few subjects, which justify a stronger educational influence (Chambon, 1990). In a 2010 study by Candolfi, most (58%) of the parent respondents ranked physical education in sixth and seventh place out of nine subjects (mother tongue, mathematics, two foreign languages, music, visual arts, history and computer science). However, the role of physical education compared to other subjects in the curriculum should not be minimized. Even if parents of middle school students theoretically agree with this, and the respondents participating in our study demonstrate that they support this statement, there are parents who agree with giving up physical education classes in favor of other subjects considered basic, as demonstrated by the results of other studies (Earley & Fleet, 2021; Stevens et al., 2008; Coe et al., 2006). As for us, we support increasing the number of hours allocated to this subject precisely in order to build a healthy generation from all points of view. This is especially true in the Hungarian education system, for example, where physical education classes are mandatory for all students, both in primary and secondary school, five days a week (World Health Organization, 2021). At the same time, in France, the "30 minutes of daily physical activity" program was launched in September 2022 in the 36,250 primary schools in the country, the French government being aware that daily physical activity contributes to well-being and health, fundamental conditions for learning well. This program is complementary to the three hours of physical education and sports, a mandatory subject. Included in the national sports-health strategy, this measure reaffirms the role of the school in promoting health through physical activity (MENESR, 2024). 94% of teachers in France believe that the 30 minutes of daily physical activity improve the well-being of students.

From a physical point of view, physical education lessons contribute to improving physical fitness, developing muscles, coordination and combating sedentary lifestyle (Nelson & Gordon-Larsen, 2006), which is a form of maladaptive behavior. It generates cardiovascular diseases, diabetes, cancer and chronic respiratory diseases, which account for 74% of global deaths (World Health Organization, 2022). Also, within physical education lessons, students receive or should receive information about the importance of a balanced diet, about

body hygiene and the benefits of regular physical activities, for the development of healthy habits in the long term. In the European Union, various programs have been implemented to promote a healthier lifestyle from an early age: active breaks in playgrounds equipped with sports equipment and infrastructure; active breaks during lessons to break up prolonged sitting hours and after-school physical activities to engage children in sports and programs to encourage students to walk or cycle or use other forms of active transport instead of relying on motorised vehicles (World Health Organization. Copenhagen, 2021).

On the other hand, by physical exercises, the students' mental activity is stimulated and the mental fatigue is removed: by engaging the physiological functions which are connected to movement, then, the mental functions are indirectly improved (Higashiura et al., 2006), cognition and academic performance (Donnelly et al., 2016). The specialists agree that the interventions of physical activity for children should optimize the physical aptitude, to promote behaviours connected to health which should compensate obesity and facilitate the mental development (Tomporowski et al., 2011). It would be equally desirable, that during the physical education lessons the psycho-emotional stress should be diminished, that the state of mind should be improved and the self-esteem could be increased. Numerous studies have presented the connections between the physical activity and the general well-being (Ströhle, 2009). The emotional well-being is promoted in schools (Appleton & Hammond-Rowley, 2000; Bywater & Sharples, 2021), the physical exercises having positive effects in this direction.

There are proofs of the positive correlations between different measures of psycho-motor performance, cognitive abilities and academic performances (Planinsec & Pisot, 2006). Researchers (*Stevens et al., 2008; Trudeau & Shephard, 2008*) have proved that the improved cognitive performance is connected to physical activity, among the most important activities with small children, they mention free play and guided play or physical education. That is why, they consider that the physical activity could be stored with more hours, taking time from other subjects, without any risk regarding the students' academic results. Likewise, adding time to the "academic" subjects or "curricular" and the reduction of the allotted time for the subject physical education do not improve the results in these subjects, but it could be harmful for the health. In the same train of ideas, the connection with school and school satisfaction are factors which contribute to the reduction of school abandon (Libbey, 2004). The present orientations regarding physical activity for children and adolescents recommend generally at least 60 minutes of daily moderate to intense physical activities, all the more so as 81% of the adolescents (aged between 11 and 17) are physically inactive (Guthold et al., 2019).

The activities diversity in the physical education lesson helps the students to be more involved, to discover what activities they like more, contributing to the development of physical and psychic skills, values, among which friendship, self-control, helping others, fairness and responsibility (Temel & Mamak, 2023; Bessa et al., 2021), an important role also having the positive feedback from the teacher. If the experience is not positive and successful, the students can become unmotivated, with a passive and reproductive behaviours, without being able to make decisions or to solve problems.

The strategies used by the teacher during the physical education classes are of a real importance. The studies achieved on this subject have revealed the importance of the didactic activity adaptation to the level and possibilities of each student. Van Munster et al. (2019) treat the differentiated teaching by three main approaches: (a) normalised instruction – traditional curriculum without differences in the program; (b) differentiated instruction – adapted elements specifically for each disabled student; and (c) universally projected instruction, based on the principles of the Universal Design for Learning (UDL) and accessibility for all students. This is the reason why, we should mention the efficiency of the preparation methodology introduction for the future teachers of physical education and sport with activities aiming inclusive education (Demchenko et al., 2021).

