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Candidat: Conf.univ.dr. Ioan TURCU

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Sustainability and Social Responsibility of Romanian Sport Organizations

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Abstract: Sports organizations worldwide are discovering their power of influence over the fans and communities in which they operate, making more and more specialists and practitioners question these organizations' social responsibility and sustainable development. In sports organizations, although research is increasing, social responsibility and sustainability are topics that require special attention because sports organizations can instill values in a large number of people in different fields. In our paper, we propose a conceptual framework that allows for integrated research into corporate social responsibility (CSR) and the sustainability of sports organizations for sustainable management and identifies their influences on the overall performance. Based on the conceptual framework, we developed a scale for measuring sports organizations' social responsibility and sustainability, which we applied within sports organizations in Romania. The empirical study involved 280 respondents selected from the first two leagues of four sports areas (football, handball, volleyball, basketball). To support the conceptual framework, we used quantitative research methods in a transversal analysis: structural equation modeling and artificial neural network analysis. The conclusions of the empirical study in Romania show that social responsibility and sustainability are essential for the sustainable management of sports organizations and significantly influence the organization's overall performance. Among the pillars of sustainability, the social and human impact performance, given the specifics of sports organizations (involving large masses of people). Furthermore, legal and philanthropic responsibilities significantly influence CSR and organizational performance among CSR responsibilities.

Keywords: social responsibility; sustainability; sport organizations; performance

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1. Introduction

In recent decades, issues of social responsibility of organizations towards society and their sustainable development, which ensure economic survival without affecting the natural and social environment, have been on the national and international agenda [1]. Social responsibility has become increasingly important for many organizations because there is pressure from the communities in which they operate and in society in general for the organization to assume legal, ethical, and philanthropic responsibilities in addition to economic ones [2]. As sports in clubs and leagues organized at the national and international level can remove many of the cultural, social, ethnic, and religious barriers, sports organizations have become an essential vector of influence in the field of social responsibility and sustainability [3]. Sports organizations managers are increasingly aware of the strategic importance of taking social responsibility and ensuring sustainability and

their significant influences on overall performance. Sports organizations have many stakeholders, are very involved in the activities of organizations, and can influence the behavior of many people. Sports organizations managers have begun to understand the benefits of ethical, responsible, and sustainable behavior, which can lead to reduced operational costs, greater loyalty and increased fan and employee satisfaction, risks of sanctioning for lower laws and regulations, improved practices and activities, and public image [4]. Although the importance of social responsibility and ensuring sustainability in sports organizations has been recognized, there is little research on an integrated view of these areas, especially the influence on the organizations' overall performance.

Sustainable management combines the concepts of management with sustainable development. To have sustainable management, sports organizations must assume social responsibilities and get on the path of ensuring sustainability. This paper proposes an integrated framework for analyzing sports organizations' social responsibility and sustainability, providing a tool for measuring the effects of sports organizations' policies in these fields. From the beginning of the proposed theoretical framework, the measurement instrument reflects the responsibilities assumed within the CSR and the sustainability dimensions, as perceived by a category of main internal stakeholders—the employees of some sports clubs in Romania. The structure of the paper involves six sections. The Section 1 introduces the research topic, while the Section 2 reviews the literature. The Section 3 sets out the methodology and the tools used. The Sections 4 and 5 are an outline of the results, discussion, theoretical contributions, and practical implications The Section 6 provides conclusions and research limitations.

2. Literature Review

2.1. Corporate Social Responsibility and Sustainability

Since ancient times, individuals have been engaged in sports activities for social reasons, either individually or in a team [5]. However, in recent decades, sports organizations (clubs) have become more professional due to the transformation of sports into a mass phenomenon. As a result, sports organizations and economic activity have become an essential part of both the economy and society. Given the developments that characterize all economic organizations, sports organizations are no exception by engaging in sustainable and socially responsible business practices [6]. Moreover, for a long time, sports organizations have long been seen as social institutions and not economic ones, which makes stakeholders' expectations about responsible and sustainable behavior higher.

Due to the multidimensional concept of CSR, Carroll's model is one of the most commonly used models in the field of CSR. Carroll [7,8] theorized the existence of four dimensions of social responsibility, adding to the economic one (the classical dimension that dominated capitalism until the emergence of theories on social responsibility and the role of stakeholders in the evolution of an organization), including legal, ethical, and philanthropic obligations [7]. He framed these responsibilities in a pyramid, placing at the core the economic responsibility on which all other responsibilities rest. Legal responsibilities imply the development of the organization's activities in compliance with the norms and regulations in the field. Ethical responsibilities involve imposing moral conduct and ethical behavior that consists of carrying out the organization's activities in compliance with values and codes that are self-imposed by the organization, based on the values within the communities in which it acts and society as a whole [9–11]. Finally, philanthropic responsibility involves voluntary efforts by which the organization returns some of the benefits it receives to the community.

The Triple Bottom Line concept developed by John Elkington [12] highlights organizational sustainability, which changed the sustainability paradigm for all organizations and institutions. The three dimensions defined by Elkington—people (social and human dimension), planet (environmental dimension), and profits (economic dimension)—have become a benchmark in research on ensuring sustainability, being the three pillars of sustainable approaches. Slaper and Hall [13] highlighted several challenges regarding ap-

plying the Triple Bottom Line, including identifying appropriate indicators for assessing the three dimensions and calculating their contribution or impact on overall sustainability.

Recent research addressing the issue of social responsibility and sustainability at the level of sports organizations has shown that a responsible and sustainable approach has led to positive results for sports organizations [14–17]; these results were related in particular to improving the reputation and image of the organization [18,19].

2.2. CSR and Sustainability in Sport Organizations

The limited literature has identified that environmental responsibilities influence the involvement of sports organizations in CSR [20–22], requiring a framework that incorporates the dimensions of sustainability into the sports organizations' social responsibilities. Kim et al. [21–25] suggest that involvement in CSR activities facilitates positive perceptions of an organization. The conclusions presented by [26] supported this suggestion; they further add to it by postulating that positive perceptions can lead to long-term benefits, such as attracting and retaining talented employees. Most studies show that some advantages of CSR are related to marketing, image, and reputation [15,27]. Although the benefits of CSR have been theorized and researched for a long time, there is still a significant gap in how involvement in social responsibility activities can also take on a sustainable dimension, with clear influences on the organization's overall performance.

Sports organizations have business models other than regular ones, so they require specific management techniques, with CSR in this area not making a distinctive note [28]. One of the specifics of sports activity organized in clubs and leagues is the irrational passion of fans for a sports team, which can lead them to adopt the values of that organization or their members (athletes). According to CSR and sustainable development, the paper proposed a tool for measuring social responsibility and sustainability in sports organizations [4,29–31].

Kolyperas et al. [32] pointed out a lack of vision on social responsibility and ensuring sustainability in sport. For the sports sector to integrate organically into general economic activity and society, sports organizations need to improve their understanding and involvement in social responsibility activities. Babiak and Wolfe [20] and the authors of [33,34] suggest that professional sports organizations cannot ignore social responsibility and sustainability, as they are vectors in all economic activities. Robertson et al. [35] suggest that, in addition to professional sports organizations, fan associations should put pressure on the responsible behavior of the organization and support the organization in its social actions. Breitbarth and Harris [29] show that these approaches can generate significant benefits for the sports organization and the community in which it operates. Bradish and Cronin and Fifka and Jaeger [36,37] find that CSR effectively manages sustainable development.

Smith and Westerbeek [38] argue that stakeholders' perspectives are crucial to encourage social responsibility in sports organizations. Such an approach makes it possible to increase equity and diversity and improve social relations. Walters [39], based on the theoretical framework developed by Smith and Westerbeek [38], details the range of health, education, and social inclusion activities that each community sports trust is involved in, identifying the community sports trust model as an ideal vehicle for an organization to meet their social objectives. Zeimers et al. [40] relate organizational learning to social responsibility, revealing patterns of learning institutionalization for CSR in a particular European sport federated setting. Rowe et al. [41] propose community-oriented practices as a concept to describe the community-focused activities undertaken by professional sports teams, considering that CSR can be a vector for community development.

Starting from the results of previous research and the purpose of the paper, we formulated a set of three hypotheses based on the theoretical model applied in an empirical study:

Hypothesis 1 (H1). *Of the responsibilities at the CSR level, ethical and philanthropic responsibilities have a positive effect on CSR in the perception of the sports organizations' employees.*

Hypothesis 2 (H2). *In the perception of sports organizations' employees, the social and human dimensions have a positive effect on sustainability.*

Hypothesis 3 (H3). *Both constructs (social responsibility and sustainability) positively influence the overall performance of sports organizations' sustainability.*

3. Methodology

3.1. Research Design

The paper aims to identify the relationships between the social responsibility of sports organizations and the dimensions of the Triple Bottom Line in sustainability policies and their influence on the overall performance of the sports organization. Figure 1 shows the conceptual model of the research.

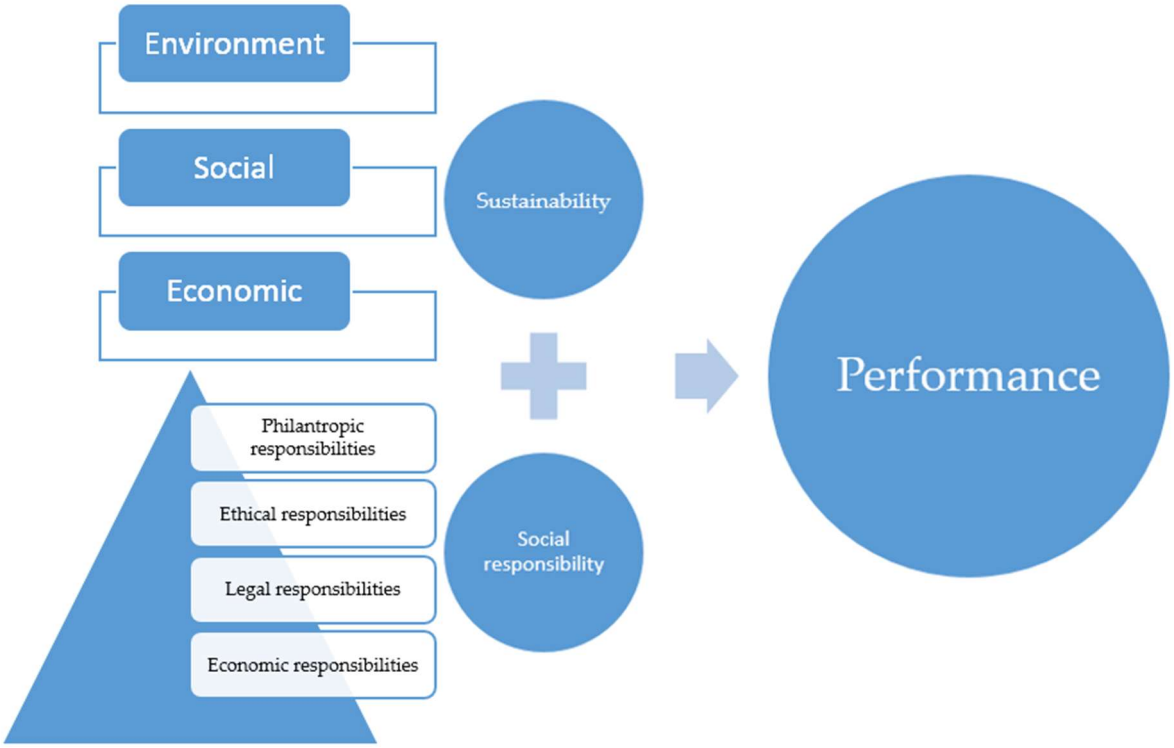

Figure 1. Conceptual framework of research on sustainability and social responsibility of sports organizations. Source: own design.

A quantitative study analyzed and evaluated the responsibilities within CSR and the dimensions of sustainability in sports organizations. After the research, based on which the questionnaire was built and formulated hypotheses, we conducted an empirical study using quantitative methods on sports organizations in Romania.

3.2. Measures

The evaluation tool is a questionnaire based on results of other empirical studies on CSR and sustainability [4,42–45]. The questionnaire containing 30 items addresses an essential category of stakeholders for any organization, especially critical to sports organizations: employees. Of the 30 items, 4 items represent sport-related variables: sports area (football, handball, volleyball, and basketball), the league in which the sports club is located (first or second), the type of employee activity (sports or support activities), and the position (manager or subordinate). The other 26 items include CSR responsibilities (economic, legal, ethical, and philanthropic), the dimensions of sustainability (economic, environmental, social, and human), and the overall performance of the sports organization. In addition, we added three aggregate variables (corporate social responsibility and overall

performance). We calculated corporate social responsibility (CSR) and sustainability (S) as averages of the items allocated to corporate social responsibility and sustainability, respectively. The overall performance of sports organizations is a hybrid construct of employee perception (measured on an increasing scale from 1 to 25), the organization's financial situation, the position in the league standings, and the number of declared fans of the team managed by the sports organization. Data collected from employees on their perception of performance were summed with points awarded (maximum 25 points) by researchers based on data collected about sports organizations. Appendix A (Table A1) presents the questionnaire structure.

We performed another test by calculating Guttman's Lambda coefficient (λ) to test the reliability. The values of λ_2 (a measure similar with Cronbach's alpha) and λ_3 are the most used in performing statistical reliability tests [45]. Table 1 shows the values recorded by Guttman's Lambda coefficient (λ) for the 29 items.

Table 1. Guttman's Lambda (λ) values.

Coefficient	Value
Lambda 1	0.837
Lambda 2	0.902
Lambda 3	0.867
Lambda 4	0.810
Lambda 5	0.916
Lambda 6	-
Items	29

Both values recorded by Gutmann's coefficients λ_2—0.902 and λ_3—0.867, respectively) show good reliability of the variables that make up the questionnaire, allowing for the recording of relevant and replicable results [45]. Table 2 shows the detailed reliability for each item.

Table 2. Detailed reliability scores.

	Scale Mean If Item Deleted	Scale Variance If Item Deleted	Corrected Item—Total Correlation	Cronbach's Alpha If Item Deleted
EcR1	191.80	226.626	0.585	0.861
EcR2	191.85	239.927	−0.087	0.871
EcR3	192.20	227.939	0.434	0.863
EcR4	191.95	229.038	0.558	0.862
EcR5	191.55	233.583	0.263	0.866
LeR1	192.00	217.576	0.696	0.856
LeR2	191.85	231.038	0.298	0.865
LeR3	192.20	237.232	0.090	0.868
EtR1	191.45	233.785	0.247	0.866
EtR2	192.25	233.826	0.196	0.867
EtR3	191.85	227.098	0.689	0.861
EtR4	192.10	224.636	0.689	0.859
EtR5	191.75	237.967	0.026	0.869
PhR1	192.00	215.152	0.743	0.855
PhR2	192.15	215.482	0.870	0.853
PhR3	192.35	230.028	0.560	0.863
PhR4	192.10	230.899	0.293	0.865
PhR5	192.25	226.755	0.476	0.862
EnR1	192.90	222.919	0.577	0.860
EnR2	191.90	232.616	0.217	0.866
EnR3	192.25	237.260	0.082	0.868
EnR4	192.35	230.028	0.560	0.863

Table 2. *Cont.*

	Scale Mean If Item Deleted	Scale Variance If Item Deleted	Corrected Item—Total Correlation	Cronbach's Alpha If Item Deleted
SoR1	192.20	215.515	0.852	0.854
SoR2	192.75	216.553	0.827	0.854
SoR3	192.30	225.465	0.524	0.861
SoR4	192.40	212.162	0.848	0.852
P	115.35	138.513	0.711	0.909
CSR	188.20	224.202	0.385	0.863
S	188.35	208.210	0.774	0.851

The factor analysis highlighted six components in which the items that characterize the six types of responsibilities (economic, legal, ethical, philanthropic, environmental, social, and human). Table 3 shows the communalities and the rotated component matrix, built using the Varimax rotation method with Kaiser normalization (11 iterations in the rotation process).

Table 3. Rotated component matrix.

Communalities			Rotated Component Matrix					
			Component					
	Initial	Extraction	1	2	3	4	5	6
EcR1	1.000	0.873	0.948					
EcR2	1.000	0.962	0.923					
EcR3	1.000	0.974	0.907					
EcR4	1.000	0.878	0.809					
EcR5	1.000	0.827	0.678	0.522				
LeR1	1.000	0.944	0.600	0.592				0.419
LeR2	1.000	0.875		0.936				
LeR3	1.000	0.955		0.900				
EtR1	1.000	0.696	0.387	0.798				0.357
EtR2	1.000	0.852	0.499	0.643			0.441	
EtR3	1.000	0.923			−0.872			−0.361
EtR4	1.000	0.755			−0.859		0.376	
EtR5	1.000	0.951	0.490	0.478	0.696			
PhR1	1.000	0.944	0.490	0.478	0.696			
PhR2	1.000	0.966	0.551	0.430	0.572			
PhR3	1.000	0.987				−0.853	0.323	
PhR4	1.000	0.752				−0.714		
PhR5	1.000	0.958	0.575			0.645		
EnR1	1.000	0.927	0.630			0.639		
EnR2	1.000	0.945	0.341		−0.540	0.596		
EnR3	1.000	0.903	0.460		−0.493	0.545		0.433
EnR4	1.000	0.987					0.828	
SoR1	1.000	0.932		0.366			−0.766	
SoR2	1.000	0.918			−0.464		0.661	
SoR3	1.000	0.931		0.478				0.726
SoR4	1.000	0.870			0.321		−0.475	0.706

3.3. Selected Sample

To carry out the research, we selected the sports clubs from Romania from the most important sports areas. The researched population consists of all the employees of these sports clubs operating in the first and second leagues in selected sports areas. The sampling method was stratified sampling. For stratification, we used demographic and sport related variables: sports area, league, type of activity, and position. Within the layers, we used random sampling. According to the defined demographic and sport related variables,

the initial sample was composed of 294 individuals—employees of sports organizations. However, from the questionnaires received, we removed 14 due to their partially filled questionnaire (more than a quarter of the questions remained unanswered), resulting in a sample of 280 respondents. Therefore, the sample follows the structure of the population demographic and sport-related criteria; the sampling error is 4.3% with a 95% level of confidence. Table 4 shows the sample frequencies based on demographic and sport-related variables.

Table 4. Descriptive statistics.

Area	**Frequency**	**Percent**	**Age**	**Frequency**	**Percent**
Football	84	30.0	18–30 years	68	24.0
Handball	70	25.0	31–45 years	94	34.0
Volleyball	70	25.0	46–60 years	95	34.0
Basketball	56	20.0	over 60 years	23	8.0
Total	280	100.0			
League	**Frequency**	**Percent**	**Gender**	**Frequency**	**Percent**
1	126	45.0	Male	114	76.0
2	154	55.0	Female	66	24.0
Total	280	100.0			
Activity	**Frequency**	**Percent**	**Position**	**Frequency**	**Percent**
Sport	84	30.0	Managerial	70	25.0
Support	196	70.0	Subordination	210	75.0
Total	280	100.0		280	100.0

Respondents assessed their perceptions of CSR responsibilities and the dimensions of sustainability within the organization where they are employed. We measured all items using a Likert scale with five response options (1—total disagreement with the allegation, 2—partial disagreement with the allegation, 3—neutral position on the allegation, 4—partial agreement with the allegation, and 5—complete agreement with the allegation).