The students' safety during the physical education classes, the avoidance of injuries represents a very important aspect that the physical education teachers have in mind. These are responsible for the good functioning of sport installations and equipment in the gym rooms, the running tracks etc. The teacher is obliged to check the safety of each element of the equipment each time when this is used during classes. We should constantly insist on the basic safety rules during every class, in order to make the students conscious about their observance during the whole learning process. (Capel, 2002). Experts consider that the number of accidents during the physical education lesson is increasing in the last years (Fitzgerald & Deutsch, 2016), among the most common dangers during the physical education classes being: broken arms, legs, luxation, contusions, tendonitis, muscle ruptures and muscle strains and scars. Unfortunately, despite the concept of olympism, sport is often a carrier of unjustified violence and even extremely severe aggression. Thus, researchers plead that through sport the interpersonal aggressiveness should be reduced by competent use of specific methods and means for largely understood sport activity (Klimczak et al., 2014), resilience and assertiveness representing important psychological variables in preventing injuries (Patenteu et al., 2024). However, the existence of rules and becoming aware of their existence does not represent though, a guarantee in what concerns the students' safety (Podstawski et al., 2015).

An increased attention should be awarded to the professional responsibility in physical education, to the attitude that the physical education teachers

manifest towards the lesson itself. Their behaviour and the way in which they interact with the students can positively or negatively influence the children's perception of physical education. They have the potential to offer multiple desirable educational and health results, on condition that the profession of physical education should not be only a profession but manifesting responsibility in applying the most efficient didactic strategies and in their involvement in a continuous professional improvement (Armour, 2009).

The teachers should be greatly aware of their potential as models to be followed and the obligation to offer the students development feedback (Keay, 2005), empathic behaviours in their interaction with heterogeneous groups of students (Schnitzius et al., 2021, Chia et al., 2022). We should keep in mind the positive influence of the teacher on the students' performance (Hattie, 2009), this being a typical measure of the teachers' efficiency (Kim et al., 2019). The results of the studies indicated that the students involved in the lessons of physical education taught by active teachers rather than in those taught by less active teachers (Cheung, 2020).

CONCLUSIONS

As the aim of education is the formation of a complete and harmonious personality, this can't be developed by a single form of education but it supposes a tight connection of physical education with other forms of education, such as intellectual, moral, aesthetic and social education (Rodić, 2014).

This research proposed to find out the parents' perception of the secondary school students regarding the lesson of physical education and sport. The answers to the questions in the given questionnaire have highlighted the fact that the parents are aware of the role played by physical education in the improvement of the students' health and well-being. They have high and very high expectations concerning the students' physical, emotional, mental, academic and social health in the wake of their participation in the physical education lesson. The parents want the physical education teacher to be a model for their children, to adapt the lesson contents to the typology of the students' personality, to be creative. For an increased quality of the physical education classes the children's motivation is necessary, as well as the use of a diversity of didactic strategies.

The future research could investigate to what extent the parents' expectations of the physical education lesson are supported by their personal example of being involved in physical activities or they represent only a desideratum for their children's well-being. The previous studies have highlighted the importance of the personal example given by parents in the students' motivation to do physical activities (Guzauskas & Sukys, 2021).

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Physical Education and Sport in Romania: Between Ideal, Reality, and Prospects for Reform

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ABSTRACT. Physical Education and Sport (PES) represent a foundational pillar in contemporary educational architecture, supporting the holistic development of individuals. This study provides an integrative analysis of the educational ideal in this field, the systemic realities in Romania, and potential directions for reform, benchmarked against European best practices. Through a comparative approach, it highlights the convergences and divergences between Romania and other countries in Central, Southeastern, and Baltic Europe, offering a reflective framework for developing a sustainable, inclusive, and student-centered physical education.

Keywords: *physical education, curricular reform, international comparison, educational policies, public health*.

REZUMAT. ***Educația fizică și sportul în România: între ideal, realitate și perspective de reformă.*** Educația fizică și sportul (EFS) constituie un pilon fundamental în arhitectura educațională contemporană, susținând dezvoltarea integrală a individului. Studiul de față oferă o analiză integrativă a idealului educațional în domeniu, a realităților sistemice din România și a direcțiilor posibile de reformă, raportate la bune practici europene. Printr-o abordare comparativă, sunt evidențiate convergențele și diferențele dintre România și alte state din Europa Centrală, de Sud-Est și din regiunea baltică, oferindu-se

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un cadru de reflecţie asupra dezvoltării unei educaţii fizice sustenabile, incluzive şi centrate pe elev.

Cuvinte-cheie: *educaţie fizică, reformă curriculară, comparaţie internaţională, politici educaţionale, sănătate publică*.

INTRODUCTION

Physical education has undergone significant transformation over the past decades, reflecting broader global shifts in social, cultural, and educational paradigms. Whereas earlier approaches prioritized performance, competition, and athletic selection, the contemporary discourse increasingly frames physical education as a vehicle for promoting health, social inclusion, and personal development (Marín-Suelves & Ramón-Llin, 2021; Marques, 2021). This conceptual reorientation underscores the role of physical education not merely as a school subject, but as a multifaceted educational instrument contributing to the development of active, autonomous, and socially responsible individuals (Berki & Tarjányi, 2022; Habyarimana, Tugirumukiza & Zhou, 2022).