3.4. Empirical Analysis

To establish the relationships between the variables and the selected influences, we used quantitative research methods in a transversal analysis to test the hypotheses articulated based on the literature review and our observations in sports organizations. The methods used in the research were structural equation modeling and analysis of artificial neural network (to identify the influences in a multivariable set), which are methods used by other authors to determine the influences of the independent variables on dependent variables [10,46–48]. We used structural equation modeling to test substantive theories, which infers observable and latent variables [46–50]. Latent variables cannot be measured directly by a visible variable, making it necessary to consider structural equation modeling [51].

Structural equation modeling is based on Equation (1) [52]:

$$\eta = B\eta + \Gamma\xi + \zeta \quad (1)$$

where:

η, ξ—endogenous and exogenous latent variables;

B—matrix of regression coefficients relating the latent endogenous variables to each other;

Γ—matrix of regression coefficients relating the endogenous variables to exogenous variables;

ζ—disturbance.

Artificial neural network analysis uses a multilayer perceptron (MLP) [53], with Formula (2):

$$y = (\sum_{i=1}^{n} w_i x_i + b) = \varphi(W^T X + b) \quad (2)$$

where:

b—bias;
w, x—vectors of weights and inputs;
φ—activation function.

4. Empirical Results

To test the hypotheses established starting from the research purpose, we used structural equation modeling (SEM) applied to the data collected from the sample selected using the SmartPLS v3.0 software. The conceptual model applied to the collected data is shown in Figure 2.

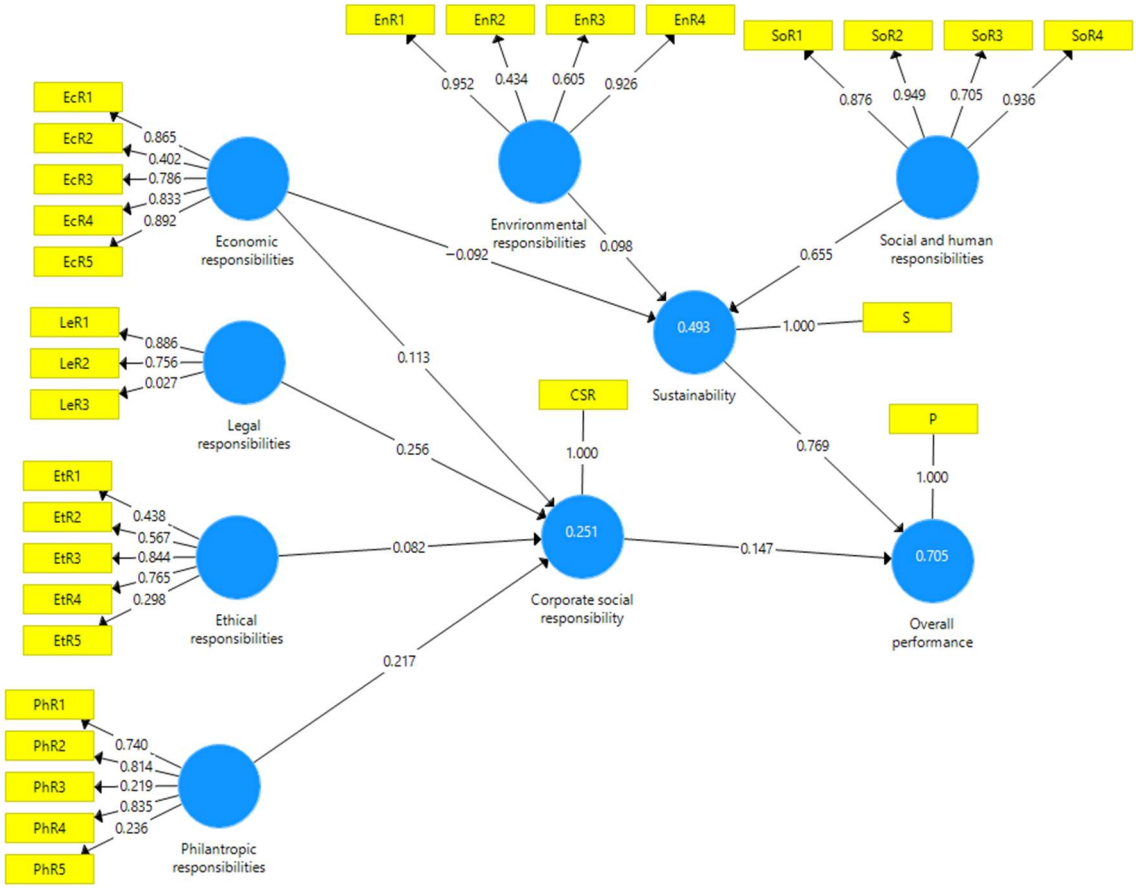

Figure 2. The conceptual framework applied to collected data. Source: developed based on collected data using SmartPLS v3.0.

To increase the model's validity and reliability, those items with a load of less than 0.7 must be removed [54]. Figure 3 shows the improved model by eliminating items that reduce validity and reliability.

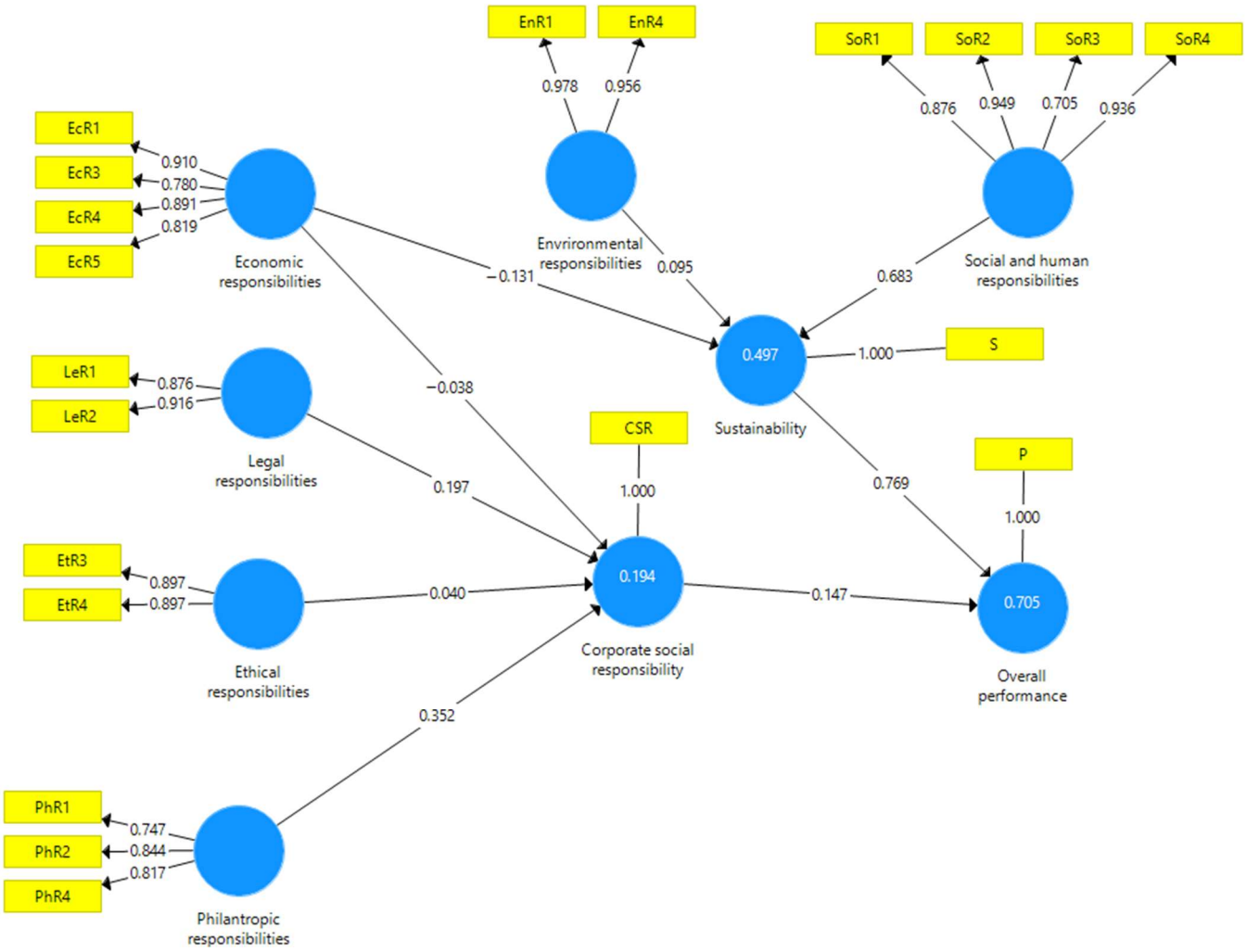

Figure 3. Improved applied model. Source: developed based on collected data using SmartPLS v3.0.

Table 5 shows the validity and reliability of the model after eliminating the items that were not compatible with the other questionnaire items. Again, one can observe the model's high validity and reliability: Cronbach's alpha coefficients are all over 0.7, composite reliability recorded values over 0.8, and average variance extracted records values over 0.6 [55].

Table 5. Model reliability and validity.

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted
Corporate social responsibility (CSR)	1.000	1.000	1.000	1.000
Economic responsibilities (EcR)	0.875	0.904	0.913	0.725
Environmental responsibilities (EnR)	0.933	1.014	0.966	0.935
Ethical responsibilities (EtR)	0.758	0.758	0.892	0.805
Legal responsibilities (LeR)	0.757	0.774	0.891	0.803
Overall performance (P)	1.000	1.000	1.000	1.000
Philanthropic responsibilities (PhR)	0.759	0.736	0.845	0.646
Social and human responsibilities (SoR)	0.896	0.952	0.926	0.761
Sustainability (S)	1.000	1.000	1.000	1.000

The evaluation of discriminant validity is an essential condition for the model validity. Table 6 shows the Fornell–Larcker matrix, in which the main diagonal is the square root of the AVE. Below are the values of the inter-correlation coefficients of the latent variables.

Table 6. Assessment of discriminant validity using the Fornell–Larcker criterion.

	CSR	EcR	EnR	EtR	LeR	P	PhR	SoR	S
CSR	1.000								
EcR	0.269	0.852							
EnR	−0.092	0.197	0.967						
EtR	0.319	0.442	0.583	0.897					
LeR	0.266	0.399	0.528	0.364	0.896				
P	0.464	0.444	0.298	0.710	0.291	1.000			
PhR	0.394	0.598	0.273	0.635	0.196	0.625	0.804		
SoR	0.240	0.504	0.763	0.772	0.583	0.634	0.703	0.872	
S	0.413	0.233	0.591	0.722	0.435	0.829	0.424	0.690	1.000

Table 7 shows path coefficients to illustrate the significance of the established influences between the model variables.

Table 7. Path coefficients.

	Path	Coefficients	T-Statistics	*p*-Values
H1	Economic responsibilities -> Corporate social responsibility	−0.033	0.293	0.770
	Legal responsibilities -> Corporate social responsibility	0.197	1.303	0.071
	Ethical responsibilities -> Corporate social responsibility	0.040	0.366	0.714
	Philanthropic responsibilities -> Corporate social responsibility	0.352	2.954	0.003
H2	Economic responsibilities -> Sustainability	−0.131	1.694	0.091
	Environmental responsibilities -> Sustainability	0.095	1.133	0.237
	Social and human responsibilities -> Sustainability	0.633	7.842	0.000
H3	Sustainability -> Overall performance	0.769	19.352	0.000
	Corporate social responsibility -> Overall performance	0.147	2.566	0.011

Studying the data from Table 7 and Figure 3, we see that the H1 hypothesis is partially confirmed. Employees of sports organizations included in the research sample consider that philanthropic and legal responsibilities are the most important in terms of social responsibility by the organization. The research of the H2 hypothesis led to its confirmation. In the perception of the sports organizations' employees, the most important dimension of sustainability is the social and human one, which was to be expected, given the subjectivism of the respondents. The third hypothesis (H3) is also confirmed. The two constructs (social responsibility and sustainability) positively influence the overall performance of sports organizations, sustainability being more critical in the perception of sports organizations' employees.

To consolidate the research results regarding the influence of social responsibility and sustainability on the total performance of sports organizations, we applied an analysis of artificial neural networks. The model used was MLP, which allows for the establishment of relationships between input variables and output variables through a hidden layer. In our research, we used the two constructs (social responsibility and sustainability) as input variables, the output variable the overall performance of sports organizations. The hidden layer is represented by the perception of sports organizations' employees. The model

also involves external factors acting through biases on the hidden and output layers. The hyperbolic tangent type activates the hidden and output layers from the upstream variables. The formula for this type of function is as follows (Formula (3)):

$$f(n) = \frac{e^n - e^{-n}}{e^n + e^{-n}} = \frac{e^{2n} - 1}{e^{2n} + 1} \quad (3)$$

n—input variable;
f(n)—output variable.

Figure 4 shows the diagram of the relationships established in the MLP model between the input and output variables.

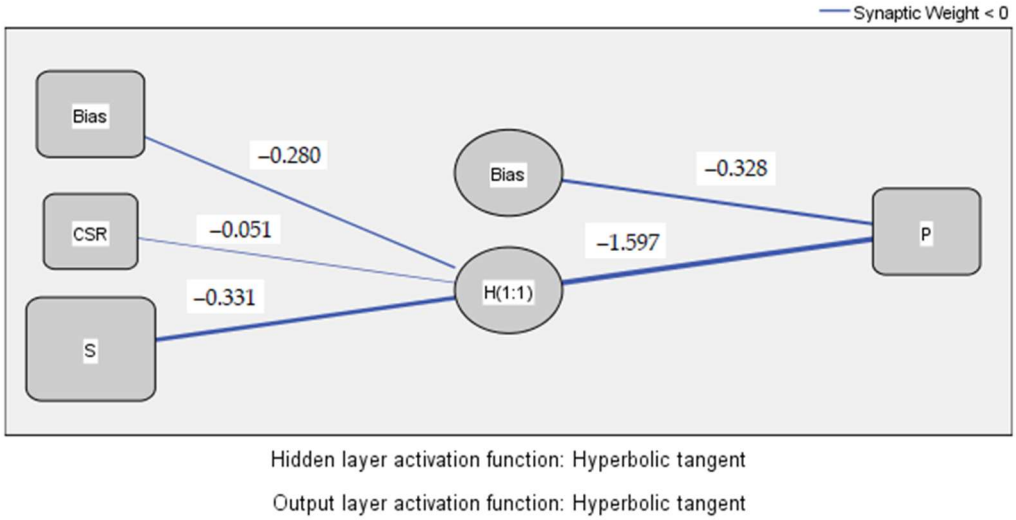

Figure 4. MLP model on overall performance. Source: developed using SPSS v.20.

The analysis of Figure 4 and the data in Table 8 reveals the existence of significant influences of social responsibility and sustainability on the overall performance of sports organizations. Therefore, the H3 hypothesis is also confirmed. A decrease in the level of social responsibility and ensuring sustainability has a strong influence in decreasing the performance of sports organizations. The bias on the hidden layer has a significant influence, indicating the impact of external factors of the model on the perception of sports organizations' employees. The bias on the exit layer has a relatively small influence compared to the influence of the hidden layer, highlighting the importance of the perception of sports 'organizations' employees in terms of social responsibility and ensuring organizational sustainability.

Table 8. The predictors of the MLP model.

Predictor		Predicted	
		Hidden Layer 1	Output Layer
		H(1:1)	Performance
Input Layer	(Bias)	−0.280	
	CSR	−0.051	
	S	−0.331	
Hidden Layer 1	(Bias)		−0.328
	H(1:1)		−1.597

Figure 5 shows the absolute and normalized importance calculated for the input variables in terms of the influence on the output variable through the hidden layer.

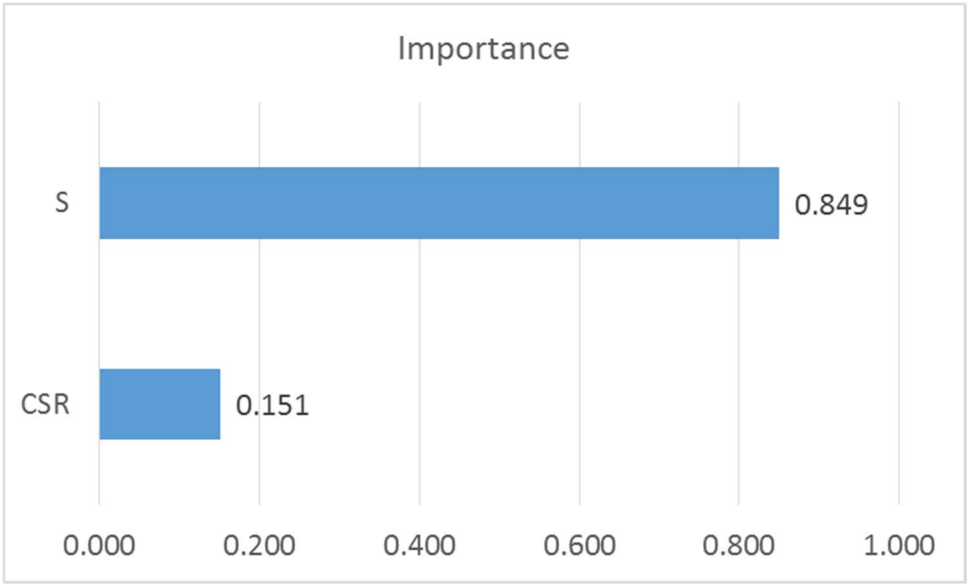

Figure 5. Importance of variables from MLP model. Source: developed using SPSS v.20.

Both constructs (social responsibility with absolute importance of 0.151 and relative importance of 17.7% and sustainability with the fundamental importance of 0.849 and relative importance of 100%) have a positive influence on the overall performance of sports organizations, with sustainability being more critical in the perception of sports organizations' employees.

5. Discussion

Many people on the planet consider sports to be a part of their lives [56]. Therefore, sports organizations can use their abilities to influence a large mass of people to solve several social problems, thus contributing to the welfare and well-being of society [57]. Research on CSR social responsibility initiatives has focused on CSR initiatives implemented by local [51,58] or national [59] leagues and on the benefits of the communities where these sports activities occur. Smith and Westerbeek [38] support the encouragement of implementing social responsibility in sports organizations, giving the possibility to increase equity and diversity and improve social relations. Zeimers et al. [39] propose that sports organizations use organizational learning to increase social responsibility. Accepting the environmental dimension of sustainability by the employees of sports organizations aligns with previous research findings [20,38–40,50]. The changing values determine the emphasis on care for the environment in sports organizations in society and the increased commitment of employees to the expectations of several external stakeholders. Caring for the environment can also bring economic benefits, strengthening legitimacy [42]. In a similar way to [4], we combined the model of sustainable development offered by the Triple Bottom Line approach with its multidimensional model [17] on social responsibility. The ultimate goal of improving social responsibilities and a sustainable approach to performance is to increase profitability and ensure sustainability, making significant contributions to society [60]. Rowe et al. [41] propose community-focused activities undertaken by professional sports teams to turn CSR into a vector for community development.

Additionally, following the research, we found that the support of cultural and social events in the community, support for NGOs, contribution to health and well-being in the community, and solving social problems are essential factors in the philanthropic responsibility of sports organizations. Furthermore, as [61] charitable events note, CSR is the most popular practice in professional sports organizations. These findings are in line with the results obtained by [4,56], according to which sports organizations are already dedicated to promoting community activities that have a positive impact on society.

Walters [39] also identified the community sports trust model as an ideal vehicle for an organization to meet its social objectives.

Social responsibility and sustainability initiatives are essential strategic components used by organizations to improve their image and reputation. Compliance with the rules, regulations, and legal norms provides stability and credibility, making legal responsibilities important in employees' perception of CSR. Ensuring that operation meets all legal standards seems to be an essential factor in the legal obligation of sports teams. Rules and regulations defend the majority's interests, respecting them and ensuring all organizations' smooth running [17,18]. Regarding sustainability and environmental protection, the attempt to use renewable resources for sustainable development are essential factors in guaranteeing the solid sustainability of sports organizations. Our research results are in line with findings from other studies [4,43,44], highlighting the relationship between sports and the environment.

5.1. Theoretical Implications

Sustainable management of sports organizations can be achieved by assuming social responsibilities and ensuring sustainable development. Implementing social responsibility and sustainability in sports organizations allows them to return some of their benefits to the community. Using sports as a means to increase social responsibility and sustainability is an opportunity for both responsible sports organizations and those in other fields who use sports in their efforts to contribute to communities.

Our paper aimed to provide an integrated conceptual model for studying the assumption of responsibilities in CSR and the application of the dimensions of sustainability in sports organizations. This model superimposes social responsibilities and sustainability dimensions providing a theoretical framework for their combined implementation. The results of this paper support the findings of other researchers on the importance of taking social responsibility and ensuring the sustainability of sports organizations [24,38,59,61]. However, more research is needed on how CSR and sustainability can be applied in an integrated way, especially the effects on overall performance, leading to emulation among the employees of sports organizations.

5.2. Practical Implications

Managers of sports organizations can carry out sustainable management if they are aware of the assumption of social responsibilities (economic, legal, ethical, and philanthropic) and the need to implement the three dimensions of sustainability: economic, social, and environmental. Although corporate social responsibility is an accepted concept in most corporations, the social responsibilities of sports organizations are underdeveloped. This paper aims to make these responsibilities transparent and superimpose them on sustainability dimensions. Furthermore, sport is a social activity that attracts many individuals to propose a change in communities and contribute to the sustainable development of society. Therefore, corporate managers and sports managers can combine economic, social, and environmental responsibilities by maximizing the social benefits of sustainable management to society.

To conduct the research effectively, we developed a tool for measuring and evaluating CSR and sustainability, which we applied within sports organizations in various areas and leagues in Romania. One of the results of this study is the confirmation of the multidimensional nature of a sports organization's social responsibility and sustainability, in line with the results of previous research [4,61–63]. The study was conducted on the perception of employees of sports organizations, the most important internal stakeholder. Their perceptions show that the most critical responsibilities of a sports organization are legal and philanthropic, and the dimensions of sustainability, both social and human, are particularly distinct. This result is also affected by a single category of stakeholders (employees). Therefore, managers of sports organizations can use the tool to increase the degree

of commitment of employees in the field of social responsibility and their involvement in ensuring the organization's sustainability, as the basis of sustainable management.

6. Conclusions

More and more organizations operating in the world of sport are addressing various forms of social responsibility in recent decades. Managers of sports organizations find resources for these actions in financial benefits [64], improving image and reputation [56,57], fan loyalty [57,65], and attracting potential talent [66]. In addition, sports organizations have deep roots in their communities, which has led them to adopt CSR as a standard practice [67,68]. However, social responsibility is an asset for the organization if management communicates CSR actions effectively to inform stakeholders and influence their perceptions [57,69].

The paper seeks to provide a theoretical model and a practical tool for measuring and evaluating the social responsibility and sustainability of sports organizations. However, this paper has some limitations, which can be opportunities for future research. First, the applied research tool (questionnaire) included 30 items established following the literature analysis. Of the 30 items, we removed 5 items after studying the validity of the sample selected from the employees. Considering several categories of stakeholders in future research will increase the validity and reliability of the proposed instrument, allowing for more detailed and more accurate results. Secondly, the collection of data in only four areas of sport and two categories of leagues does not allow for the extrapolation of the results of this research to the level of all sports organizations. Future studies on representativeness criteria are needed to enable such an extrapolation of results. Thirdly, a limitation derived from this research's cross-cutting nature, which does not assess employees' perceptions of differences in different periods. A future direction of research may be to conduct a longitudinal study. Therefore, it would be interesting to repeat the study once the sports industry has recovered. In conclusion, the paper provides a generous research framework that can lay the groundwork for further investigations to confirm the results and expand the conceptual framework on social responsibility and the sustainability of sports organizations.

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Appendix A

Table A1. The structure of the questionnaire.

Construct	Variable	Code
Sport-related variables	Area	Area
	League	League
	Activity	Act
	Position	Pos
Economic responsibilities	Fans' satisfactions	EcR1
	Fans' increasing actions	EcR2
	Long-term success	EcR3
	Cost management	EcR4
	Maximize profits	EcR5
Legal responsibilities	Compliance with the law	LeR1
	Compliance with the rules and regulation	LeR2
	Respecting the rights of fans	LeR3
Ethical responsibilities	Fair play in the competitions	EtR1
	Compliance with the ethical values	EtR2
	Accountability to fans' needs and demands	EtR3
	Data protection and privacy	EtR4
	Avoiding unethical behavior	EtR5
Philanthropic responsibilities	Supporting community events	PhR1
	Supporting NGOs	PhR2
	Supporting community health and wellness	PhR3
	Helping social cases	PhR4
	Improving the community welfare	PhR5
Environmental responsibilities	Protect the environment	EnR1
	Environmental awareness training for fans	EnR2
	Using of renewable resources	EnR3
	Sustainable development	EnR4
Social responsibilities	Employee engagement	SoR1
	Gender and diversity	SoR2
	Human rights	SoR3
	Labor standards	SoR4
Overall performance	Performance	P

Source: developed by authors based on [4,38–40].

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Article

Self-Esteem, Individual versus Team Sports

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Abstract: On the basis of the integrative concept of self-esteem discussed in sport-related literature, various studies refer to its importance in the context of sports activities. Self-esteem is often understood as a personality trait because it tends to be durable and stable. No accurate description is available regarding the types of sports in which subjects participated. The main purpose of the research was to identify and compare the levels of self-esteem and self-confidence of athletes practicing individual and team sports. The self-esteem and self-confidence levels were measured by the Rosenberg Self-Esteem Scale (Rosenberg 1979) and the Self-Confidence Test (Romek, 2000). All participants were males. Subjects were divided into two categories: 40 for individual sports and 40 for team sports. There were two evaluation periods: P1, the beginning of the preparation period, and P2, the beginning of the competition period. There were statistically significant differences for P1 ($p < 0.002$) and P2 ($p < 0.003$). The differences between the average values of the two periods were 5.8 points and 3.8 points, both favorable to the group of athletes who practiced individual sports. There were significant differences between the individual and team athletes in self-esteem level. Individual athletes presented a higher level of self-esteem.

Keywords: self-esteem; individual sport; team sport

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1. Introduction

While watching sports competitions, it can be often seen that athletes are satisfied with victory, unhappy in cases of failure, and excited to compete again regardless of the result. Athletes do not seem to give up. The efforts they show are great, involving sacrifices on various levels, such as being 100% involved in the training, forgetting about themselves and others, not having enough time to spend with family and friends or to socialize, etc. It seems that nothing can stop them from their desire to participate and win sports competitions. Are all athletes the same, regardless of their sport? Do they all see themselves as winners? Self-esteem refers to the personal value that each individual gives himself or, in other words, how much a person likes and appreciates himself or herself. Self-esteem is often understood as a personality trait because it tends to be durable and stable. For this concept, Mullai et al. [1] used synonymous terms, such as pride, self-worth, self-regard, self-respect, and self-integrity. Rosenberg [2] defined self-esteem as a complex cognitive and affective synthesis. He also distinguished between high self-esteem (positive) and low self-esteem (negative). Higher self-esteem is more often associated with success in all areas of life, and low self-esteem is considered to imply depression and anxiety [3–5].

On the basis of the comprehensive analysis, some specialists [6,7] consider that self-esteem constitutes a complex psychological construct that concerns four distinct dimensions: basal physics (the body ego); complementary valorization components, including emotional–affective; cognitive; and a broad social dimension. These four sectors seem to be unevenly developed and are considered the main reason why we feel the urge to maximize our potential and successes and, on the other hand, to minimize personal deficits and shortcomings. Self-esteem has as its core the self, which constitutes both the confluence area of the four dimensions mentioned above and the impetus that drives and coordinates the resources of each one. Butler and Gasson [8] drew attention to the fact that self-esteem becomes difficult to conceptually delimit because, in the specialized literature, the term in question has been extended to self-worth, self-belief, self-concept, self-awareness, and self-image. This aspect makes it quite challenging to include all these visions in a complete and universally accepted definition.

On the basis of the integrative concept of self-esteem discussed in sports-related literature, various studies refer to its importance in the context of sports activities. D'Anna et al. [9] conducted a study measuring self-esteem in several categories of athletes (n = 78). The general conclusion of this research highlighted the fact that no gender differences were reported, and the subjects with high self-esteem had the ability to perform much better in high-performance sports. The competition itself has the effect of consolidating an increased level of self-esteem as well. Another study [10] covered all sports participation, and the role of gender in predicting self-esteem was assessed. The research pointed out that there were no gender differences concerning self-worth, while it was noted that females reported high self-esteem when participating in several non-competitive sports. No further accurate description is available regarding the types of sports in which the subjects participated. Our study aimed to identify this aspect more precisely, particularly the possible connections between the categories of sports (with close specific characteristics) and the athletes' levels of self-esteem.

Numerous studies evidence the beneficial impact of exercise (different types over different periods) on self-esteem [11–15]. In a synthesis effort, the main characteristic that refers to individual sports is that the athletes can target personal performance goals without responsibility to the team [16,17]. The athlete can progress at his own pace; he needs independence, self-discipline, perseverance, and self-control. In cases of success, the credit belongs entirely to him, but he can find no other reason but himself when he fails. Many sports need an individual approach, e.g., athletics, swimming, fencing, gymnastics, wrestling, skiing, skating, golf, and tennis. Practicing an individual sport promotes the development of self-respect and the focus of attention, but it can also cause difficulties when competitions are lost. In these situations, there may be a problem related to faith in their own skills.

A vital element of all team sports is team spirit, which includes cooperation, trust, and respect, regardless of personal performance level. Teammates feel success and failure equally. Team sport involves the excellent opportunity to socialize, but at the same time, they might initiate rivalries between teammates, with a negative impact on both individuals and the team. In general, the complexity of these sports is notable because of the higher number of participants. The game responsibilities are most often divided unequally depending on the athlete's possibilities, skills, and roles. The teammates can substitute themselves, help and support each other, and coordinate their actions in a unitary way toward achieving the team's goal. Important determinants are effective communication, perseverance, patience, and altruism. Numerous sports require a team approach, e.g., football, basketball, hockey, handball, volleyball, and rugby. Experts assume that significant personality differences exist between the two categories of athletes [18–21].

It is hypothesized that the level of self-esteem differs regarding the type of sport practiced, especially when discussing individual and team sports and the interactions that occur in sports activities. Our research aimed to identify and compare the self-esteem levels of athletes who practice individual sports and those who practice team sports. The

general objective was to verify if and how much the type of sport practiced affects the level of self-esteem.

2. Materials and Methods

2.1. Participants

Eighty senior-level male Romanian athletes (age = 22 years, SD = 2.31, age range: 18–26 years) who had been practicing the sport for 10–15 years were distributed as follows: 40 athletes—individual sports group (8 alpine skiing, 4 cross-country skiing, 2 biathlon skiing, 15 contact sports, 6 tennis, and 5 athletics) and 40 athletes—team sports group (14 soccer, 6 basketball, 12 handball, 3 volleyball, and 5 hockey). The athletes were members of various sports clubs in Romania that activated the first league. We chose to use only men in this research because the priority of the research was to show the difference between individual and team sports, not to combine gender. The training schedules differed according to the training periods; in the competition period, athletes trained 8 hours/week, and in the preparation period, they trained 16 hours/week. Group sampling was adopted. The participants signed informed consent before data collection. Responses were anonymous to ensure confidentiality.

2.2. Materials and Procedures

All athletes included in the research completed a battery of specific scales to investigate the self-esteem level. The paper-and-pencil method was applied to complete the scales. The participants were questioned during two distinct periods: P1, the beginning of the training period, and P2, the beginning of the competition period. Considering the variety of sports and the different competition calendars for specific disciplines, the time difference between P1 and P2 was 2 months (60 days) on average. During the interval between P1 and P2, the athletes focused on performing the training. The participants had different coaches depending on the sports discipline they practiced. There were no planned (intentional) interventions with actions that could affect the increase or decrease of self-esteem. No athletes had sports competitions during this time. Self-esteem was measured by the following specific psychological tools:

Rosenberg Self-Esteem Scale, which comprises 10 items of four response variants between Total Disagreement (1 point) and Total Agreement (4 points). Scores are presented in the range of 10–40 points, and when rating the answers, the following classification of values was utilized as a standard: Low self-esteem (10–16 points); Average self-esteem (17–33 points), High self-esteem (34–40 points) [2], α = 0.82—value calculated for the sample of athletes.

Self-Confidence Test: includes 30 items, 10 for each of the following three scales: self-confidence (α = 0.91), social courage (α = 0.82), and initiation of social contacts (α = 88). Values of (α) were calculated for the sample of athletes. There are 3 answer variants possible for each item. The value can be 1, 2, or 3 points [22].

2.3. Statistical Analysis

Statistical analysis was performed by the IBM SPSS statistics program (IBM Corp., version 26.0; Inc., Chicago, IL, USA). Means $\pm$ standard deviation were calculated for each outcome measure. Independent *t*-tests were used to assess differences between the individual and team sports groups for P1 and P2 with significance set at $p < 0.05$; separate dependent-sample *t*-tests were used to assess differences between periods for the individual and collective sports groups with significance set at $p < 0.05$.

3. Results

The statistical analysis presented in Table 1 reports significant differences between the two categories of athletes for P1 ($p < 0.002$) and P2 ($p < 0.003$). The differences between the two periods' average values were 5.8 points and 3.8 points, both favorable to the individual sports athletes. Analysis at the intra-group level reported increased self-esteem

in P2 compared with P1 for both groups. The difference regarding the average obtained in the case of individual sports between the two testing periods had a value of 4.4, and in terms of team sports, the value obtained was 6.4. The overall summary shows that the individual sports athletes obtained the highest score (32.20 points) at P2, and the lowest score (22 points) was observed in P1 for athletes practicing team sports. A decrease in the standard deviation was present for P2 in both categories of sports. Individual sports had an SD of 3.15 in P1 and an SD of 1.98 in P2. For team sports, the SD was 3.91 in P1, and the SD was 2.95 in the period of testing P2.

Table 1. Results obtained for Rosenberg Self-Esteem Scale.

Sports	Testing Periods	*N*	Mean ± SD	S Error M	*t*	*p*
Individual	P1	40	27.80 ± 3.15	0.99	3.73	0.002
	P2	40	32.20 ± 1.98	0.62		
Team	P1	40	22 ± 3.91	1.24	4.13	0.001
	P2	40	28.40 ± 2.95	0.93		
Individual vs. Team	P1	80	27.80 ± 3.15	0.99	3.64	0.002
			22 ± 3.91	1.24		
Individual vs. Team	P2	80	32.20 ± 1.98	0.62	3.37	0.003
			28.40 ± 2.95	0.93		

P1—period 1; P2—period 2; *N*—number of participants; differences in Rosenberg Self-Esteem Scale between groups and periods are presented as means ± standard deviation. $p < 0.05$—significant difference.

According to the data presented in Table 2, the component "self-confidence" showed statistically significant differences between the two groups of athletes, both for P1 ($p < 0.010$) and P2 ($p < 0.027$). These values of the significance threshold were below 0.01 and 0.05, respectively. Progress of 1 point for individual sports and 1.4 points for team sports was observed between the two testing periods. The "social Courage" component revealed no relevant differences between the two categories of athletes analyzed. The component "initiation of social contacts" presented significant differences between the studied groups. For both the P1 and P2 periods, the group of athletes practicing individual sports presented higher values of the means expressed by $p < 0.010$ and $p < 0.018$, respectively. The progress in scores between P1 and P2 was 0.9 points for individual sports and 1.2 points for team sports.

Table 2. The results obtained in the Self-Confidence Test.

Scale	Sports	Testing Periods	*N*	Mean ± SD	S Error M	*t*	*p*
Self-confidence	Individual	P1	40	8 ± 1.15	0.36	2.02	0.058
		P2	40	9 ± 1.05	0.33		
	Team	P1	40	6.50 ± 1.17	0.37	2.81	0.010
		P2	40	7.90 ± 0.99	0.31		
	Individual vs. Team	P1	80	8 ± 1.15	0.36	2.87	0.010
				6.50 ± 1.17	0.37		
	Individual vs. Team	P2	80	9 ± 1.05	0.33	2.40	0.027
				7.90 ± 0.99	0.31		
Social courage	Individual	P1	40	7.70 ± 1.63	0.58	0.16	0.879
		P2	40	7.80 ± 1.22	0.38		
	Team	P1	40	7.10 ± 1.10	0.35	0.44	0.669
		P2	40	7.30 ± 0.94	0.30		
	Individual vs. Team	P1	80	7.70 ± 1.63	0.58	0.92	0.349
				7.10 ± 1.10	0.35		
	Individual vs. Team	P2	80	7.80 ± 1.22	0.38	1.02	0.322
				7.30 ± 0.94	0.30		
Initiation of social contacts	Individual	P1	40	8 ± 1.15	0.36	1.96	0.065
		P2	40	8.90 ± 0.87	0.27		
	Team	P1	40	6 ± 1.88	0.59	1.42	0.171
		P2	40	7.20 ± 1.87	0.69		
	Individual vs. Team	P1	80	8 ± 1.15	0.36	2.86	0.010
				6 ± 1.88	0.59		
	Individual vs. Team	P2	80	8.90 ± 0.87	0.27	2.60	0.018
				7.20 ± 1.87	0.69		

P1—period 1; P2—period 2; *N*—number of participants; differences in Rosenberg Self-Esteem Scale between groups and periods are presented as mean ± standard deviation. $p < 0.05$—significant difference.

4. Discussion

We conclude that the individual sports category subjects had a higher level of self-esteem than the athletes practicing team sports. This confirms the primary hypothesis of our research. A possible explanation of this fact might be the impact connected with some specific characteristics of the respective sports category on the development of those who practice it, especially in the sphere of the individual's personality. In individual sports, the effort, pressure of competition, and actions taken based on the sport's success or failure belong to the athlete. The athlete is aware of this aspect, he is prepared from a mental point of view, and he is supported and motivated in this direction by the people close to him (the coach, staff, and family). All participants evaluated in the study had been practicing their respective sports for a long time at the senior level, so there was a notable impact on individuals from a psychosocial perspective. The team sports category characteristics refer to the team as a social group. In team sports, only the leaders stand out, which draws attention to the fact that almost everything the other teammates do is transferred to the team. A part of the individual's issues are related to the team; the responsibilities and expectations are not always distributed equally among the team members. We believe that these aspects have determined the scores that manifested as the difference in self-esteem levels between the two sports categories. For both categories of athletes, it was observed that the level of self-esteem increased from P1 to P2. This interval marks the beginning of the training period and the beginning of the competition period. The tendency of self-esteem to increase shows that the athletes achieved their goals in basic training; progress was made, thus ensuring a fair, promising, and optimistic mood when starting competitions. The score value reflected an average level of self-esteem (at the upper limit of this standard level).