In Romania, this transition has occurred in a discontinuous and fragmented manner, hindered by the absence of a coherent strategic vision and the implementation of sporadic reforms. Although national education policies have gradually aligned with European principles emphasizing inclusive, learner-centered physical education, actual practices at the school level often remain anchored in traditional models that prioritize standardized assessments, hierarchical ranking, and quantitative evaluation. These efforts have further been constrained by inadequate infrastructure, limited opportunities for continuous professional development among teaching staff, and a lack of modern educational resources.

This article examines these dynamics through a thematic and comparative analysis situated within the broader European context, identifying both the strengths and challenges specific to the Romanian educational landscape. By drawing on successful models from other European countries, the study proposes strategic directions for the reconfiguration of physical education in Romania, aiming to better align it with the actual needs of students and the evolving demands of contemporary society.

1. The ideal of physical education and sport

The educational ideal of physical education and sport (PES) is grounded in a holistic vision of human development, encompassing not only the traditional goals of motor performance and athletic competition, but also the comprehensive formation of the individual across physical, mental, emotional, and social dimensions (Bălăceanu & Popescu, 2019; Ionescu, 2020).

The promotion of physical and mental health represents a core component of this vision, aiming not only to prevent sedentary behavior and associated health conditions, but also to support psychological well-being, stress reduction, and the enhancement of self-esteem through movement-based activities (Furrer, 2023; Haegele et al., 2021).

The development of social and ethical competencies within physical activities facilitates the internalization of values such as respect, responsibility, teamwork, and fair play, thereby contributing to the cultivation of a strong moral character (Furrer et al., 2020, Ştefănescu, 2023).

Encouraging cooperation, trust, and self-improvement reflects the orientation of physical education toward creating an environment in which each student is supported in overcoming personal limits, building self-confidence and mutual trust, and experiencing individual growth within a collective context (Bailey et.al.,2009, Ionescu, 2020).

Fostering social inclusion through shared motor activities highlights the potential of physical education to reduce social, cultural, or ability-based barriers, promoting the active participation of all students regardless of their physical aptitude or socio-economic background (Furrer, 2023; Haegele et al., 2021).

Thus, the ideal of PES entails a deeply humanistic educational approach that integrates movement and sport into the broader process of shaping active, empathetic, and healthy citizens.

2. European Approaches to Physical Education and Sport

At the European level, physical education and sport are recognized as essential components of education for active citizenship, health, and social cohesion (UNESCO, 2015). In recent decades, European education policies have increasingly steered physical education towards an integrative model, emphasizing inclusion, transversal competencies, and the quality of motor experience, rather than standardized athletic performance (UNESCO, 2021).

Among the key strategic directions promoted across Europe are:

- **Physical education for all** – a universal approach that ensures equal access and active participation regardless of gender, ability level, cultural background, or disability. This principle is supported by

foundational documents such as the *International Charter of Physical Education, Physical Activity and Sport* (UNESCO, 2015), as well as recent initiatives for inclusive physical education (UNESCO, 2021);

- **A focus on health and well-being** – physical activity is increasingly integrated into public health strategies, serving as a key tool in preventing chronic diseases, combating sedentary lifestyles, and promoting mental health among children and adolescents (UNESCO, 2021);
- **Formative and progress-centered assessment** – a shift away from rigid evaluations based on quantifiable physical performance, towards individualized methods that value student progress, engagement, and personal development (UNESCO, 2021);
- **Ongoing professional development for teachers** – investments in teacher training aim to equip physical education professionals with modern competencies, particularly in inclusive pedagogy, educational technology, educational leadership, and health education (UNESCO, 2021);
- **Interdisciplinarity and the integration of European values** – physical education is increasingly seen as a platform for intercultural, ethical, environmental, and civic education, fostered through international projects and partnerships that promote cooperation, mobility, and the exchange of best practices (UNESCO, 2021).

These strategic directions provide a coherent framework for the reform of physical education, aligned with the challenges of contemporary society and with the ideal of an education focused on the holistic development of the learner (UNESCO, 2015; UNESCO, 2021).

3. The Issue of Physical Education in Romania

Romanian physical education reflects a complex historical trajectory, shaped by profound transformations in response to shifting political and social contexts. During the communist era, physical education held a pronounced ideological function, serving as a tool for collective discipline, propaganda, and elite sports selection. The communist regime sought to exert total control over Romanian society between 1948 and 1989, viewing higher education and sport as crucial domains for constructing the so-called "new man" (Constantin & Maier, 2014). The instrumentalization of sports heroes was already a practice in Soviet Russia, and Romania adopted this model. As a result, physical education and sport were closely monitored by the political regime, which aimed to expand the number of specialists in the field (Haţegan, 2018).

Following 1990, the transition to a democratic system prompted a reconfiguration of values and objectives (Zanca, 2024). However, this process often unfolded in a fragmented, inconsistent, and incoherent manner. Today, the Romanian physical education system faces a range of systemic challenges that hinder both the effectiveness of educational activities and their formative impact on students:

- Uneven curriculum implementation leads to significant disparities between schools, depending on available resources, institutional profiles, or individual teacher initiative. This lack of uniformity undermines the coherence of the educational process at the national level.
- Infrastructure deficits in rural areas remain a critical issue, as many schools lack access to gymnasiums, appropriate equipment, or properly arranged outdoor spaces for motor activities. This inequity significantly limits the chances of students from disadvantaged environments to benefit from high-quality physical education (World Vision Romania, 2024).
- A dominant summative assessment model focuses on measuring standardized physical performance, to the detriment of formative assessment approaches that emphasize individual progress, active participation, and the development of motor and social competencies.
- A pronounced disconnection from competitive sport has resulted in a gap between the educational system and sports institutions, which undermines the early identification and guidance of students with athletic potential, as well as the promotion of a culture of physical activity across the entire school population.
- Outdated professional training limits the ability of physical education teachers to respond to contemporary educational challenges. The absence of coherent and ongoing professional development programs focused on modern methodologies, inclusive education, and interdisciplinarity perpetuates rigid and outdated teaching practices (Miron & Petrovici, 2019).

These factors contribute to a diminished perception of the value of physical education among students, parents, and even policymakers, highlighting the urgent need for systemic interventions aimed at repositioning physical education at the core of a balanced and holistic educational experience for contemporary learners.

4. International Comparative Analysis

The comparative analysis (Prodea, 2025) focused on physical education models from Central Europe (Poland, Czech Republic, Hungary), Southeastern Europe (Bulgaria, Serbia, Greece), and the Baltic region (Estonia, Latvia, Lithuania). These models were assessed based on six key criteria: curriculum model, pedagogical paradigm, assessment, infrastructure, teacher training, and the connection to performance sports.

Central European countries demonstrate significant progress in modernizing physical education, emphasizing student-centered approaches, autonomy, and formative assessment, while implementing coherent reforms tailored to current educational contexts.

Southeastern Europe retains a more traditional approach, characterized by limited resources and a weak integration of performance sports into the educational system.

The Baltic countries present examples of best practices, distinguished by coherent educational policies, modernized infrastructure supported by European funding, and an integrative vision of student development.

Central Europe: Poland, Czech Republic, Hungary

This region is distinguished by coherent initiatives aimed at modernizing physical education, influenced by contemporary European trends and adapted to national contexts. Emphasis is placed on student-centered approaches, curricular autonomy, and formative assessment, within a framework supported by clear educational policies (OECD, 2025, Ministry of Education Youth and Sports of the Czech Republic, 2020, Ministry of Education of Hungary,2022, Ministry of Education of Poland, 2021).

- *Curricular model*: Curricular reforms have aimed to shift from rigid, uniform content to flexible structures aligned with 21st-century competencies. For example, Poland and the Czech Republic emphasize students' holistic development by integrating physical education into broader goals of personality formation and civic values.
- *Pedagogical paradigm*: Constructivist, learner-centered pedagogy is promoted, highlighting autonomy, initiative, and cooperative learning. Teachers are encouraged to adopt active and differentiated teaching methods.
- *Assessment*: Formative assessment prevails, aiming to support individual progress, self-reflection, and student engagement in their own development. Standardized testing has been replaced with portfolios and guided self-evaluation.

- *Infrastructure*: Countries in the region benefit from well-maintained or modernized sports infrastructure, particularly in urban areas, often supported by European Union funding.
- *Teacher training*: Initial and continuing teacher education programs are aligned with European standards, with a strong focus on interdisciplinarity, psycho-pedagogical competencies, and the continual updating of instructional methodologies.
- *Connection to competitive sports*: Hungary, in particular, has implemented integrated policies between schools and sports clubs, supporting talented youth through "sports school" structures.
- *Notable example*: Hungary allocates five hours of physical education per week in the primary cycle, reflecting a strong institutional commitment to children's health and development.

Southeastern Europe: Bulgaria, Serbia, Greece

Countries in this region generally maintain a traditional approach to physical education, characterized by systemic continuity but limited by resource constraints, fragmented reforms, and a weak integration of competitive sport within the school system (Tismăneanu, 2014, TIMSS Bulgaria,2019, UNESCO, 2015, Youth Wiki Serbia, 2022).

- *Curricular model*: Curricula are typically oriented toward standardized physical activities and quantifiable performance objectives, with insufficient emphasis on students' psychosocial dimensions or creativity.
- *Pedagogical paradigm*: Pedagogy is often teacher-centered and frontal. Active participation and individualized approaches are rarely employed due to a lack of modern methodological resources.
- *Assessment*: Summative assessment dominates, focusing on standardized physical testing with little adaptation to students' developmental levels or interests.
- *Infrastructure*: Many schools operate with outdated sports facilities, and in rural areas, appropriate infrastructure is often nonexistent. Funding is insufficient, and European investments are not fully utilized.
- *Teacher training*: Initial training programs are often theoretical and weakly connected to modern teaching practice. The lack of continuous professional development limits teachers' adaptability.
- *Connection to competitive sports*: There is a marked separation between school-based physical education and competitive sports, with few institutional bridges or mechanisms for talent identification and support.

- *Notable example*: In Serbia and Bulgaria, the school curriculum includes only two hours of physical education per week, with no effective extracurricular programs to support youth sports.