All these aspects also indicate realism, optimal confidence in one's strengths, and a competitive experience—a context in which exuberance and depression do not manifest. A particular aspect of the research was highlighted on the social courage scale within the Self-Confidence Test. Although the average level was higher for the individual sports category, no statistically significant differences between the two groups of athletes were reported. The level of social courage had no relevant changes between P1 and P2 for any athlete. It seems that this component has a stable tendency. It seems to be a constant within self-esteem, and it is not affected as the other two aspects are. This value scale was similar for all athletes, with no relation to the specificity of the sport practiced. From our perspective, knowledge of the athlete's level of self-esteem is an essential factor because it reflects the reliable self-evaluation of each athlete, with both positive and negative aspects. Only an optimal level of self-esteem can provide the necessary emotional background for the athlete. The optimal state is when an individual can train effectively to obtain the relevant sports results. Extreme levels of self-esteem (very high or very low) are harmful [23–25]. Although the subjects of our research were at appropriate stages, an aspect revealed by the average values, the identification of the "optimum" is made at the individual level; the calibration is performed on the basis of a detailed and personal analysis, with reference to individual particularities, expectations, possibilities, etc. The comparative approach (individual versus team sports) for self-esteem can bring benefits to the category of team sports as well. For example, if the coaches and staff believe that the team's self-esteem level is too low and that this could affect the sports performance, there is a possibility to solve this problem by adopting a training strategy and an approach specific to the individual sports. Since it was observed that those in the individual sports category had higher levels of self-esteem, a viable option would be the training known in the literature as individualized training [26–28]. It is necessary to take into account all the particularities of this type of training and the positive effects that can be obtained physically, technically, tactically, and psychologically by increasing self-esteem.

Çağlayan and Uçan [29] reported no significant differences in self-esteem scores between athletes and non-athletes based on the Rosenberg Self-Esteem Scale results. The same result was obtained for individual and team sport athletes and non-athletes. No significant

differences between male individual and team sports athletes in terms of their abilities to express emotions and self-esteem were reported by Akelaitis and Malinauskas [30]. On the basis of our findings, we reported significant differences between the individual and team athletes in self-esteem levels.

We mention the fact that the phrase "social courage" refers to a set of actions that involves certain risks, which are taken mainly for the benefit of others but also with reference to self for welfare and/or performance in various fields of activity [31,32]. The concept of initiating social contacts represents an individual's ability to develop social relationships with a great impact on long-term attitudes, behaviors, and perceptions [33].

We believe that self-esteem analysis in two sports categories makes the meanings a little too general, but this limitation may constitute future research ideas for which studies could involve fewer sports disciplines and include more participants. Another limiting aspect is that we did not control other factors that could have influenced self-esteem, positively or negatively, for the interval between P1 and P2. We will try to dedicate future research to these aspects to better understand the factors that might affect the athlete's self-esteem during specific training. The level of an athlete's self-esteem is valuable knowledge. The involvement of athletes in training and competition depends on this level, and it determines sports performance.

5. Conclusions

There are significant differences in self-esteem levels between individual and team athletes. It was noted that for both categories of athletes, the level of self-esteem increased between the two periods of investigation, which we consider positive, as it reflects the growing satisfaction of athletes in achieving short-term goals. Individual athletes presented higher levels of self-esteem. Self-esteem is an aspect that can be further analyzed, corrected, maintained, and stimulated for optimal performance in sports.

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Effect of 8-Week β-Alanine Supplementation on CRP, IL-6, Body Composition, and Bio-Motor Abilities in Elite Male Basketball Players

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Abstract: The purpose of this study was to evaluate the effect of 8-week β-alanine supplementation on C-Reactive Protein (CRP), interleukin-6 (IL-6), body composition, and bio-motor abilities in elite male basketball players. Twenty male basketball players (age: 23 + 0.6 years; body mass: 78.3 + 4.8 kg; height:185.3 + 5.4 cm, %BF, 15.2 ± 4.8) volunteered to participate in this study. They were divided into a β-alanine group (BG, N = 10) and a placebo group (PG, N = 10). All players were preparing for university competitions and had played for over five years. Players used 6.4 g/d of β-alanine in BG and maltodextrin in PG. The participants were involved in regular basketball training three months before the study. CRP, IL-6, body composition parameters, and bio-motor abilities were measured before starting the exercises and after completing the eight-week training period. The research findings showed a significant decrease in CRP and IL-6 and an increase in anaerobic peak power between the pre-test and post-test, as well as between BG and PG groups ($p < 0.05$). Although the other measured factors were a relative improvement compared to the pre-test and also compared to PG, these changes were not statistically significant ($p < 0.05$). Eight weeks of β-alanine supplementation ameliorated increases in IL-6 and CRP associated with in-season physical stressors in collegiate basketball players. These changes in pro-inflammatory cytokines suggest that β-alanine supplementation may be a useful nutritional strategy for immune regulation and can also improve anaerobic performance compared to PG.

Keywords: beta-alanine; pro-inflammatory; youth sports; performance; basketball

1. Introduction

Basketball is a multi-sprint sport that includes phases of a high-intensity activity such as sprinting, running, and jumping, less intense movements such as jogging and walking, and active or passive recovery [1]. According to studies, basketball players can run several kilometers throughout a game, including several high-speed forward and lateral movements and decelerations from frequent sprint efforts [2,3]. Each basketball player can make more than 50 vertical jumps per game [3]. In the men's elite competition, the maximum heart rate is up to 191 beats per minute, and the average heart rate in these

players is 171 beats per minute, or 91% of the maximum heart rate [2]. Data from the blood lactate levels of elite male and female basketball players show that anaerobic metabolism plays a significant role in providing energy in a basketball game. The mean blood lactate levels for male basketball players were 8.5 ± 3.1 mmol/L, and the mean for international women's games was 5.7 ± 2.1 mmol/L. Many activities in basketball are conducted at near-maximum intensities and with anaerobic capability [1,2]. Most play-related activities, on the other hand, are carried out at low to medium intensity (i.e., 40 to 50%) and are followed by recovery through aerobic energy pathways. Aerobic fitness may be more significant in recovery during frequent high-intensity intermittent exercise sessions rather than offering an immediate performance boost. Although the aerobic contribution to a short-term sprint is minor, it grows as the velocity is increased more frequently [4]. According to the results of studies, the average VO_{2max} value for female basketball players is about 44 to 54 mL/kg/min, and for male basketball players it is about 50 to 60 mL/kg/min. Although values vary by position, guards tend to have a higher aerobic capacity than centers [5,6].

Weekly micro-cycles of training, taper, competition, and recovery make up a competitive season. Due to involvement in local or international events, elite clubs may play different games during a weekly micro-cycle. The need for players to play two to three games each week increases the load placed on them, increasing the chance of injury and performance degradation due to tiredness, muscular damage, and/or inflammation [7]. Acute-phase inflammatory responses characterized by phagocyte infiltration into muscle, free radical generation, and increased cytokines and other inflammatory chemicals are linked to exercise-induced muscle injury. Tumor necrosis factor-alpha (TNF-α), interleukin 1-ß (IL-1-ß), and CRP are only a few of the blood biomarkers that have been employed as indicators of systemic inflammation [8,9]. The acute phase reaction to tissue injury is similar to the inflammatory response. Several cytokines implicated in inflammation, such as TNF-α, IL-1-ß, IL-6, and IL-10, are related to increased plasma levels after strenuous exercise [10].

The HPA axis is hypothesized to be stimulated by IL-6 as part of a natural negative feedback loop that enhances cortisol (an anti-inflammatory mediator) production from the adrenal cortex, while inhibiting pro-inflammatory cytokine release [9]. Furthermore, IL-6 has recently been linked to glucose homeostasis by indicating low muscle glycogen levels. Reduced glycogen availability, calcium homeostasis alterations, and increased reactive oxygen species production can activate transcription factors controlling IL-6 synthesis. Increased circulating IL-6 stimulates the creation of acute-phase proteins like C-Reactive Protein (CRP) in hepatocytes during inflammation [8]. Cortisol and cytokines cause muscle proteins to break down, releasing amino acids into the bloodstream, prompting hepatocytes to absorb these amino acids and synthesize new acute-phase proteins. Cortisol and IL-6 peaks in the circulation preceded CRP peaks in the current investigation, confirming similar findings. CRP elevation has been linked to monocyte activation and the production of adhesion molecules that attract leukocytes. Histidine is a necessary amino acid for protein synthesis in the liver, muscle glycogen storage, and tissue repair, all of which help to lower inflammatory markers like IL-6 and CRP [11]. Carnosine has also been shown to have antioxidant qualities, as well as stimulating effects on the immune system and neurotransmitters (L-carnosine lowers the neural activities of sympathetic nerves and enhances those of parasympathetic nerves) [12].

In basketball, there are anthropometric and bio-motor components. The anthropometric component measures the human body's composition and describes its proportions. Body weight, height, and fat thickness are all factors in the anthropometric component of basketball [13]. The five basic bio-motor abilities are strength, endurance, speed, flexibility, and coordination. Each exercise in training will tend to develop a particular motor ability. For example, when an exercise load is maximal, it is a strength exercise [14]. Basketball is a team activity that requires much physical fitness and strengthens many bio-motor abilities. Examples of bio-motor components in basketball include speed, agility, strength, coordination, and endurance [13]. Supplementing with β-alanine has been viewed as a

potential ergogenic enhancer, mainly for high-intensity sports like basketball, because it is a precursor to carnosine, the most effective intramuscular buffer [15]. B-alanine supplementation is an unnecessary amino acid that combines with the amino acid histidine to produce carnosine [16].

According to several studies, strenuous exercise increases the expression of various pro- and anti-inflammatory cytokines in the skeletal muscle and blood [17,18]. IL6 expression is up-regulated during the exercise-induced inflammatory process and has an anti-inflammatory effect, causing the release of anti-inflammatory interleukins such as IL10 and reducing TNF-α production [19]. Exogenous supplementation of β-alanine has been proven in vitro and in animal models to raise muscle carnosine concentration [20]. Also, they showed that consumption of β-alanine resulted in a considerable rise in carnosine levels in skeletal muscles, which was linked to better exercise performance [20].

This study aimed to evaluate if 8 weeks of β-alanine supplementation (6.4 g/d) had any effect on the synthesis of exercise-induced cytokines, particularly CRP and IL-6, in elite male basketball players compared to a placebo. We also looked into the impact of β-alanine supplementation on body composition and bio-motor ability. Our hypothesis was that a high dose of β-alanine, along with a longer duration of consumption, would improve body composition and bio-motor capacity and affect CRP and IL-6 levels.

2. Materials and Methods

2.1. Participants

Twenty male basketball players (age: 23 + 0.6 years; body mass: 78.3 + 4.8 kg; height: 185.3 + 5.4 cm, % BF, 15.2 ± 4.8) volunteered for the study and were randomly assigned to receive either beta-alanine (BG, N = 10) or placebo (PG, N = 10). Subjects had not taken any creatine supplement in the three months before the study. The first group consumed a daily BG (6.4 g/d of β-alanine), and the second group consumed a placebo (6.4 g/d of malt dextrin) in a double-blind format. The computer-generated random table did the randomization [21].

All players were preparing for university competitions and had played for over five years. After explaining all procedures, risks, and benefits, each subject gave informed consent to participate in this study. All subjects signed and accepted the informed consent with the recommendations of the Helsinki Declaration for Human Research and the Ethics Committee of the Faculty of Physical Education and Mountain Sports, Transilvania University of Brasov, Romania, protocol code 54 and agreement 55, date of approval 17 January 2022. The participants were involved in regular basketball training three months before the study. The criteria for selecting and including individuals in this research were not to use additional nutritional supplements and not to consume anabolic steroids or other anabolic agents known to increase performance during the last year. Screening for steroid use, addition, and supplementation was accomplished via a health questionnaire during subject recruitment.

2.2. Sample Size

We determined the design's power and sample size using the statistical approach examined in this study with G-Power software (University of Düsseldorf, Dusseldorf, Germany). Among them were the following [22]: The achieved power was calculated using the a priori and F tests; ANOVA: repeated measurements, within-between interaction analysis, number of groups = 2, number of measures = 6, error probability for $\alpha = 0.05$, error probability for 1-β = 0.80, and effect size at minimum level = 0.25. In the study with 20 participants, there is an 84.2% (actual power) likelihood of effectively rejecting the null hypothesis that there is no difference in the variables.

2.3. Experimental Approach to the Problem

The present study was of an independent group with a pre-and post-test of a semi-experimental design. The participants were randomly divided into two groups based on

their specific positions, and players from each position in the game were equally present in both groups. Participants consumed 6.4 g/day (i.e., beta-alanine or maltodextrin) with 300 mL water approximately 1 h prior to training and every morning. Players were assessed for their fitness status and blood sampling two times. The first was assessed in the week before preparing for the match and the second was after 8-weeks. For each period, the players were assessed for three consecutive days. The first day included assessments of anthropometric and body composition (e.g., height, body mass, and body fat), and blood tests. On the second day, anaerobic power was assessed with lactate measurement. Finally, on the third day, the aerobic power test was conducted. Testing days were performed for each participant under a similar environmental condition (21–23 °C temperature and 50% humidity) simultaneously within two-day physical fitness tests [1]. At all sessions, the test had time between 3:30 p.m. and 6:30 p.m. All players presented individual wellness questionnaires before the start of each training session and reported a training load 30 min after each training session. Then, each training load was calculated with the training time. Participants recorded their nutrition for two full days and delivered it to the researchers before the pre-test.

2.4. Measurements

2.4.1. Blood Sampling

For analyzing the biochemical variables, the blood taking took place after 12–14 h of fasting during two stages (before and after 8 weeks). In the first stage, the examinees were asked to perform exercises two days before the test. They then attended the medical diagnostic laboratory. The temperature and time of the test were recorded to maintain the conditions in the next stage. Blood was collected directly from the forearm vein by a nurse. After collecting 10 mL of blood, all samples were centrifuged at 3000 rpm for 10 min, and 0.1 mL of the separated supernatant was collected. This process has been analyzed in the laboratory below −80 degrees Celsius. All research variables collected were measured and analyzed by the Gyeonggi-do company.

After this stage, the subjects under study were under specialized exercise for four weeks and were invited again to the laboratory to give blood, as in the first stage, after passing the desirable time and 24 h after the last exercise session. 1L-6 and CRP were tested.

Using an ELISA kit, CRP levels were measured by a nephelometry method (manufactured by the Binding site in the UK). The minimal operating sensitivity of the processor and the kit was 0.04 mg/dL, and the coefficient of variation between and within the processing was 5 and 4/7%, respectively.

IL-6 levels were measured by an immunometric method using an ELISA kit (manufactured by the BioVendor, Heidelberg, Germany). The minimal operating sensitivity of the processor and the kit was 0.92 pg/mL, and the coefficient of variation between and within the processing was 3/4 and 5/2%, respectively.

2.4.2. Body Composition (Body Fat%)

Body composition was analyzed using the InBody720 system (Biospace, Seoul, Korea). The precise body composition analyzer "InBody720" uses 30 Impedance Measurements by using six different frequencies (1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz, 1000 kHz) at every 5 segments (Right Arm, Left Arm, Trunk, Right Leg, Left Leg). Using the 8-point tactile electrode method, InBody measures body composition by segment, and it has body composition analyzing technology that does not resort to empirical estimation such as gender or age [23,24]. Tests were always conducted at the same time of day. All measurements were performed by an expert with five years of background in this area. All anthropometric and body composition measurements were taken in the morning.

2.4.3. Dosage and Supplement Administration

Considering the effective strategies of beta-alanine supplementation (4.8–6.4 g/day) in previous studies, the participants were instructed to consume 6.4 g/day of beta-alanine

or maltodextrin supplements for eight weeks [25]. A capsule with 100% purity was provided for consumption. The GNC American company obtained the β-alanine supplement CarnoSyn [26–29]. The supplement and placebo were in capsule form and were similar in appearance. The participants were randomly assigned in a double-blind manner to receive either β-Alanine or placebo. The PG consumed maltodextrin capsules (Samyang Genex, Seoul, Korea) in the same manner as the BG.

No other side effects (skin tingling, gastrointestinal discomfort) or weight gain were reported by those individuals supplemented with βA, and subjects in the PL group reported no side effects.

2.4.4. Countermovement Jump

The CMJ was utilized to evaluate lower-body power [30,31]. At that point, a standardized warm-up of 10 to 15 min of running was taken after five to six sprint-specific drills, one or two CMJs, even bounds, and vertical bounces. This was followed by one or two trial hops for testing familiarization. Members stood within the center of the contact tangle with hands on the hips. They were taught to plummet quickly until a knee angle of roughly 90° was accomplished, and after that, hop vertically with high speed. Five minutes of rest were given between attempts, and the best execution was recorded in centimeters [32]. Within the CMJ the intra-class relationship (ICC) was 0.96.

2.4.5. Anaerobic Test

A running-based anaerobic sprint test (RAST) was used to measure anaerobic power. For this test, two photocells were based 35 m from each other. Each participant had to run at a maximum speed of six repetitions and take 10-s rest between each repetition. After performing a warm-up with the exact instructions as other tests, the participants began running at maximum speed. After crossing the 35-m line, they rested for 10 s (seconds were counted aloud by the investigator), immediately started again at the end of ten seconds, and this process continued for six repetitions. The records of each participant were calculated with the following formulas and considered for anaerobic power variables: RAST of peak power (RPP) = the highest value; RAST of minimum power (RMP) = the lowest value; RAST of average power (RAP) = sum of all six values ÷ 6; and RAST of Fatigue Index (RFI) = (Maximum power − Minimum power) ÷ Total time for the six sprints.

2.4.6. Lactate Measurements

Blood lactate was measured using a lactometer device immediately after 10 min of training. Lactate was determined using a Lactate Pro 2 device, a palm-sized blood lactate test meter that quickly measures lactate from a small blood sampling (only 0.3 µL). Speedy measurements are completed in just 15 s, offering high performance in a small size.

2.4.7. VO_{2max} Measurements

Bruce's test measured the maximum oxygen consumption (VO_{2max}). The treadmill is started at 2.74 km/h (1.7 mph) and a gradient (or incline) of 10%. At three-minute intervals, the incline of the treadmill increases by 2%, and the speed increases as the guideline. The test should be stopped when the subject cannot continue due to fatigue or pain, or due to many other medical indications. The subjects' heart rate was also recorded as the heart rate when they stopped test. The device is made in Italy.

2.4.8. Control of Food Intake

Forty-eight hours before and after the test, the Food Frequency Questionnaire (FFQ) was given to the subjects, and they were asked to record their food intake during this period. Dietary monitoring procedures, energy, and macronutrient intake associated with this sample have been previously described in detail. In a nutshell, individuals met with a nutritionist who gave them dietary recommendations that delivered 1.55 times their basal metabolic rate in calories. Players used to eat the same items for 72 h before each

measure stages and keep track of their intake. To measure compliance, total calorie and macronutrient intake was measured (Table 1) with Nutrition 4 version 3.5.2 software [10].

Table 1. The analysis of the average daily caloric and macronutrient intake.

Variables	Groups	Pre-Season Mean ± SD	Post-Season Mean ± SD	*p*
Carbohydrate (g)	BG	349.30 ± 18.70	355.15 ± 19.8	0.82
	PG	347.18 ± 22.36	342.8 ± 23.5	
Protein (g)	BG	128.26 ± 53.67	125.12 ± 26.5	0.658
	PG	127.65 ± 54.19	119.96 ± 36.8	
Fat (g)	BG	68.32 ± 14.24	69.52 ± 9.23	0.642
	PG	67.86 ± 13.80	65.2 ± 4.9	

Mean (M) ± standard deviation (SD). BG: β-alanine group; PG: placebo group.

2.5. Monitoring Internal Training Loads

Internal training loads in players were used to assess and control exercise pressure, with a 0–10-scale rating of perceived exertion (RPE, Borg's CR-10scale). Each player's RPE was collected at the end of each specific training to ensure that the perceived effort referred to the training only. In this study, a printed CR-10 scale modified by Foster et al. was used to assist the players in making their responses. All participants of this study were familiarized with this modified scale for RPE before the commencement of this study [33,34].

Wellness Measures

Subjective wellness measures were collected using a modified psychological questionnaire based on the recommendations of Hooper and Mackinnon (1995) used by previous studies. The questionnaire comprises subsets of perceived sleep quality, stress, muscle fatigue, and soreness, with each question scored on a 7-point scale (with '1′ and '7′ representing 'very good' and 'poor' wellness ratings, respectively) [35]. Overall wellness (Hooper index) was determined by summing the four scores.

2.6. Statistical Methods

The Shapiro-Wilk and Leven's tests were used to evaluate the normality and homogeneity of variances to analyze data. All data are reported as means ± standard deviations. Changes between the pre and post-test were assessed using a repeated-measures analysis of variance (ANOVA), followed by the Bonferroni post-hoc test for pairwise comparisons. Partial eta-square (ηp^2) was calculated as the effect size of the repeated-measures ANOVA. If the variable was not statistically normal, the Kruskal-Wallis H test was used to analyze the intergroup differences. To calculate the percentage of changes, the post-test average value is subtracted from the pre-test value and is listed as a percentage in the table.

$$\textbf{Percentage Change } (\%) = [(\text{post-test value} - \text{pre-test value})/\text{pre-test value}] \times 100$$

Furthermore, the effect size of Hedge's g (95% CI) was reported. The Hopkins threshold was used to calculate the effect size as follows: <0.2 = trivial, 0.2 to 0.6 = small, >0.6 to 1.2 = medium, >1.2 to 2.0 = large, >2.0 to 4.0 = very large, and >4.0, almost perfect. The significance level was considered at $p \leq 0.05$ [36].

3. Results

There were significant ($p = 0.003$, $f = 11.676$, $\eta p^2 = 0.393$) main effects on time for body mass, but there was no significant group by time interaction ($p = 0.57$, $f = 0.324$, $\eta p^2 = 0.018$). It was the same for fat, as there were significant ($p = 0.003$, $f = 16.764$, $\eta p^2 = 0.482$) main effects of time, but there was no significant group by time interaction ($p = 0.11$, $f = 2.767$, $\eta p^2 = 0.133$) (Figure 1).

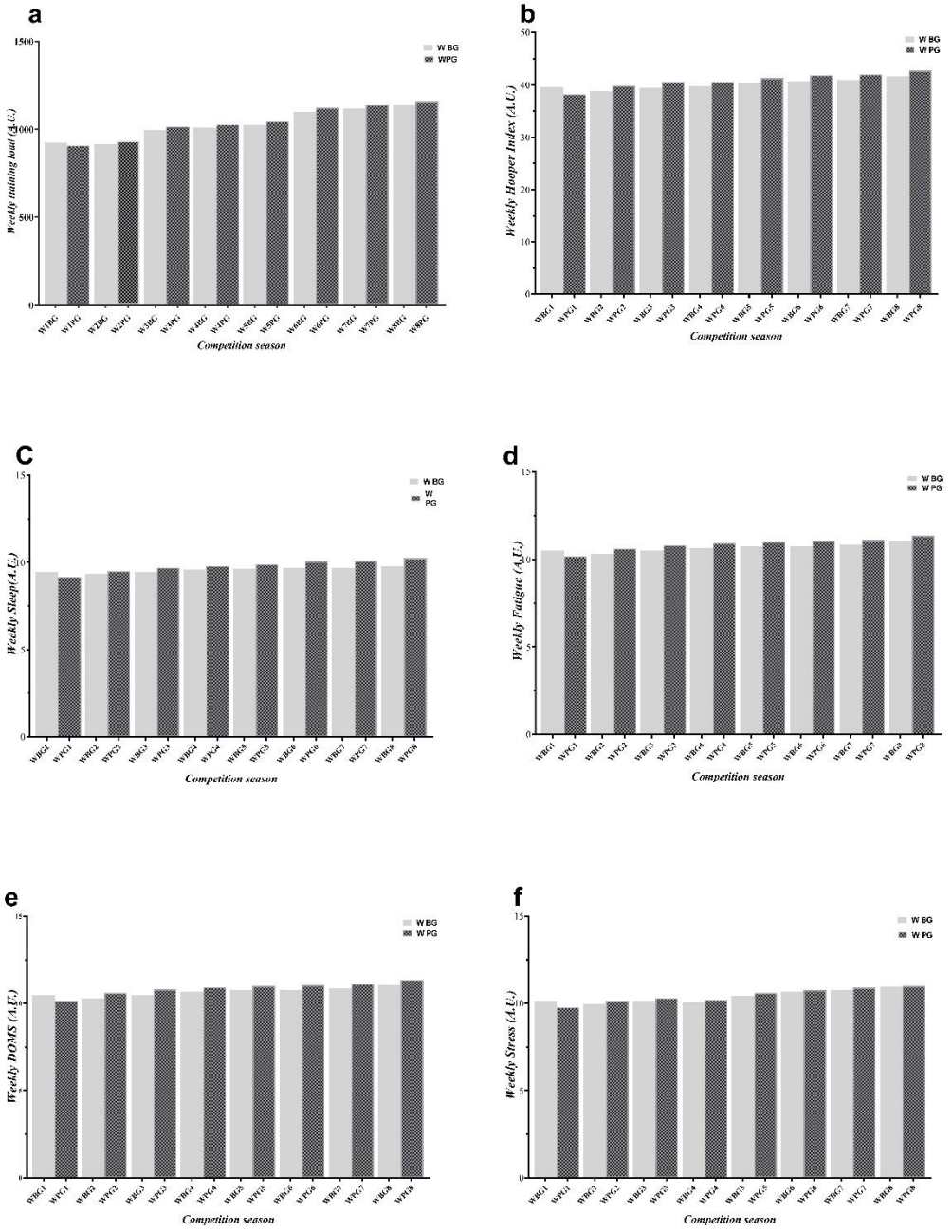

Figure 1. Change in (**a**) Training Load, (**b**) Hooper Index, (**c**) Sleep, (**d**) Fatigue, (**e**) DOMS and (**f**) Stress for 8-week in BG and PG. A.U.: Arbitrary Unit; PG: Placebo group, BG: β-alanine; DOMS: delayed onset muscle soreness.

According to the results presented in Table 2, there were significant main effects of time (p = 0.01, f = 14.089, ηp^2 = 0.439) and group by time interaction (p = 0.01, f = 15.346, ηp^2 = 0.460) for IL-6. Post hoc analysis showed that IL-6 was significantly less at the post-test compared to the pre-test in BG ($p < 0.001$), but for PG there was no significant difference ($p > 0.05$) between periods. There were significant main effects of time (p = 0.001, f = 29.569, ηp^2 = 0.622) and group-by-time interaction (p = 0.001, f = 260.431, ηp^2 = 0.935) for CRP. Post hoc analysis demonstrated that CRP was significantly less in the post-test compared to pre-test in BG ($p < 0.001$), while PG was more significant in the post-test compared to the pre-test ($p < 0.001$). Percent changes in CRP between pre-and post-test were significantly (p = 0.001) greater in PG than BG (0.6% > −0.12%).

Table 2. Changes of cytokines levels and body composition during pre-, mid-, and post-season.

Variables	Groups	Pre-Season M ± SD	Post-Season M ± SD	*p*-Value	Mean Pre-Post Season		Mean Pre-Post Season% Changes	Effect Size Cohens D
					Lower	Upper		
Body mass (kg)	BG	72.45 (0.59)	71.95 (1.3)	0.77	−1.2	0.2	−0.5	−0.8T
	PG	72.25 (0.92)	71.55 (0.92)	0.08	−1.7	0.3	−0.7	−0.5T
Fat (%)	BG	19.35 (0.70)	18.45 (0.49)	0.42	−1.4	−0.3	−0.9	−1.2T
	PG	19.25 (0.42)	18.87 (0.42)	0.72	−0.7	0.01	−0.3	−0.8T
IL-6 (Pg/mL)	BG	5.98 (0.68)	5.42 (0.33)	0.007 *,#	−1.07	−0.05	−0.5	−0.8T
	PG	6.14 (0.42)	6.15 (0.31)	0.21	−0.34	0.36	0.01	0.02T
CRP (mg/L)	BG	0.83 (0.08)	0.70 (0.03)	≤0.01 *,#	−0.14	−0.1	−0.12	−15.06T
	PG	0.84 (0.09)	0.90 (0.01)	≤0.01 *,#	0.05	0.07	0.6	6.4P
Lactate (mg/L)	BG	4.28 (0.28)	4.25 (0.21)	0.16	−0.2	0.2	−0.03	−0.1T
	PG	4.47 (0.21)	4.55 (0.22)	0.40	−0.1	0.2	0.08	0.38S
Heart Rate (BMP)	BG	194.8 (5.39)	195.2 (5.05)	0.34	−4.5	5.3	0.4	0.07T
	PG	193.4 (4.83)	194.9 (4.35)	0.91	−2.8	5.8	1.5	0.3S

Mean (M) ± standard deviation (SD). PG: Placebo group; BG: β-alanine group; * Represents a statistically significant difference compared Pre-test to Post-test; # Represents a statistically significant difference compared to the PG (exact *p*-value is reported in the text). Cohen's D was interpreted as T trivial, S small, M medium, L large, V very large, and P almost perfect.

There were no significant ($p = 0.66$, f = 0.19, $\eta p^2 = 0.01$) main effects of time for lactate, and there was no significant group by time interaction ($p = 0.54$, f = 0.389, $\eta p^2 = 0.021$).

According to the results presented in Table 3, there were significant ($p = 0.001$, f = 18.766, $\eta p^2 = 0.510$) main effects of time, but there was no significant group by time interaction ($p = 0.08$, f = 3.447, $\eta p^2 = 0.191$) for VO_{2max}. There were significant ($p = 0.046$, f = 4.583, $\eta p^2 = 0.203$) main effects of time for heart rate (Table 2), but there was no significant group by time interaction ($p = 0.231$, f = 1.536, $\eta p^2 = 0.085$).

Table 3. Changes of bio-motor abilities during pre- mid- and post-season.

Variables	Groups	Pre-Season M ± SD	Post-Season M ± SD	*p*-Value	Mean Pre-Post Season		Mean Pre-Post Season% Changes	Effect Size Cohens D
					Lower	Upper		
VO_{2max} ($mL \cdot kg^{-1} \cdot min^{-1}$)	BG	58.1 (0.87)	60.1 (1.37)	0.007	−3.0	−0.920	−2.000	−1.4T
	PG	58.5 (0.52)	59.3 (0.82)	0.22	−1.4	−0.151	−0.800	−0.94T
Fatigue	BG	43.2 (1.23)	38.4 (1.34)	0.03	3.6	6.0	4.8	3.5V
	PG	43.3 (1.25)	39.3 (0.94)	0.03	2.9	5.0	4.0	4.2P
RPP (w)	BG	862.1 (33.3)	881 (45.7)	0.002 *,#	−56.5	18.7	−18.9	−0.4T
	PG	850 (5.12)	858.3 (4.73)	0.002 *,#	−12.9	−3.66	−8.3	−1.7T
RMP (w)	BG	411.4 (15.1)	425.5 (7.53)	0.243	−25.3	−2.8	−14.1	−2.07T
	PG	410.8 (5.24)	415 (5.35)	0.89	−9.1	0.7	−4.2	−1.6T
RAP (w)	BG	606.3 (4.62)	616 (6.14)	0.13	−14.8	−4.5	−9.7	−0.3T
	PG	606.4 (9.16)	608 (5.66)	0.24	−9.3	4.9	−2.2	−1.5T
CMJ (cm)	BG	42.4 (1.42)	44.9 (0.72)	0.90	−3.6	−1.5	−2.5	−3.5T
	PG	42.2 (0.82)	44.2 (0.68)	0.61	−2.7	−1.3	−2.0	−2.9T

Mean (M) ± standard deviation (SD). PG: Placebo group; BG: β-alanine group; * Represents a statistically significant difference compared Pre-test to Post-test; # Represents a statistically significant difference compared to the PG (exact *p*-value is reported in the text). Cohen's D was interpreted as T trivial, V very large, and P almost perfect.

There were significant ($p = 0.001$, f = 30.502, $\eta p^2 = 0.629$) main effects of time for RPP, and there was a significant group by time interaction ($p = 0.045$, f = 4.632, $\eta p^2 = 0.205$). Post hoc analysis revealed that RPP was significantly ($p < 0.01$) higher in post-test than pre-test for both groups. Percent changes in RPP between pre-and post-test were significantly ($p = 0.001$) greater in BG than PG (18.9% > 8.3%).

There were significant ($p = 0.012$, f = 7.773, $\eta p^2 = 0.302$) main effects of time for RMP, but there was no significant group by time interaction ($p = 0.09$, f = 3.087, $\eta p^2 = 0.172$).

There were significant (p = 0.006, f = 9.702, ηp^2 = 0.350) main effects of time for RAP, but there was no significant group by time interaction (p = 0.109, f = 2.839, ηp^2 = 0.158).

There were significant (p = 0.001, f = 207.172, ηp^2 = 0.920) main effects of time for fatigue, but there was no significant group by time interaction (p = 0.184, f = 1.911, ηp^2 = 0.109). There were significant (p = 0.001, f = 52.602, ηp^2 = 0.745) main effects of time for CMJ, but there was no significant group by time interaction (p = 0.380, f = 0.811, ηp^2 = 0.045).

4. Discussion

Basketball has gained enormous popularity worldwide due to its fascinating aspects as a team sport that includes high-intensity activity (sprinting, running, and leaping) phases [1]. When these demands are required to meet the physical and physiological needs of the players, as well as to prevent injuries and deal with inflammation and tissue damage, supplementation with some substances is needed [37]. The goal of the recent study was to investigate the effect of β-alanine supplementation on the state of the pro-inflammatory cytokines CRP and IL-6 as well as the body composition and bio-motor ability of male university basketball players. We hypothesized that 8 weeks of β-alanine supplementation reduces pro-inflammatory cytokines. The results confirmed that 8 weeks of β-alanine supplementation prevented an increase in pro-inflammatory cytokines. In addition, it increased the anaerobic power of trained basketball players. Although both groups reported equal internal workloads, similar energy and macronutrient intakes, and comparable degrees of exhaustion, stress, and sleep, as previously documented, these alterations took place [10].

In the present study, CRP and IL-6 decreased significantly in BG; according to studies, β-alanine supplementation is a non-essential amino acid that combines with the amino acid histidine to produce carnosine, and carnosine significantly reduces the increase in the inflammatory cytokine IL6 [38]. However, IL-6 increased in PG, but this increase was not statistically significant. In addition, there was a significant increase in CRP in PG in male basketball players of the university team. These changes in the basic indicators of pro-inflammatory status in athletes point to the relationship between β-alanine supplementation and the reduction of pro-inflammatory cytokines. The increase of CRP and IL-6 in the PG group with the findings of Kinoshita et al. (2013), who examined the status of pro-inflammatory cytokines in wheelchair basketball players showed that playing basketball caused a significant increase in CRP and IL-6 in male basketball players [39]. The findings of a recent study on the reduction of CRP and IL-6 levels in the BG Group by Dicker are in alignment with the findings of Su-Yeon Jin et al. [40]. They investigated the effects of 4 Weeks of B-alanine intake on inflammatory cytokines after 10 km long distance running exercise in male students and showed that taking 4 weeks of B-alanine supplements reduced the level of inflammatory cytokines. In study participants, it effectively maintains immune system function that is temporarily reduced after prolonged exercise [40]. In the current study, β-alanine supplementation was employed for the first time in basketball players, and results suggest that it may be a valuable nutritional tactic for reducing inflammation and promoting faster workout recovery [10].

The measured data about body composition (body mass and fat) in both groups of subjects decreased after eight weeks, but these changes were insignificant. It seems that the slight weight loss was due to training during this period and is not the effect of β-alanine supplementation. Kern and Robinson (2010) investigated the effects of β-alanine supplementation on performance and body composition in collegiate wrestlers and football players. They found that after eight weeks of β-alanine supplementation at 4 g per day, wrestlers in both the β-alanine and PG lost body mass. However, the supplement group increased lean mass by 1.1 pounds, while the PG lost lean mass. Also, both football groups gained body mass t in football tests [41]. These findings are not consistent with the findings of recent research. It seems that the reason for the inconsistency of the obtained results is the difference in the type of exercise activity of the subjects and also the difference in the

amount of β-alanine supplement consumption. Contrary to the recent study by Kern and Robinson, the amount of β-alanine supplementation in their study was lower than in the current study. Also, in the current study, lean mass was not measured, and it is possible that the weight loss in the β-alanine group was due to a decrease in fat weight, and the subjects in this group showed an increase in lean mass.

In the section related to VO_{2max}, lactate concentration, and heart rate, no significant difference was observed between the two groups' pre-test and post-test. According to studies, β-alanine can increase the synthesis of L-carnosine and reduce the amount of accumulated lactate in the blood through buffering [41]. The results of the recent research did not agree with the results of Jordan et al. (2010). Jordan et al. investigated the effect of β-alanine supplementation on the onset of blood lactate accumulation (OBLA) during treadmill running. This study showed that VO_{2max} increased in the β-alanine group, and cumulative lactate and heart rate decreased in this group [42]. It seems that the difference in the obtained results is due to the difference in the physical fitness of the subjects of the two studies. In a recent study, semi-professional athletes from the university basketball team, who were probably at their best in VO_{2max}, lactate concentration, and heart rate due to their high physical fitness, were used, and did not have a bias for further improvement through supplementation.

In the measured parameters related to bio-motor ability, only the data related to RPP were significant in both the BG and PG groups. Furthermore, there was a significant difference between the two groups in the post-test, and BG was significantly higher than PG. The results were consistent with the results of Ribeiro et al. (2020), who examined the effect of β-alanine supplementation on the performance of elite female soccer players. Ribeiro et al. showed that β-alanine supplementation increases the aerobic capacity measured in the RAST test [25].

There are limitations to this study and suggestions for other research directions. First, this study only included a small number of participants, which may be why some critical findings were not obtained. Also, maltodextrin (like all sugar compounds) is known to have a pro-inflammatory effect, so the placebo may have acted as a negative stressor in the control group and this may have influenced the results. Despite telling individuals to eat similar kinds and amounts of food, we cannot determine whether within-subject variations in micronutrient intake altered inflammatory and hematological measures. Second, while we could monitor internal workload and recovery indicators, we could not use tools to assess external workloads, like GPS devices. Future studies must examine the temporal changes in inflammatory markers over time with β-alanine supplementation in greater detail and ascertain whether the alterations in inflammatory cytokines are sustained with extended supplementation periods. Finally, additional research is necessary to measure changes in physical performance metrics to better correlate the improvements in inflammation markers and immune cells observed in response to β-alanine supplementation.