The Baltic Region: Estonia, Latvia, Lithuania

The Baltic countries present models of good practice, distinguished by coherent educational policies, EU-supported modern infrastructure, and an integrative vision of student development (The Times, 2025, Sport Factsheet Estonia, 2018, Sport Factsheet Letonia, 2021, Sport Factsheet Lituania,2021).

- *Curricular model*: The curriculum is flexible, competence-based, and adaptable to the specific needs of each school. Emphasis is placed on diverse physical activities, the integration of traditional sports, and the promotion of movement beyond formal lesson time.
- *Pedagogical paradigm*: A student-centered approach is promoted, wherein physical education contributes to holistic development—physical, mental, and social. Participatory, interdisciplinary methods and outdoor activities are commonly used.
- *Assessment*: A complex assessment system is employed, combining self-evaluation, individual progress tracking, and age- and developmentally-appropriate performance criteria.
- *Infrastructure*: Educational infrastructure modernization programs, supported by the European Union, have resulted in modern, digital, and environmentally sustainable facilities, including in rural areas.
- *Teacher training*: Training systems emphasize continuous professional development, international collaboration, and the integration of digital technologies in education.
- *Connection to competitive sports*: Student participation in local clubs is encouraged through partnerships between schools and municipal sports structures. Early selection strategies and individualized support systems are in place.
- *Notable example*: Estonia stands out for its digitized system of monitoring students' physical activity, integrated into their general educational record.

The comparative tables below synthesize the main positive European trends in physical and sports education in contrast to the current situation in Romania. The analysis is structured around six core criteria, offering a clear picture of the gap between international best practices and the realities of the Romanian educational system.

Results of the Comparative Analysis

Available data on physical education in secondary education were analyzed for the following countries: Romania, Hungary, Poland, the Czech Republic, Bulgaria, Estonia, Lithuania, Latvia, Serbia, and Greece. The information is structured according to six key criteria: curricular model, pedagogical paradigm, assessment, connection with competitive sports, infrastructure, and teacher training.

Regarding a comparative analysis between the orientations of the studied European countries and Romania, from the perspective of physical education and sports, the following table (Table 1) presents several summarized coordinates.

Table 1. Comparative Thematic Analysis of European Trends and Romania

Criterion	European Trends	Romania – Current Situation
Curricular Model	3–5 hours/week (Hungary, Latvia, Poland)	2 hours/week, uneven implementation between urban and rural areas
Pedagogical Paradigm	Student-centered, autonomy, well-being (Czech Republic, Estonia, Poland)	Slow transition from traditional model to student-centered approach
Assessment	Formative assessment, self-reflection, progress (Poland, Estonia, Czech Republic)	Predominantly summative assessment, limited formative initiatives
Infrastructure	Strategic investments, urban-rural equity (Poland, Latvia, Estonia)	Significant rural-urban disparities, lack of modern facilities
Teacher Training	Initial + continuous, integrated training (Czech Republic, Estonia, Lithuania)	Bologna system, lack of practical training and continuous professional development
Connection with Competitive Sports	Stable institutional partnerships (Hungary, Poland)	Post-2000 disconnection between schools and sports clubs

On the other hand, regarding the criteria for comparative analysis between the orientations of the studied European countries from the perspective of physical education and sports, the following table (Table 2) presents several summarized coordinates.

Table 2. Analysis Criteria for the Studied Countries

Country	Curriculum Model	Pedagogical Paradigm	Assessment	Link to Performance	Infrastructure	Teacher Training
Romania	2 hours/week, health focus	Transition towards student-centered model	Summative + initiatives	Disruption after 2000	Rural inequality	Bologna system, no coaching
Hungary	5 hours/week in primary	Integrated curriculum	Continuous assessment	School–club collaboration	Modernized	Teacher + coach
Czechia	Flexible, holistic curriculum	Reflective, well-being focused	Portfolios, self-assessment	Mass sport	Standardized post-2000	Integrated pedagogy
Poland	Health emphasis, 3 hours	Global development	Competency-based + feedback	Stable linkage	Major investments	Initial + ongoing training
Bulgaria	2 hours/week	Slow/Traditional transition	Predominantly summative	Weak linkages	Unequal infrastructure	University-level training
Estonia	2–3 hours/week	Innovation and student autonomy	Personal progress	Separate from clubs	Very good	Modern university education
Lithuania	2–3 hours/week	Daily physical activity	Individual feedback	Mass sport	Under modernization	Bologna + workshops
Latvia	3 hours/week	Mixed (rural/traditional)	Practical + summative	Moderate linkage	Good urban, moderate rural	Specialized university training
Serbia	2 hours/week	Traditional	Physical assessment	Poor integration	Variable	Faculties of sport education
Greece	1–2 hours/week	Recreation, urban health	Participation, attendance	Private clubs, not school-based	Deficient rural areas	Specialized university training

5. Thematic Analysis: Convergences and Differences in European Physical Education Models

To more clearly capture European trends and to propose a vision applicable to the modernization of physical education in Romania, a thematic approach organized around transversal analytical criteria is useful.

a. ***Curriculum Models: Between the Minimum Requirement and the Expansion of Health Education***

Most of the analyzed countries allocate 2–3 hours per week for physical education (Romania, Bulgaria, Serbia, Lithuania, Estonia), with the notable exception of Hungary, where physical education is compulsory for 5 hours per week at the primary level. This extension is correlated with national policies aimed at preventing chronic diseases and promoting an active lifestyle as a major educational objective (Bailey et al., 2009; Dumitru & Pantea, 2018).

b. ***Pedagogical Paradigms: Transitioning from Traditional to Student-Centered Approaches***

In Central Europe (Czechia, Poland, Hungary) and the Baltic countries (Estonia, Lithuania, Latvia), the pedagogical paradigm of physical education has evolved toward student-centered models emphasizing personal development and well-being (Dyson, 2015; Popescu, 2020). In contrast, Romania, Bulgaria, and Serbia continue to exhibit traditional paradigms focused predominantly on immediate physical performance and standardized assessment (Răduță & Ionescu, 2017).

c. ***Student Assessment: From Grading to Competency-Based Evaluation***

In new educational models, assessment increasingly relies on competencies and individualized feedback (Poland, Estonia, Czechia), emphasizing student progress and active involvement in self-assessment (Black & Wiliam, 2009; Stoica et al., 2019). Romania and Greece, however, predominantly use summative final grading, which limits the formative potential of physical education lessons (Marinescu, 2016).

d. ***Infrastructure: A Factor of Educational Equity***

Countries with strategic investments in school infrastructure (Poland, Estonia, Latvia) manage to ensure equitable conditions for practicing physical education (UNESCO, 2015; Petrescu & Vlad, 2021). In Romania, Bulgaria, and Serbia, a significant gap persists between urban and rural areas, affecting the quality of the educational process and limiting children's access to adequate facilities (Dumitru & Pantea, 2018).

e. ***Teacher Training: A Pillar of Reform***

Successful models in Czechia, Poland, and Estonia include both initial and continuous teacher training adapted to new pedagogical and public health requirements (Darling-Hammond et al., 2017; Răduţă & Ionescu, 2017). In Romania, although the Bologna system has been implemented, the lack of modern practical modules and the absence of specialized continuous training maintain a professional competence gap (Popescu, 2020).

Thematic analysis clearly demonstrates that the success of reforms in physical education depends not solely on the number of physical education lessons or curriculum modernization but on a coherent set of factors: infrastructure, ongoing professional development, formative assessment, and paradigms focused on the holistic development of the student, as is evident in the following comparative chart (Figure 1).

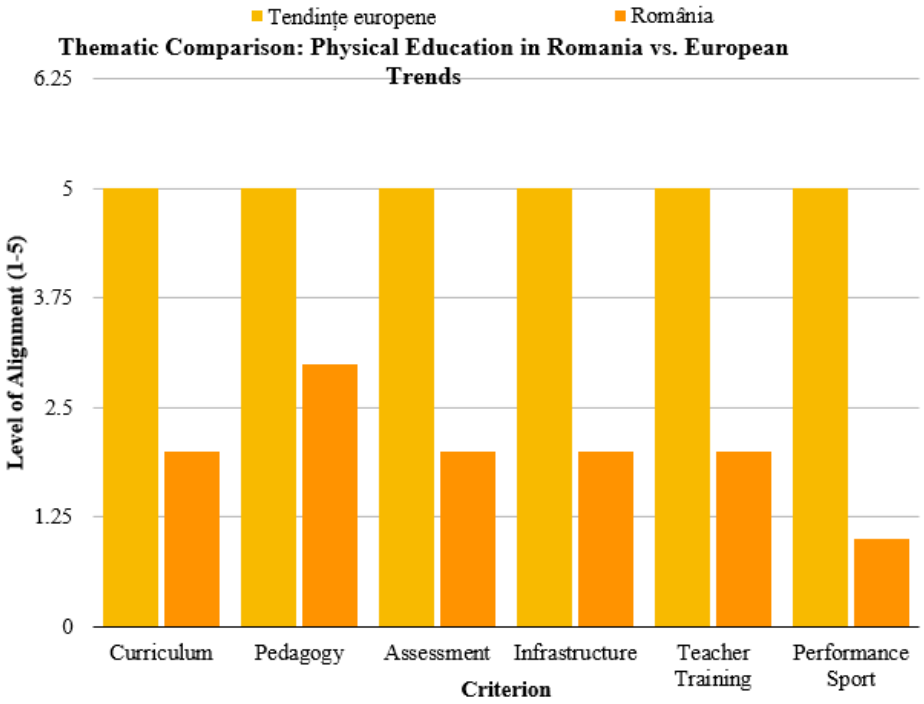

Fig. 1. Thematic Comparison of Physical Education and Sport in Romania vs. European Trends

6. Strategic Reform Directions: Recommendations for Sustainable Educational Policies

Based on comparative analyses and the realities identified within the Romanian education system, a clear orientation of educational policies toward strengthening the role of physical education as a major public interest domain is necessary. To this end, the following action directions are proposed:

Increasing the Number of Physical Education Hours

Expanding physical education to at least 3 hours per week during lower and upper secondary education would significantly contribute to achieving public health and personal development objectives. Examples from Hungary, Latvia, and Poland demonstrate that allocating increased time for physical activity within the student schedule does not negatively impact academic performance; rather, it enhances it by improving concentration and psychological balance (Bailey et al., 2013; Popescu, 2020; Schmidt et al., 2017).