5. Conclusions

The purpose of this study was to evaluate the effect of 8-week β-alanine supplementation on CRP, IL-6, body composition, and bio-motor abilities in elite male basketball players. We have succeeded based on the result showing a significant decrease in CRP and IL-6 and an increase in anaerobic peak power between the pre-test and post-test, as well as between the BG and PG groups. In addition, the result suggested that beta-alanine supplementation may have improved maximal anaerobic power. Although the other measured factors indicated a relative improvement compared to the pre-test and also compared PG, these changes were not statistically significant, and it was not the same direction based on the aim of this study. These changes in pro-inflammatory cytokines suggest that beta-alanine supplementation may be a suitable nutritional strategy to regulate the immune system, and future research is needed to confirm these results and test the effects of beta-alanine supplementation on other pro-inflammatory cytokines and immune system markers are required.

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Research article

Effects of Tabata and HIIT Programs Regarding Body Composition and Endurance Performance among Female Handball Players

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Abstract: (1) Background: The purpose of the study was to analyze the effect of two different training modes towards the development of body composition, aerobic and anaerobic endurance of female handball players aged 18-23, in COVID-19 pandemic. (2) Methods: 18 female handball players from the second division were divided into two groups: Group 1 subjected to Tabata Program (n=9) and Group 2 trained using HIIT Program (n=9). (3) Results: Paired Sample T-Test was carried in the statistical analysis and the significance level was determined ($p < .005$). The group subjected to HIIT training achieved greater increases in endurance performance than the group carrying out Tabata training ($p < .005$). (4) Conclusions: Different results were obtained when studying changes regarding segmental analysis of upper, lower limbs and trunk. Both groups undergoing Tabata and HIIT training registered improvements.

Keywords: COVİD-19 pandemic; handball game; aerobic and anaerobic endurance; fitness programs

1. Introduction

Handball is a very strenuous body-contact sport characterized by highly developed motor skills such as speed, explosive power, endurance, and strength [1].

Anthropometric characteristics, such as body size, body mass, body mass index, and body fat percentage, play a highly important role when discussing sport success and results [2-4]. Body size has a strong positive effect on throwing performance and isometric strength [3, 4].

Moderate intensity aerobic exercise in outdoor environments with special attention to maintaining safe distance with others and surfaces may be a proper alternative. However, the hazards of high-intensity exercise in public gyms and crowded environments may outweigh the benefits and should be avoided [5].

A high aerobic capacity appears to be important to maintain a high level of performance over the 60 minutes of playing time. Aerobic capacity and maximal aerobic power can distinguish between women handball players of different levels: more aerobically resistant players are at a clear advantage during international handball competitions [6].

The effects of high-intensity interval training on the human body's aerobic energy-releasing system were thoroughly examined by Fox & Mathews [7, 8]. He showed that the improvement of the body's maximal oxygen uptake (VO_2max) after high-intensity interval training is linearly related to the oxygen demand (expressed as % VO_2max) of the high-intensity interval training, indicating that exercise intensity is a key factor for the improvement of the body's maximal aerobic power after high-intensity interval training [8, 9].

Intermittent training and interval training differ significantly, and it is important to keep in mind that Tabata training is an intermittent-exercise training method [10, 11].

In team sports like handball, players are characterized as strength-and-power athletes. Athletes are usually large and muscular. However, depending on the specific position, body composition varies slightly [12].

After a study upon the structural and functional characteristics of elite Croatian handball players, a strong negative correlation was found between body fat and maximal running speed. Experienced coaches can used this information in the process of designing a training program to maximize the fitness development of handball players, with one purpose only, to achieve success in handball [13].

Muscle strength is an important factor in handball performance [14]. Most researchers agree that higher maximal power and strength may be associated with an advantage in blocking, hitting, pushing [15], and ball throwing velocity [16-19]. Nevertheless, little is known about changes in power and strength with regard to training in women's handball players. Body size, fat-free mass, and percent of body fat seem to be important factors in physical performance, even within a rather homogenous group of highly skilled athletes.

The aim of the study was to provide information regarding the modifications that appear in athletes by using two different training programs. Because of that, we hypothesize that by analyzing two different training modes we can obtain the influence between the physical capacity and body composition of the subjects understudy.

4. Materials and Methods

2.1. Participants

This study involved 18 female athletes aged 18-23 who play performance handball. The participates were separated in two groups, Group 1 trained using Tabata Program and Group 2 using HIIT Program. The average height of the athletes included in Group 1 was determined as 175.1 ± 3.95 (cm), their average body weight as 71.4 ± 3.9 (kg), their average body mass index as 23.3 ± 0.82 (kg/m^2) the average body fat percentage as 26.9 ± 1.04 (%), muscle percentage had the value of 11.4 ± 1.84(%). Regarding the athletes from Group 2, the average height was calculated as 176.7±4.52, their average body weight as 72.8 ± 5.96 (kg), their average body mass index as 23.2 ± 1 (kg/m^2) the average body fat percentage as 27.2± 1.65 (%) and muscle percentage had the value of 12.8 ± 2.25(%).

2.2. Procedure

2.2.1. Training program

18 female handball players participated in a training program, four days per week, with training sessions of 25 respectively 45 minutes. Subjects were divided in two groups: Group 1 (9 athletes) used Tabata Scheduled training and Group 2 (9 athletes) the High Intensity Interval Training Program. Initial and final assessments were used to observe the evolution of body composition and physical performance respectively aerobic and anaerobic endurance of participants. The stage plan was scheduled on a period of two months. Tables 1 and 2 present the programs used by the subjects understudy.

Table 1. Tabata Training Program

Brief warm-up;
The exercises are performed 8 times, one set of each move, completing the full series 2 times.
Exercises are worked on maximum intensity for 20s and 10s rest between them.
At the end of the program 5 minutes of stretching exercises were required.
First & second weeks - Exercises
Mountain climbers
Squat jumps
Burpees
Ski moguls
Jumping rope
Third &fourth weeks – Exercises
Burpees
Squats
Mountain climbers
Push-ups
Crunches
Fifth & sixth weeks – Exercises
Squat thrust to frog jump
Side skaters
Russian twist
Plank with row
Broad jump to fast feet
Seventh and eight weeks – Exercises
Rotating lunge switches
Squat jumps
Broad jump to fast feet
Squat thrust to frog jump
Crunches

Table 2. High Intensity Interval Training Program

Brief warm-up for 3-5 minutes;
The program will be repeated 5 times.
After each cardio exercise rest for maximum 30s.
The exercises are worked for 45s.
First and second weeks – Exercises
Squat thrust curl
Lateral lunge with single-arm row
Overhead triceps chop
Deadlift wide row
Reverse lunge with overhead arm circle
Single-leg deadlift row to single-arm press
Lat pullover to sit-up
Third and fourth weeks – Exercises
Renegade row
Grasshopper
Push-up frog pop
Side plank press
Low squat curl
Fifth and sixth weeks – Exercises
Squat thrusts
Mountain climbers
Russian twists
Jumping jacks
High knees
Seventh and eight weeks – Exercises
Spider lunge pledge
Standing long jump
Switch kick
Tuck jump
Criss-cross pickup

2.2.2. Anaerobic endurance

It assumes a sprint running test consisting of three maximal sprints of 15 meters, with a 90s rest period between each sprint, on an indoor court. During the 90s recovery period, the subjects walked back to the starting line. Time was recorded using stopwatches. The run with the lowest time was selected for further analysis.

2.2.3. Aerobic endurance

The Cooper 12 minutes Run Test was performed on the stadium with the size of 400m/turn. The players divided into groups of four started from a standing position. At 11 minutes and at 11 minutes 30 seconds after the beginning of the test, the athletes received verbal information about the time. The total number of meters with the assigned accuracy was recorded on the sheet for all the tests.

2.3. Analyses

In the analysis of the data, the statistical significance of the variables was determined with the Paired Sample T-Test. The data was evaluated with the SPSS 15 statistics software. Data are presented as the mean ± SD. Paired Sample T-Test was used to test the interaction between interventions (Tabata Training and HIIT Training) and between assessments of every group (first and second assessments).

3. Results

Measurements for each participant were undertaken within two categories: anthropometrical and body structure characteristics and endurance performance.

Table 3 shows the results from Groups 1 and 2 at the first and second assessments regarding body composition. The Paired Sample T-Test analysis size was used on assessments between each Group. This category showed statistically significant differences with a high effect between the two measures. Significant qualitative differences between the results of the first and second assessment during a monitored two months regarding the subjects from Group 1 (Tabata Training) were found in body weight ($t = 4.96$, $p < .005$), body mass index ($t = 4.94$, $p < .005$), body fat percentage ($t = 11.6$, $p < .005$), muscle percentage ($t = 4.35$, $p < .005$), segmental analysis of right foot fat and muscle mass ($t = 4.81$, $p < .005$; $t = 8.35$, $p < .005$), left foot muscle mass ($t = 7.82$, $p < .005$), upper limbs fat and muscle mass (right hand fat mass $t = 14.1$, $p < .005$; right hand muscle mass $t = 10.09$, $p < .005$; left hand fat mass $t = 9.16$, $p < .005$; left hand muscle mass $t = 5.7$, $p < .005$), trunk muscle mass ($t = 10.4$, $p < .005$). No significant differences were determined at analysis of fat mass in left foot and trunk ($t = 2$, $p < .081$; $t = 3.13$, $p < .014$). Group 2 that followed the HIIT Training Program had significant differences at the following indicators: body fat percentage ($t = 8.34$, $p < .005$), muscle percentage ($t = 4.71$, $p < .005$), segmental analysis of right foot fat and muscle mass ($t = 3.77$, $p < .005$; $t = 6.79$, $p < .005$), left foot muscle mass ($t = 6.81$, $p < .005$), upper limbs fat and muscle mass (right hand fat mass $t = 8$, $p < .005$; right hand muscle mass $t = 7.34$, $p < .005$; left hand fat mass $t = 10.11$, $p < .005$; left hand muscle mass $t = 4.76$, $p < .005$), trunk fat and muscle mass ($t = 4.46$, $p < .005$; $t = 4.27$, $p < .005$). No significant differences were found in the parameters of left foot fat mass, body weight and body mass index of Group 2.

Table 3. Antropometric and body structure characteristics (mean±SD) of Group 1 and Group 2

Variables		Group 1 – Tabata Training Program (n=9)		Group 2 – High Intensity interval Training Program (n=9)	
		1st assessment	2nd assessment	1st assessment	2nd assessment
Body Weight (kg)		71.44±3.90	67.5±4.87*	72.8±5.96	71.2±6.02NS
Body Height (cm)		175.1±3.95	-	176.7±4.52	-
Body Mass Index		23.3±0.82	22.01±1.23*	23.2±1.007	22.7±1.42 NS
Body Fat (%)		26.9±1.04	18.4±2.18*	27.2±1.65	19.7±2.65*
Muscle (%)		11.4±1.84	12.5±2.06*	12.8±2.25	14.1±2.70*
Right foot segmental analysis (kg)	**Fat**	3.37±0.41	3.07±0.37*	3.64±0.45	3.4±0.47*
	Muscle mass	8.47±0.45	8.95±0.51*	8.81±0.68	9.28±0.74*
Left foot segmental analysis (kg)	**Fat**	3.2±0.57	3±0.30 NS	3.41±0.41	3.32±0.51 NS
	Muscle mass	8.28±0.42	9.11±0,.6*	8.6±0.63	9.51±0.78*
Right hand segmental analysis (kg)	**Fat**	0.87±0.10	0.54±0.13*	1.06±0.23	0.62±0.12*
	Muscle mass	2.77±0.28	3.02±0.29*	2.84±0.26	3.14±0.33*
Left hand segmental analysis (kg)	**Fat**	1.03±0.15	0.55±0.14*	1.18±0.20	0.65±0.18*
	Muscle mass	2.56±0.31	3.05±0.28*	2.68±0.325	3.2±0.38*
Trunk segmental analysis (kg)	**Fat**	6.01±1.48	5.42±1.31 NS	6.5±1.68	6.17±1.72*
	Muscle mass	27.9±4.73	29.7±4.69*	29.9±2.11	31.9±2.19*

Note: Data is presented as mean ±sd; *Statistically significant differences between 1st and 2nd assessments ($p < .005$); #Statistically significant differences between Groups 1 and 2 ($p < .005$)

The descriptive results of the aerobic and anaerobic endurance of the subjects understudy are presented in Table 4. The performance of the women handball players after a period of two months training increased in both anaerobic and aerobic endurance. For the determination of the anaerobic endurance we used 3x15 meters Sprint Run and the data show a significant difference between the results obtained in the first and second assessment from Group 1($t = 7.07$, $p < .005$) and Group 2 ($t = 5.48$, $p < .005$). Regarding the aerobic endurance the Cooper Test Run for 12 minutes was used to show the physical evolution of the women handball players. Results show a qualitative increase of the results before and after the two months of training using Tabata ($t = 12.4$, $p < .005$) and HIIT Program ($t = 11.05$, $p < .005$).

Table 4. Descriptive statistics of anaerobic and aerobic endurence of Groups 1 and 2

Variables	Group 1 – Tabata Training Program (n=9)		Group 2 – High Intensity interval Training Program (n=9)	
	1st assessment	2nd assessment	1st assessment	2nd assessment
Anaerobic endurance (s)	5.66±1.41	4±1.11*	5.77±1.09	4±0.5*
Aerobic endurance (meters)	2388.5±57.8	2545.1±60.1*	2385±47.6	2553.1±70.4*

Note: Data is presented as mean ±sd; *Statistically significant differences between 1st and 2nd assessments ($p < .005$); #Statistically significant differences between Groups 1 and 2 ($p < .005$)

4. Discussion

Modern handball has developed into a fast-paced, full body contact sport, with short high anaerobic bouts interspersed with aerobic actions [20].

As a result of this evolution, variables related to constitution and conditioning abilities have become determinants of handball performance. In the last five years, 20% of the research published on handball were upon the physical capacities and conditions topic [21].

According to literature, body mass is determinant for performance, in the throwing events [22]. This study presents significant differences in body mass between the moments of evaluation that can be confirmed by the big differences in BMI, muscle and body fat percentages.

The research was conducted upon endurance performance and focused on aerobic and anaerobic endurance. Data showed increased levels of both, after 2 months, both Groups (Tabata and HIIT) had significant differences. The difference between this research and others that concerned handball is the fact that these athletes were obligated to start training indoor due to the pandemic and took a forced competition break in which the body and mind of the subjects suffered different changes.

Handball involves a large number of cyclic movements and acyclic activities with only short breaks. Consequently, a highly developed anaerobic endurance capacity seems to be necessary for players [23]. Regarding anaerobic endurance after using two programs that focus upon anaerobic endurance, respectively Tabata and HIIT Programs, these study demonstrated that young women handball players can obtain good results, after the scheduled training program, they had significant differences between the assessments at 3x15m Sprint Run Test.

Several scientists showed that players cover 4000–6500m/game, which makes advantageous to have a well-developed aerobic and anaerobic endurance capacity [24]. Accordingly, both athletes and coaches seem to ignore that aerobic capacity may help not only to keep endurance capacity and to avoid fatigue, but also help to maintain concentration, technical skills, and coordination until the end of the game [25-28]. Due to the presented above this research was conducted upon the endurance performance, mainly aerobic and anaerobic capacity of the players.

The study realized by Tabata et al. [10] found that HIIT improved aerobic capacity to a similar degree as moderate-intensity continuous training, but also resulted in a 28% increase in anaerobic capacity. Those findings led to the development of a wide variety of HIIT programs. Although there are many different ways to perform HIIT, all of the programs are characterized by periods of very heavy effort combined with periods of either complete rest or low intensity recovery. Tabata training has evolved to include a variety of modes and exercises performed in the classic 20-10 pattern.

Movements in team-handball are characterized mostly by short accelerations (0-3 m) with stops (30-40 per game) and changes in direction (30-40 per game) and less by sprints (10-30 m) over the entire game field [24, 29, 30], constituting only 1-3% of the total playing time per match were attributed to sprints or fast running. Tests including changes in direction might be more suitable to measure team-handball performance, although learning effects could influence the results (especially in training studies) and these tests could not resemble the real demands in team-handball competition.

5. Conclusions

This study provides information on the behavior of athletes during the COVID-19 pandemic. It is a novelty because they have not faced a competitive break in which they were forced to train indoor. The training programs aimed to maintain a good capacity for effort but also to secure parameters related to body mass indices. In addition, two training programs were chosen that are directly related to the specific effort encountered in the handball game. No significant differences were obtained between the two programs, Tabata and HIIT, but the physical parameters were maintained at a high potential, so that at the resumption of the competition program the team obtained victories in the following matches.

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Validity and reliability evidence for the Behavioral Regulation in Sport Questionnaire with Romanian professional athletes

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ABSTRACT

Background. Despite the importance attributed to athletes' motivation in sports performance and well-being; no measures of motivation toward sport were found in the Romanian sport context.
Objective. Grounded in self-determination theory, this research aimed to adapt and to gather validity and reliability evidence supporting the use of the Behavioral Regulation in Sport Questionnaire (BRSQ) in the Romanian sport domain.
Method. The participants were 596 Romanian professional athletes (age: $M = 22.91$, $SD = 5.84$; sports experience: $M = 11.14$, $SD = 5.03$), who 273 practiced individual sports and 323 team sports. They completed an online questionnaire survey assessing their perception of behavioral regulation, resilience and burnout in sport.
Results. Confirmatory factor analysis supported the six-factor correlated model, which was invariant across age and sport. Correlations among latent factors configured a *simplex* structure, underpinning the self-determination *continuum*. Average variance extracted values from .50 to .70 endorsed convergent validity. Scores for heterotrait-monotrait ratio of correlations as high as .88, as well as 95% confidence intervals of each interfactor correlation that did not include 1.00 supported discriminant validity. Values over .70 for Cronbach's alpha, McDonald's omega and Raykov's coefficients showed a good level of reliability for each factor. Linear regression analysis revealed that while intrinsic motivation, integrated regulation and identified regulation positively predicted resilience, introjected regulation, external regulation and amotivation positively predicted burnout.
Conclusions. The BRSQ is shown to be a valid and reliable measure of the six types of behavioral regulation in the Romanian sport context.

Subjects Kinesiology, Psychiatry and Psychology, Sports Medicine
Keywords Self-determined motivation, Autonomous motivation, Controlled motivation, Sportspeople, Psychometric properties

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INTRODUCTION

Motivation plays a key role in sport performance and well-being of athletes (*Clancy et al., 2016*; *Gillet & Vallerand, 2016*; *Badau & Badau, 2018*; *Jankauskiene et al., 2019*; *Gherghel et al., 2021*). Unlike classical motivational theories that exclusively conceived motivation in quantitative terms (see *Eccles & Wigfield, 2002*), self-determination theory (SDT) conceptualizes motivation both from a quantitative and qualitative perspective (*Ryan & Deci, 2020*). To illustrate, an athlete with a great quantity of motivation might not undertake the target behavior, if the motivation implied were of a low quality (*Gustafsson et al., 2018*). This distinctiveness in conceptualizing motivation has made that SDT become the predominant theoretical framework for the study of motivation in the sport context (*Clancy et al., 2016*). To measure motivation toward sport, several SDT-based instruments were developed at the international level over the last decades (*Clancy, Herring & Campbell, 2017*); however, there are no scales to date that assess motivation in the Romanian sport setting. Taking into consideration that the Behavioral Regulation in Sport Questionnaire (BRSQ; *Lonsdale, Hodge & Rose, 2008*) constitutes the most broadly used instrument in judging the athletes' perception of motivation toward sport (*Clancy, Herring & Campbell, 2017*; *Rodrigues et al., 2020*), the purpose of this study was to adapt and to examine the psychometric properties of the BRSQ using a sample of Romanian professional athletes.