Reforming Assessment Toward a Formative Approach

Shifting from predominantly summative assessment (standardized grades) to one centered on competencies, self-reflection, and individual progress is essential. This requires revising assessment descriptors and training teachers in the use of formative tools such as portfolios, progress sheets, and individualized feedback (Black & Wiliam, 2009; Răduță & Ionescu, 2017; Stoica et al., 2019).

Reconnecting Physical Education with Performance Sport

School physical education can once again become a platform for selection and guidance toward performance sport by fostering partnerships between schools and local sports clubs. A functional model can be inspired by Hungary, where such collaboration is institutionally integrated (Dumitru & Pantea, 2018; Weiss & Smith, 2002).

Investing in School Sports Infrastructure

Modernizing school infrastructure - especially in rural areas - is a fundamental condition for educational equity. A phased national strategy is required to prioritize access to gymnasiums, multifunctional sports fields, and minimum equipment for motor activities (Petrescu & Vlad, 2021; UNESCO, 2015).

Strengthening Initial and Continuous Teacher Training

Physical education teacher training must be adapted to the current context, including inclusion, technology, and health education. The introduction

of applied modules, experiential learning, and mandatory continuous professional development is recommended, as practiced in Estonia and Poland (Darling-Hammond et al., 2017; Răduţă & Ionescu, 2017; Popescu, 2020).

7. Students' Perception: Between Relaxation, Obligation, and Perceived Uselessness

In the context of a coherent reform of physical education, integrating the student perspective —being the direct beneficiary of the educational process - is essential. Without understanding how students perceive, experience, and value physical education and sport (PES) lessons, any change risks being merely structural, without producing real impact on motivation and participation (Bailey, 2006; Marinescu, 2016).

Recent surveys reveal an ambivalent relationship with PES. Students' perceptions of physical education and sport reflect an increasingly nuanced relationship, marked by evolving expectations and a high degree of self-awareness regarding their own needs. Surveys conducted across diverse European educational contexts indicate a mixed attitude toward this discipline: on one hand, students recognize the importance of physical activity for health and personal balance; on the other hand, they express reservations about how PES lessons are currently organized and delivered (Kirk, 2010; Stoica et al., 2019; Popescu, 2020).

Gender and physical status are influential factors and represent disparities in participation between girls and boys remain visible at lower and upper secondary levels. Girls are more likely to avoid physical education classes, citing discomfort, body exposure, or the irrelevance of activities to their interests. Additionally, overweight students or those with disabilities may experience indirect exclusion or social anxiety during lessons (Smith & Wrynn, 2013; Dumitru & Pantea, 2018).

Among the main requests formulated by students are:

- ***The necessity for a wide variety of activities*:** students experience monotony generated by the repetition of the same games or exercises and express a desire to participate in diverse physical activities - from alternative sports (parkour, urban dance, yoga) to unconventional movement forms (hiking, outdoor games, functional training) (Lundvall & Meckbach, 2017; Marinescu, 2016).
- ***The right to choose*:** a clear need for personalization of the educational experience emerges. Students want the possibility to select activities based on their interests, skill levels, or mood, suggesting a trend toward autonomy and active involvement in their own educational journey (Black & Wiliam, 2009; Popescu, 2020).

- ***Integration of technology and music*:** young populations perceive technology as a medium for expression and motivation. The use of physical activity monitoring apps, music in coordination exercises, or multimedia resources in teaching is seen as a natural necessity (Casey et al., 2017; Răduță & Ionescu, 2017).
- ***Assessment focused on general physical development rather than performance*:** students express discomfort with standardized evaluation criteria, which they perceive as outdated and demotivating. They call for an approach that privileges individual progress, well-being, engagement, and collaboration - elements that support the development of a positive long-term relationship with movement (Bailey et al., 2009; Stoica et al., 2019).

Overall, these perspectives suggest a clear desideratum: the reconfiguration of physical education lessons into a space for expression, inclusion, and personal development capable of responding not only to curricular requirements but also to the psychosocial realities of contemporary generations (Dyson, 2015; Dumitru & Pantea, 2018).

Student participation in the design of physical education lessons it appears to be becoming an indispensable component of the current approach, thus a modern educational model cannot be constructed without student involvement in co-designing lessons. This entails regular consultation, adjusting content to their interests, and encouraging self-assessment and reflection on their own physical and psychological development (Black & Wiliam, 2009; Marinescu, 2016).

Transforming physical education in Romania requires a shift in focus from "what is taught" to "what the student experiences in physical education lessons." Integrating the student perspective is not a decorative element but an essential condition for the success of any authentic educational reform (Kirk, 2010; Popescu, 2020).

8. The Future of Physical Education and Sport (PES): Reform Directions

In the context of rapidly accelerating social, cultural, and technological changes, physical education and sport (PES) face a necessary and profound reconfiguration. To maintain its relevance and effectively contribute to the development of the younger generation, PES must transcend the traditional model and transform into a dynamic educational space centered on the student and the needs of contemporary society. Thus, the following essential reform directions emerge:

Curriculum Reorganization Around Educational and Health Themes

It is imperative that PES is no longer viewed solely through the lens of physical performance but as a strategic component of education for health, emotional balance, and an active lifestyle. The curriculum should incorporate topics such as postural education, prevention of chronic diseases, effort hygiene, nutrition, and stress management alongside physical motor activities (Bailey et al., 2009; Ministry of Education Romania, 2020).

Diversification of Physical Activities to Meet Student Interests

The future of the discipline involves shifting from a uniform and prescribed model to an adaptable one where students can experience a wide range of activities: conventional and alternative sports, recreational activities, motor mindfulness exercises, dance, hiking, or functional training. This diversification aims to stimulate active participation and reduce the phenomenon of movement rejection during adolescence (Stirling & Kerr, 2013; European Commission, 2018).

Integration of Technology and Digital Tools in Teaching and Assessment

New generations are deeply embedded in the digital environment. Integrating effort-monitoring applications, interactive platforms, augmented reality, and multimedia resources can make the learning process more engaging and personalized. Furthermore, technology can support the evaluation of individual progress in an objective and motivating way (Casey et al., 2017; UNESCO, 2021).

Creation of an Inclusive, Equitable, and Non-Competitive Environment

Future physical education must address all students, regardless of aptitude level, socioeconomic status, or individual particularities. Promoting inclusion, acceptance of bodily diversity, and cooperation over excessive competition is essential for a discipline aspiring to contribute to students' psychosocial balance and school community cohesion (Flintoff & Scraton, 2001; Council of Europe, 2019, Marín-Suelves & Ramón - Llin,2021).

These directions involve not merely content updates but an educational paradigm shift, one in which PES becomes a fundamental formative tool resonant with the ideals of humanistic, sustainable, and equitable education (Penney& Chandler, 2000).

CONCLUSIONS

To better understand Romania's position within the European physical education landscape (EUPEA 2021), it is essential to expand the comparative analysis to countries with similar challenges and resources. Studying models implemented in Bulgaria, Serbia, and Greece in Southeastern Europe, as well as in Estonia, Latvia, and Lithuania in the Baltic region, provides a relevant framework for potential development directions. The results of thematic and comparative analysis indicate that physical education in Romania is at an inflection point, oscillating between stagnation due to structural constraints and the potential for alignment with innovative European models.
The overall picture reveals the following key aspects:

Underdeveloped Curriculum and Unequal Implementation: Allocating only two hours per week and major discrepancies between urban and rural areas limit the formative and integrative function of physical education. A study by Georgescu et al. (2022) highlights that insufficient physical education hours and inadequate infrastructure in schools contribute to these disparities (Rus et al., 2019)

Fragmented Pedagogical Paradigm: Despite modernization initiatives, many schools persist with traditional methods, focusing on physical execution rather than the holistic development of students. Olănescu (2024) emphasizes the importance of assessment for learning in physical education to support student progress (Stănescu, 2015)

Summative and Student-Irrelevant Assessment: Assessment based almost exclusively on grades reduces the motivational and formative potential of lessons, failing to adapt to the diverse needs and profiles of students. Cârstea et al. (1995) discuss the need for assessment systems that consider individual progress and development (Rus et al., 2019)

Deficient Infrastructure, a Major Equity Factor: Limited access to sports halls, equipment, or fields in rural areas affects students' perception of the relevance of physical education. A survey by World Vision Romania (2024) found that 81% of children in rural areas do not participate in sports outside school hours due to infrastructure and financial constraints (Stănescu, 2015).

Professional Training Insufficiently Adapted to Current Realities: Although Romania has adopted the Bologna system, the lack of applied training, modules on public health, inclusion, or digitalization limits the impact of teachers in the field. Cojocaru et al. (2016) analyze the impact of the Bologna process on physical education and sport higher education in Romania, highlighting areas for improvement (Ştefănescu, 2024).

Disconnection from Performance Sports: The institutional rupture between schools and performance sports structures has led to the erosion of physical education's role as a form of selection, orientation, and promotion of sports talent. The "Sustainable Integration Through Sport" project (2023) emphasizes the importance of integrating sports activities to enhance educational inclusion and reduce early school leaving (www.integraresustenabilaprinsport.ro).

To ensure a sustainable future for physical education, it is imperative to formulate a coherent and long-term national strategic vision that integrates the following directions:

- Expanding the curriculum to 3–4 hours/ week.
- Orienting physical education lessons towards physical well-being, autonomy, and cooperation.
- Implementing formative assessment centered on individual progress.
- Systematic investments in school infrastructure, especially in rural areas.
- Continuous and specialized teacher training in accordance with European standards.
- Developing sustainable partnerships between schools and sports clubs.

Transforming physical education cannot be achieved through isolated measures but through a systemic effort that recognizes its essential role in promoting health, equity, and sustainable development. Physical education can become a strategic pillar of contemporary education, provided that integrated, sustainable, and student-centered educational policies are adopted. Reforms should not be fragmented or opportunistic, but part of a long-term vision anchored in European best practices.

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