Self-determination theory

SDT is a macro-theory of motivation, personality and wellness resting on organismic (*i.e.,* individuals are hypothesized to be oriented toward growth) and dialectic (*i.e.,* growth occurs through environmental interactions) assumptions (*Deci & Ryan, 1985*). SDT proposes a multidimensional conceptualization for motivation holding the idea that distinct types or qualities of motivation will yield differentiated affective, cognitive and behavioral consequences for individuals (*Ryan & Deci, 2020*). SDT distinguishes between three types of motivation that fall along a self-determination *continuum*, reflecting to what extent the behavior is intentionally and autonomously undertaken and consistent with the individual's own values and interests (*Ryan & Deci, 2020*; *Ryan et al., 2021*).

At an extreme of the self-determination *continuum* stands intrinsic motivation, conceptualized as undertaking a behavior for the inherent interest, pleasure and enjoyment, as well as curiosity and the search for new challenges. In the central part of this *continuum* lays on extrinsic motivation, which refers to the adoption of a behavior as a means to an end. Given its instrumental nature, extrinsic motivation contemplates four types of behavioral regulation depending on the variability in the internalization process (*i.e.,* "the active assimilation of a behavioral regulation that are originally alien to the self"; *Deci & Ryan, 1985*). External regulation describes the full absence of behavioral internalization, in which behavior is undertaken to fulfill external demands such as obtaining social or material rewards or avoiding punishments from an external source. Introjected regulation expresses a partial degree of behavioral internalization, in which behavior is performed by self-imposed pressures and internal contingencies in order to gain self-worth or to avoid feelings of shame and guilt. Identified regulation represents an almost complete degree of behavioral internalization, in which behavior is undertaken for its personal value

and the recognition of the benefits associated with its adoption. Integrated regulation reflects the highest degree of behavioral internalization, in which behavior is adopted by being perceived as part of the identity of the person. At the opposite extreme of the self-determination *continuum* and in contrast to intrinsic and extrinsic motivation, one finds amotivation, defined as the total absence of self-determination and intention with regard with the desired behavior.

Although the classical distinction between intrinsic motivation, extrinsic motivation and amotivation continues to be broadly recognized and accepted in the SDT-based research, the identification that some forms of extrinsic motivation are relatively autonomous has supposed a conceptual shift in the SDT framework (*Vansteenkiste, Niemiec & Soenens, 2010*). Thus, this paradigm has been replaced by a distinction between autonomous motivation (including intrinsic motivation, integrated regulation and identified regulation), controlled motivation (including introjected and external regulation) and amotivation (*Vansteenkiste, Niemiec & Soenens, 2010*; *Ryan et al., 2021*).

In this regard, the SDT postulates that autonomous forms of motivation would lead to adaptive affective behavioral and cognitive outcomes (*Ryan & Deci, 2020*; *Ryan et al., 2021*) such as performance (*Koka et al., 2020*), commitment (*Pulido et al., 2018*), intention to continue the sports practice (*Monteiro et al., 2018*) and resilience (*Trigueros et al., 2020*) among athletes. Particularly, from a theoretical viewpoint, the relationship between autonomous forms of motivation and resilience is argued in the fact that autonomously motivated athletes often tended to improve their skills and overcome challenges regardless of unfavorable and stressful events, promoting a resilient behavior (*Trigueros et al., 2020*). In contrast, the SDT posits that controlled forms of motivation and amotivation would tend to yield maladaptive outcomes (*Ryan & Deci, 2020*; *Ryan et al., 2021*) such as anxiety and disengagement (*Martinent et al., 2018*), performance failure (*Gómez-López, Courel-Ibáñez & Granero-Gallegos, 2021*) and burnout (*Lonsdale & Hodge, 2011*; *Li et al., 2013*) in the sport context. Particularly, athletes, guided by controlled reasons or amotivated, were prone to suffer from chronic psychological syndromes such as emotional and physical exhaustion, reduced sense of achievement and sport devaluation, which are strongly associated with burnout (*Li et al., 2013*).

Measuring motivation in sport from self-determination theory

Notwithstanding the importance attributed to motivation for the optimal development of adaptive performance-related outcomes in sport (*Clancy et al., 2016*; *Gillet & Vallerand, 2016*); to the best of our knowledge, there is no evidence that SDT-based measures have been utilized to assess the athletes' perception of motivation toward sport in the Romanian domain. This has hindered the full understanding of the motivational dynamics experienced by Romanian athletes throughout their season(s) or Olympic cycle(s), in addition to hampering coaches to accurately detect athletes who might be at a motivational risk at any point of the season. In this same vein, the lack of a valid and reliable measures of motivation has impeded the analysis of influence of the motivational process involved in sport both on performance-related outcomes and health among Romanian athletes. Overall, this has hampered to gain insight into the degree of involvement of athletes in

their training and/or competition, which made it impossible to build focus, intensity, ability to follow the competitional and training goals (*Clancy, Herring & Campbell, 2017*). Besides, the absence of measures of motivation in Romania has limited the international comparison between Romanian athletes and ones from another countries in terms of motivational processes. *Lonsdale, Hodge & Rose (2008)* developed for international use the BRSQ to judge the competitive athletes' perception of motivation in sport, which has become the most commonly used tool for its measurement in the sport domain (*Clancy, Herring & Campbell, 2017*; *Rodrigues et al., 2020*). According to *Lonsdale et al. (2014)*, this instrument was created in an attempt to minimize the psychometric problems detected in the previous contextual measures of motivation in sport (*e.g.*, the Sport Motivation Scale, (*Pelletier et al., 1995*; *Pelletier et al., 2013*).

The BSRQ was designed to allow for the examination of motivation toward sport by two different versions, denominated as the BRSQ-6 and the BRSQ-8 (*Lonsdale, Hodge & Rose, 2008*). The distinction among both versions refers to the specific manner to operationalize intrinsic motivation. The BRSQ-6 conceptualizes intrinsic motivation as an unitary construct in accordance with the SDT assumptions (*Deci & Ryan, 1985*). This version thereby consists of six factors assessing intrinsic motivation, integrated, identified, introjected and external regulation, and amotivation, specifying a 24-item, six-factor model. On the other hand, the BRSQ-8 relied on the tripartite conceptualization suggested by *Vallerand & Blais (1987)* for intrinsic motivation, differentiating between three specific types of intrinsic motivation (*i.e.,* intrinsic motivation to know, toward accomplishments and to experience stimulation). Hence, this version includes eight factors measuring the three subtypes of intrinsic motivation, the four regulatory forms of extrinsic motivation and amotivation, specifying a 32-item, eight-factor model. Although a small body of research has psychometrically underpinned the BRSQ-8 (*Moreno-Murcia et al., 2011*; *Filippos et al., 2019*; *Pinto-Guedes, Aparecido-Caus & Lucas-Sofiati, 2019*), the previous meta-analysis studies (*Chemolli & Gagné, 2014*; *Howard, Gagné & Bureau, 2017*) have unrecommended the consideration of the three subtypes of intrinsic motivation in measures of motivation, including the BRSQ, due to excessively high correlations among them and overlapping confidence intervals.

The previous studies have gathered a consistent basis of evidence in psychometric support for the BRSQ-6 in different contexts using athletes with distinct characteristics such as British young athletes ($\chi^2 = 557.37$; CFI = .95; TLI = .94; SRMR = .06; RMSEA = .06, (*Holland et al., 2010*)) and recreational dancers ($\chi^2 = 1027.24$, CFI = .96; TLI =.95; RMSEA = .06, (*Hancox et al., 2015*), Swedish young competitive athletes ($\chi^2 = 260.60$; CFI = .95; TLI = .94; RMSEA = .042, (*Stenling et al., 2018*), Turkish university athletes ($\chi^2 = 753.78$, CFI = .97, TLI = .97, RMSEA = .057, (*Çetinkaya & Mutluer, 2018*), French young competitive athletes ($\chi^2 = 315.06$; CFI = .94; TLI = .93; RMSEA = .047, (*Cece et al., 2019*), Spanish young athletes ($\chi^2 = 815.41$; CFI = .92; TLI = .92; RMSEA = .06, (*Viladrich, Torregrosa & Cruz, 2011*), Portuguese athletes ($\chi^2 = 995.10$, CFI = .92; TLI = .90; RMSEA = .066, (*Monteiro, Moutão & Cid, 2018*), and Brazilian young competitive athletes ($\chi^2/df = 1.87$; CFI = .94; RMSEA = .052, (*Pinto-Guedes, Aparecido-Caus & Lucas-Sofiati, 2019*)). Indeed, the six-factor correlated model psychometrically performed

better than alternative two-factor, three-factor, four-factor and five-factor correlated models proposed in previous research (*Lonsdale et al., 2014*; *Hancox et al., 2015*; *Monteiro, Moutão & Cid, 2018*; *Rodrigues et al., 2020*). Despite the good psychometric performance, previous research also found a lack both of discriminant validity between integrated and identified regulation subscales, and between introjected and external regulation factors (*Lonsdale, Hodge & Rose, 2008*; *Holland et al., 2010*), and convergent validity in the integrated regulation factor (*Monteiro et al., 2018*), as well as a marginal reliability scores in amotivation (*Tsitskari et al., 2015*). On the other hand, it is noteworthy that evidence was provided in support of measurement invariance across gender and sport (*Monteiro et al., 2019*), age and performance level (*Lonsdale, Hodge & Rose, 2008*; *Hancox et al., 2015*), time (*Stenling et al., 2018*; *Cece et al., 2019*), as well as across five European countries (*Viladrich et al., 2013*).

The present research

The objective of this research was to adapt and to analyze the psychometric properties of the BRSQ using a sample of Romanian professional athletes. First, validity based on internal structure was analyzed by a confirmatory factor analysis (CFA) approach that tested the robustness of the six-factor correlated model initially proposed by *Lonsdale, Hodge & Rose (2008)* against different alternative order-primary models identified in the prior research (*Lonsdale et al., 2014*; *Hancox et al., 2015*; *Monteiro, Moutão & Cid, 2018*; *Rodrigues et al., 2020*) and that could be underpinned by SDT. In addition, we tested the tenability of two hierarchical models to ascertain if the six types of behavioral regulation better adjusted to the classical view (*i.e.,* intrinsic motivation, extrinsic motivation and amotivation) or the new perspective (*i.e.,* autonomous motivation, controlled motivation and amotivation). Once the best-factor model was identified, we extended validity evidence based on internal structure by running two multi-group analyses of invariance across age and sport. Second, convergent and discriminant validity together with reliability were, respectively, inspected. Third, criterion validity was provided by two linear regression analyses. In both analyses, we hypothesized that the three autonomous forms of motivation (*i.e.,* intrinsic motivation, integrated and identified regulation) would positively and significantly predict resilience, while the two controlled forms of motivation (*i.e.,* introjected and external regulation) and amotivation would positively and significantly predict burnout in athletes, consistent with SDT (*Ryan & Deci, 2020*; *Ryan et al., 2021*) and previous studies (*Li et al., 2013*; *Clancy et al., 2016*; *Trigueros et al., 2020*).

MATERIALS AND METHOD

Participants and setting

The participating sample consisted of 596 Romanian professional athletes (324 men and 272 women) aged between 18 and 52 years ($M = 22.91$, $SD = 5.84$) who competed at the international and national level. They self-reported a sport experience from 7 to 28 years ($M = 11.14$, $SD = 5.03$) at the international or national level. A total of 31 distinct sports were represented with each grouped into individual ($N = 273$, including athletics,

gymnastics, rowing, weightlifting, cycling or Olympic shooting) or team sports ($N = 323$, including soccer, basketball, volleyball, rugby, ice hockey or handball).

As a first sept of the research, we estimated a minimum sample of at least 325 participants in accordance with the ratio 5 cases per each statistical parameter specified in the factor model (*i.e.,* 65 parameters) in order to ensure the trustworthiness of the validation results (*Kline, 2016*). Akin to the method followed in previous studies (*Lonsdale, Hodge & Rose, 2008*) to recruit and select participants and considering lower response rates on online survey, an e-mail was sent inviting 800 athletes to complete the questionnaire *via* an online survey; 622 athletes (77.75%) responded. Of the totality of 622 athletes, there were 8 (1.29%) cases detected as univariate outliers (*i.e.,* $Z < 3.00$) and 16 (2.57%) cases as outliers (*i.e.,* Mahalanobis D^2, $p < .001$), which were removed and leading to the final described sample of 596 athletes. The participants in this research had to meet the following inclusion criteria: (a) professional athletes who competed at the international and/or national level, (b) older 18 years old, and (c) signed an informed consent to participate in this study. To complete the online survey, we provided them with instructions and guidelines by explaining them that their participation was fully voluntary and anonymous and there were not right and false responses since we only wanted to know their perception of their training and competitions. The average time estimated for its completion was 20 min. The research was approved by the Ethics Committee of the Vasile Alecsandri University of Bacau (code: 12661/1/27.08.2021).

Measures

Motivation toward sport

To measure athletes' perceptions of motivation in sport, the Romanian version of the BRSQ (*Lonsdale, Hodge & Rose, 2008*) was used. The instrument was preceded by the stem "I participate in my sport…" and followed by 24 items (4 items per factor) that measure intrinsic motivation (*e.g.*, "Because I enjoy it"), integrated regulation (*e.g.*, "Because it's a part of who I am"), identified regulation (*e.g.*, "Because the benefits of my sport are important to me"), introjected regulation (*e.g.*, "Because I would feel ashamed if I quit"), external regulation (*e.g.*, "Because people push me to play"), and amotivation (*e.g.*, "But I question why I continue"). Responses to each item were collected by a 7-point scale ranging from 1 (not at all true) to 7 (very true).

Resilience in sport

To measure athletes' perceptions of resilience in sport, the Romanian version of the Brief Resilience Scale (*Smith et al., 2008*) was used. The instrument is preceded by the stem "Please indicate the extent to which you agree with each of the following statements" and followed by 6 items (*e.g.*, "I tend to bounce back quickly after hard times") that assess resilience. Responses to every item were collected by a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Burnout in sport

To assess athletes' perceptions of burnout in sport, the Romanian version of the Athlete Burnout Measure (*Raedeke & Smith, 2001*) was used. The instrument is preceded by the

stem "In my trainings and competitions…" and followed by 15 items (five per factor) that measure emotional/physical exhaustion. (*e.g.*, "I am exhausted by the mental and physical demands of my sport"), reduced sense of accomplishment (*e.g.*, "I am not performing up to my ability in sport"), sport devaluation (*e.g.*, "I'm not into my sport like I used to be"). Items were responded using a 5-point Likert-type scale ranging from 1 (almost never) to 5 (almost always).

Design and procedure

As this study aimed at testing the psychometric properties of a measurement instrument, an instrumental design was adopted (*Ato, López & Benavente, 2013*). The authors received permission to use this instrument from the copyright holders. The BSRQ was adapted to the Romanian context using the guidelines proposed by *Bartram et al. (2018)*. A group of 2 translators translated the instrument into Romanian and, subsequently, a distinct group of 2 translator translated the Romanian version into English. The level of equivalence of both translated versions regarding the instrument's original version was qualitatively assessed by the main author. Thereupon, a new group of 2 researchers inspected the content of every BRSQ item in the Romanian version from a qualitatively approach to guarantee that each measured the target psychological variable. Lastly, a pilot study was developed to confirm the correct understanding of the totality of items, administrating the BRSQ to 11 athletes. They stated the lack of problems in the understanding of the content of the 24 items. Altogether, these results provided validity evidence based on the BRSQ's content.

Data analysis

To provide validity evidence based on the BRSQ's internal structure, a series of CFA and two invariance analyses were run. CFA were performed using the maximum likelihood method together with the 5000-resampling bootstrapping technique, due to the violation of the multivariate normality assumption (a Mardia's coefficient = 239.31, $p < .001$) (*Kline, 2016*). The goodness of fit was assessed by several fit indexes: coefficient between χ^2 and degree of freedom (χ^2/df), comparative fit index (CFI), Tucker–Lewis index (TLI), incremental fit index (IFI), standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA) with its confidence interval at 90% (90%CI) and Akaike information criterion (AIC). The χ^2/df coefficient shows a good fit with values as high as 3, while values up to 5 represent an acceptable fit (*Kline, 2016*). CFI, TLI and IFI are excellent with values above .95, while they are acceptable when values are equal to .90 or greater (*Kline, 2016*). SRMR and RMSEA are indicative of a good fit to data with values less than .060, while values below .080 state an acceptable fit to data (*Kline, 2016*). AIC is a measure of parsimony used in the comparison of models, indicating that the model with the smallest value would be the most parsimonious and, hence, preferable (*Kline, 2016*). Standardized regression weights are acceptable when values are above .50 (*Hair et al., 2018*).

To examine measurement invariance across age and sport, and following the methodological approach by *Kline (2016)*, four progressively constrained models were tested: configural invariance (no constraints), metric invariance (constraints in item

factor loading), strong invariance (constraints in item factor loading and intercept, simultaneously) and strict invariance (constraints in item factor loading, intercept and error variance, simultaneously). Changes as high as .010 in CFI values paired with differences below .015 in RMSEA values between each two progressively constrained models would be indicative of the instrument's invariant character (*Kline, 2016*). Regarding the age invariance analysis, the groups were created using median. Particularly, the first group (*i.e.,* younger athletes) was made up of 310 athletes aged between 18 and 21 years ($M_{age} = 19.54$, $SD_{age} = 1.64$), while the second group (*i.e.,* older athletes) included 286 athletes aged between 22 and 52 years ($M_{age} = 27.64$, $SD_{age} = 5.02$).

To examine the BRSQ's convergent validity, average variance extracted (AVE) was estimated, which is appropriate with values as low as .50 (*Hair et al., 2018*). Given the concern reported in previous studies about the instrument's discriminant validity (*Lonsdale, Hodge & Rose, 2008*; *Holland et al., 2010*), four criteria were used: (a) heterotrait-monotrait (HTMT) ratio of correlations (*Henseler, Ringle & Sarstedt, 2015*), which supports the discrimination among factors with values as high as .90 (*Henseler, Ringle & Sarstedt, 2015*; *Henseler, Ringle & Sarstedt, 2015*)); (b) if the interfactor correlation is less than unity by 1.96 times its standard error (*Bagozzi & Kimmel, 1995*); (c) correlations among latent factors, indicating that values less than .90 are representative of an acceptable conceptual discrimination among variables (*Kline, 2016*); and (d) confidence intervals at 95% (95% CI) of the correlation in question does not include 1.00 (*Anderson & Gerbing, 1988*). To inspect reliability of primary-order factors, Cronbach's alpha (α), McDonald's omega (ω) and Raykov's composite reliability (ρ) coefficients were, respectively, calculated. Additionally, to examine the construct reliability of hierarchical factors, coefficient H was computed. Every coefficient shows a good level of reliability with values over .70 (*Hair et al., 2018*).

To gather criterion validity evidence, two linear regression analyses were conducted. In both analyses, the six types of behavioral regulation were introduced as independent variables, resilience and burnout were considered as dependent variables, while age and type of sport were covariates. Descriptive statistics was computed for every variable under study, while the univariate normality assumption was inspected by standardized values for univariate skewness and kurtosis coefficients. Thus, standardized values as high as 1.96 are representative of a normal data distribution (*Hair et al., 2018*). Finally, independent t-tests were run to examine differences by age and sport in the target variables. Data were statically processed using SPSS and AMOS statistical software, version 25.

RESULTS

Preliminary results

The Brief Resilience Scale in its Romanian adaptation revealed adequate fit-indexes: χ^2 (9, $N = 596$) = 43.66, $p < .001$, $\chi^2/df = 4.85$; CFI = .97, TLI = .93; IFI = .97, SRMR = .042; RMSEA = .079 (90% CI = .067–.089). Suitable values were also obtained for reliability (α = .83, ρ = .83) and convergent validity (AVE = .54). On the other hand, the Romanian version of the Athlete Burnout Measure displayed acceptable fit indexes: χ^2 (87, $N = 596$) = 405.44, $p < .001$, $\chi^2/df = 4.66$; CFI = .94, TLI = .91; IFI = .94, SRMR = .056; RMSEA

= .080 (90% CI =.068–.093). The three factors showed a good level of reliability ($\alpha = .79$, $\rho = .79$; $\alpha = .77$, $\rho = .77$; $\alpha = .82$, $\rho = .82$) and convergent validity (AVE values of .51, .60, and .61).

Main results

Confirmatory factor analyses

Table 1 shows the results obtained by CFA for each factor model tested for the BRSQ. Specifically, while none of the alternative models had a minimally acceptable fit to the data; the six-factor correlated model displayed an appropriate fit with the observed data, as well as the lowest AIC value. This suggested that the six-factor correlated model had to be used for the remaining analyses by obtaining the best psychometric performance.

Figure 1 displays standardized regression weights, correlations among latent factors and squared multiple correlations for the six-factor correlated model. Standardized regression weights were between .53 and .87, each reaching the level of statistical significance ($p < .001$). Correlations among latent factors ranged from −.53 to .89, configuring a *simplex* structure with stronger and positive correlations among adjacent behavioral regulations, weaker correlations among more distal regulations, and negative correlations among ends.

On the other hand, Table 1 also shows the results from the CFA for each hierarchical model tested. It should be underscored that the three-factor model composed by autonomous motivation, controlled motivation and amotivation was the only that obtained an acceptable fit with the data. In this model, factor loadings were of .88 and .90 for intrinsic motivation, integrated regulation and identified regulation in the hierarchical autonomous motivation factor; while introjected regulation and external regulation obtained a factor loading of .88 and .90 in controlled motivation. Correlations among hierarchical factors were: $r = -.34$ between autonomous motivation and controlled motivation, $r = -.51$ between autonomous motivation and amotivation, and $r = .80$ between controlled motivation and amotivation.

Invariance analysis

Table 2 shows the absence of changes over .010 in CFI values accompanied by differences lower than .015 in RMSEA values in the successive constrained models for both multi-group analyses. Therefore, the null hypothesis of invariance across age and type of sport could not be rejected, respectively.

Convergent and discriminant validity, and reliability analysis

Table 3 displays AVE values between .50 and .70, underpinning the instrument's convergent validity. Table 2 also shows HTMT values as high as .88 among the six latent factors together scores for correlations of each behavioral regulation lower than 1.00 by a value 1.96 times its standard error, as well as interfactor correlations between -.53 and .89 and its 95% CIs that did not exceed the unity in all cases. These four results endorsed the BRSQ's discriminant validity. On the other hand, Table 2 reflects acceptable reliability scores for the six primary-order factors with Cronbach's alpha from .75 to .90, McDonald's omega from .84 to .91, and Raykov's coefficient from .75 to .90. For the hierarchical factors,

Table 1 **Goodness-of-fit measures for all BRSQ models tested.**

Models	$\chi^2(df)$	χ^2/df	CFI	TLI	IFI	SRMR	RMSEA(90% CI)	AIC
Primary-order models								
2-factor correlated model (SDM, NSDM)	1622.44(251)	6.46	.83	.81	.83	.073	.096(.091–.100)	1720.44
3-factor correlated model (IM, EM, AMOT)	2969.36(249)	11.93	.66	.63	.66	.159	.136(.131–.140)	3071.36
3-factor correlated model (AM, CM, AMOT)	1241.08(249)	4.99	.88	.86	.88	.059	.082(.077–.086)	1344.08
4-factor correlated model (IM, AEM, CEM, AMOT)	1135.16(246)	4.61	.89	.88	.89	.057	.078 .073–.083)	1243.16
5-factor correlated model (IM, InR+IdR, ItR, ER, AMOT)	1076.35(242)	4.45	.90	.88	.90	.055	.076(.072–.081)	1192.35
5-factor correlated model (IM, InR, IdR, IntR+ER, AMOT)	1054.92(242)	4.36	.90	.89	.90	.054	.075(.071–.080)	1170.92
6-factor correlated model (six motivational forms)	857.96(237)	3.62	.93	.91	.93	.050	.066(.062–.071)	979.63
Hierarchical models								
3-factor model (IM, EM, AMOT)	1799.95(245)	7.35	.81	.78	.81	.145	.103(.099–.108)	1909.95
3-factor model (AM, CM, AMOT)	873.55(244)	3.58	.92	.91	.92	.053	.066(.061–.071)	981.38

Notes.

SDM, Self-determined motivation; NSDM, Non-self-determined motivation; EM, Extrinsic motivation; AMOT, Amotivation; InR+IdR, merged from the integrated and identified regulations factors; AM, Autonomous motivation; CM, Controlled motivation; AEM, Autonomous extrinsic motivation; CEM, Controlled extrinsic motivation.

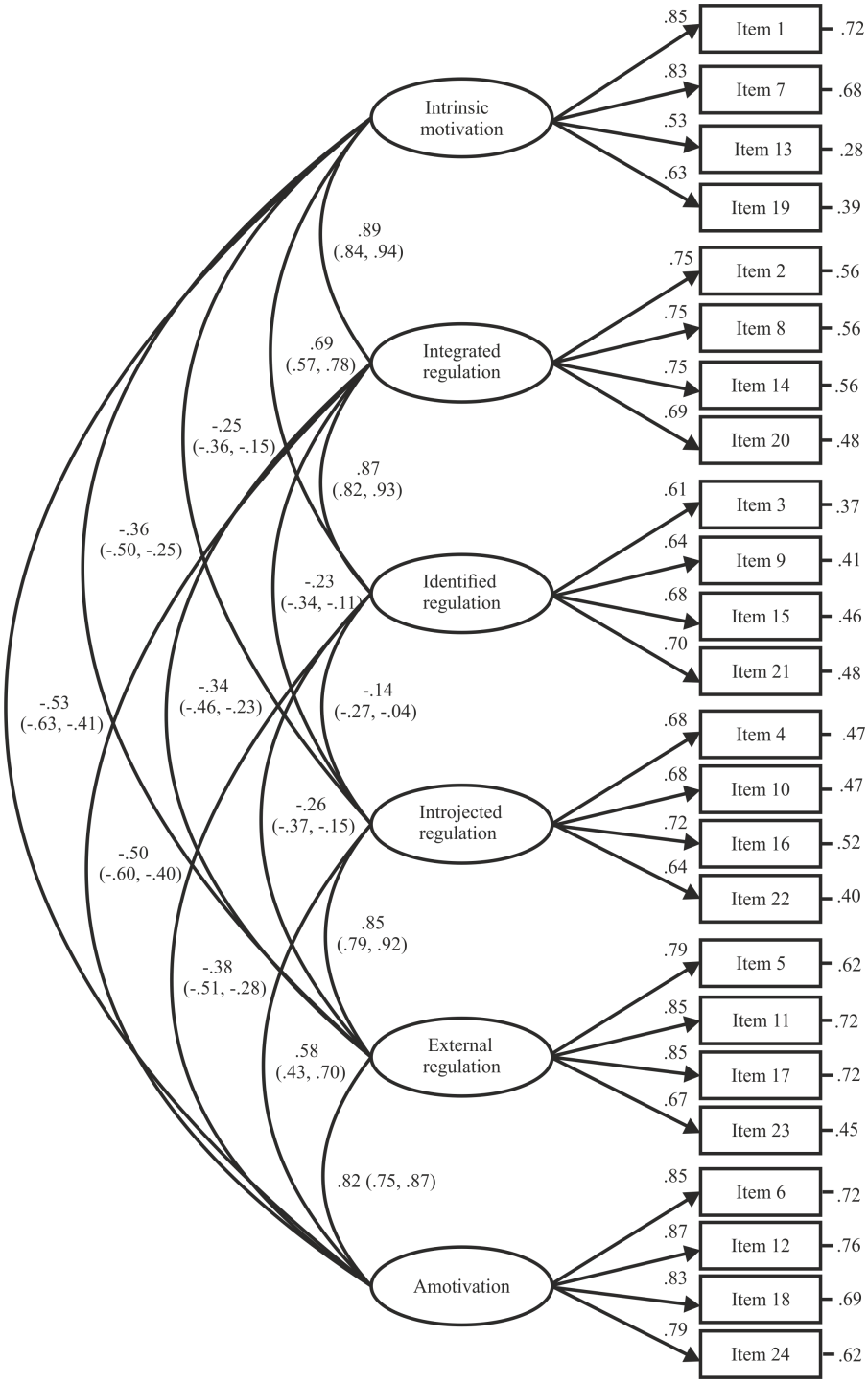

Figure 1 Confirmatory factor analysis for the Romanian version of the Behavioral Regulation in Sport Questionnaire. Note: The ellipses represent the latent factors, while the rectangles represent the different items. Numbers in parentheses show the standard error estimated by bootstrapping.

Full-size DOI: 10.7717/peerj.12803/fig-1

Table 2 Multi-group analysis of invariance.

	$\chi^2(df)$	CFI	RMSEA(90% CI)	MC	$\Delta\chi^2(\Delta df)$	ΔCFI	ΔRMSEA
			Invariance across Age				
1. Configural invariance	1331.07(474)	.903	.053(.049–.057)	–	–	–	–
2. Metric invariance	1357.97(492)	.902	.052(.049–.056)	2 *vs* 1	26.90(18)	−.001	−.001
3. Strong invariance	1436.88(516)	.897	.053(.049–.056)	3 *vs* 2	78.91(24)	−.005	.001
4. Strict invariance	1589.65(540)	.887	.057(.053–.060)	4 *vs* 3	152.77(24)	−.010	.004
			Invariance across Sport				
1. Configural invariance	1324.87(474)	.903	.053(.049–.056)	–	–	–	–
2. Metric invariance	1352.45(492)	.902	.052(.048–.055)	2 *vs* 1	28.58(18)	−.001	−.001
3. Strong invariance	1427.47(516)	.895	.052(.049–.056)	3 *vs* 2	75.76(24)	−.007	.000
4. Strict invariance	1572.51(540)	.886	.055(.051–.058)	4 *vs* 3	144.43(24)	−.009	.003

Notes.
MC, Models comparison; *vs*, versus.

a coefficient H was obtained of .93 for autonomous motivation and .92 for controlled motivation.

Linear regression analysis

Table 4 shows that, after controlling for age and sport, intrinsic motivation (β =.21, $p < .001$), integrated regulation (β =.31, $p < .001$) and identified regulation (β =.13, $p = .032$) positively and significantly predicted resilience; while introjected regulation (β =.06, $p = .036$), external regulation (β =.14, $p = .005$) and amotivation (β =.63, $p < .001$) positively and significantly predicted burnout. The total variance explained was 25% for resilience and 52% for burnout.

Descriptive statistics and differences by age and sport

Table 5 shows mean scores over mid-point of the respective measurement scale in intrinsic motivation, integrated regulation, identified regulation and resilience among athletes. Alternatively, there were mean values below mid-point of the measurement scale for introjected regulation, external regulation, amotivation and burnout. Standardized values ranged from −1.76 to 1.94 for skewness and from −0.22 to 1.71 for kurtosis, supporting the univariate normality assumption. Independent t-tests displayed that while older athletes higher scored than younger athletes in intrinsic motivation, integrated and identified regulation, and resilience; younger athletes obtained higher values of amotivation and burnout. Similarly, team sports athletes obtained higher scores in intrinsic motivation, integrated regulation and resilience, while individual sports athletes scored higher in amotivation.

DISCUSSION

The objective of this research was to gather validity and reliability evidence for the use of the BRSQ in Romanian professional athletes. The results were consistent the hypotheses raised in this study, and, therefore, provided a strong psychometric support for the BRSQ

Table 3 Reliability coefficients, convergent and discriminant validity for the BRSQ.

	α	ω	ρ	AVE	1	2	3	4	5	6
1. Intrinsic motivation	.85	.87	.85	.52	–	.89(.84, .94) [0.894]	.69(.57, .78)[0.901]	−.25(−.36, −.15) [0.888]	−.36(−.50, −.25) [0.892]	−.53(−.63, −.41) [0.891]
2. Integrated regulation	.82	.90	.83	.54	.85	–	.87(.82, .93) [0.890]	−.23(−.34, −.11) [0.890]	−.34(−.46, −.23) [0.896]	−.50(−.60, −.40) [0.865]
3. Identified regulation	.75	.84	.75	.50	.68	.83	–	−.14(−.27, −.04) [0.904]	−.26(−.37, −.15) [0.989]	−.38(−.51, −.28) [0.867]
4. Introjected regulation	.78	.88	.78	.51	−.21	−.21	−.13	–	.85(.79, .92) [0.855]	.58(.43, 70) [0.737]
5. External regulation	.85	.90	.87	.62	−.32	-.30	−.24	.83	–	.82(.74, .87) [0.837]
6. Amotivation	.90	.91	.90	.70	−.50	−.46	−.36	.68	.88	–

Notes.

Numbers above diagonal represent correlations among latent factors with its 95% confidence interval in parenthesis and values in terms of unity by 1.96 times the standard error of the correlation in square brackets. Numbers below diagonal represent heterotrait-monotrait ratio of correlations.

Table 4 **Linear regression analysis predicting resilience and burnout from behavioral regulation in athletes.**

	Resilience							Burnout						
	B(*SE*)	*β*	*p*-value	*t*	Tolerance	VIF	R^2	*B*(*SE*)	*β*	*p*-value	*t*	Tolerance	VIF	R^2
(constant)	1.55(0.31)	–	<.001	8.06	–	–	.25	2.42(0.22)	–	<.001	10.79	–	–	.52
Age	0.02(0.01)	.14	<.001	3.70	0.95	1.05		−0.01(0.01)	−.01	.799	−0.26	0.95	1.05	
Sport	0.06(0.06)	−0.01	.709	−0.37	0.89	1.11		0.01(0.02)	.01	.790	0.27	0.89	1.11	
Intrinsic motivation	0.12(0.03)	.21	<.001	3.80	0.49	2.04		−0.02(0.03)	−.03	.480	−0.71	0.49	2.04	
Integrated regulation	0.28(0.06)	.31	<.001	4.98	0.34	2.93		−0.01(0.03)	−.01	.787	−0.27	0.34	2.93	
Identified regulation	0.11(0.05)	.11	.032	2.15	0.49	2.03		−0.03(0.04)	−.04	.377	−0.88	0.49	2.03	
Introjected regulation	−0.01(0.03)	−.01	.791	−0.27	0.46	2.17		0.09(0.04)	.06	.036	2.10	0.46	2.17	
External regulation	−0.02(0.04)	−.03	.585	−0.55	0.37	2.71		0.11(0.04)	.14	.005	2.79	0.37	2.71	
Amotivation	−0.03(0.05)	−.03	.592	−0.54	0.41	2.46		0.33(0.02)	.63	<.001	13.91	0.41	2.46	

Notes.

VIF, Variance Inflation Factor.

Table 5 Descriptive statistics and differences by age and sport.

	Total sample				Younger athletes	Older athletes	*t*-tests			Individual sports	Team sports	*t*-tests		
	Range	*M*(*SD*)	γ_1	γ_2	*M*(*SD*)	*M*(*SD*)	*t*(*df*)	*p*-value	*d*	*M*(*SD*)	*M*(*SD*)	*t*(*df*)	*p*-value	*d*
Intrinsic motivation	1–7	6.33(0.87)	−1.76	1.61	6.20(0.98)	6.47(0.71)	3.78(594)	<.001	0.32	6.08(0.99)	6.54(0.68)	6.72(594)	<.001	0.54
Integrated regulation	1–7	6.30(0.89)	−1.66	1.71	6.16(0.98)	6.53(0.73)	5.10(594)	<.001	0.43	6.15(1.02)	6.49(0.73)	4.64(594)	<.001	0.38
Identified regulation	1–7	6.32(0.84)	−1.52	1.44	6.21(0.90)	6.44(0.76)	3.32(594)	<.001	0.28	6.29(0.85)	6.35(0.84)	0.86(594)	.390	0.07
Introjected regulation	1–7	2.38(1.46)	1.09	0.39	2.49(1.40)	2.26(1.52)	1.93(594)	.054	0.15	2.45(1.45)	2.32(1.48)	1.09(594)	.276	0.08
External regulation	1–7	1.85(1.24)	1.94	1.67	1.94(1.24)	1.76(1.23)	1.80(594)	.072	0.14	1.96(1.29)	1.76(1.18)	1.98(594)	.049	0.16
Amotivation	1–7	1.99(1.39)	1.72	1.25	2.10(1.42)	1.87(1.35)	2.04(594)	.042	0.17	2.23(1.51)	1.79(1.26)	3.86(594)	<.001	0.32
Resilience	1–5	3.63(0.76)	−0.13	−0.22	3.47(0.76)	3.80(0.72)	5.47(594)	<.001	0.45	3.55(0.82)	3.69(0.70)	2.28(594)	.023	0.33
Burnout	1–5	2.12(0.73)	0.63	−0.15	2.21(0.72)	2.03(0.73)	2.95(594)	.003	0.25	2.18(0.78)	2.08(0.69)	1.69(594)	.093	0.14

Notes.

γ_1, Standardized coefficient for skewness; γ_2, Standardized coefficient for kurtosis; *df* , degree of freedom; *d*, Cohen's d effect size measure.

as a valid and reliable measure of motivation from the SDT framework (*Ryan & Deci, 2020*) in the Romanian sport domain.

Confirmatory factor analyses

Similar to the results reported in previous research that compared the original six-factor correlated model with alternative correlated models of the BRSQ (*Lonsdale et al., 2014*; *Hancox et al., 2015*; *Monteiro, Moutão & Cid, 2018*; *Rodrigues et al., 2020*), the original six-factor model obtained the best psychometric performance. Indeed, the goodness-of-fit measures were similar to the distinct adapted BRSQ versions to other social-cultural contexts (*Assor, Vansteenkiste & Kaplan, 2009*; *Holland et al., 2010*; *Viladrich, Torregrosa & Cruz, 2011*; *Çetinkaya & Mutluer, 2018*). Furthermore, all standardized regression weights were higher than .50, stating the each of them adequately represented the factor theoretically intended. Correlations among latent factors displayed a *simplex* structure with stronger and positive correlations among adjacent behavioral regulations, weaker correlations among more distal behavioral regulations, and negative correlations among extremes. These findings were aligned with previous studies focused on the BRSQ (*Assor, Vansteenkiste & Kaplan, 2009*; *Viladrich, Torregrosa & Cruz, 2011*; *Hancox et al., 2015*; *Cece et al., 2019*) and they, in turn, gathered evidence to psychometrically underpin the existence of the self-determination *continuum* advocated by SDT (*Ryan & Deci, 2020*).

On the other hand, the results from CFA also underpinned a hierarchical three-factor model encompassing autonomous motivation, controlled motivation and amotivation. This suggests that intrinsic motivation, integrated and identified regulation could be representing autonomous motivation, while introjected and external regulation could be representing controlled motivation. Indeed, these findings provided support for three general types of motivation in accordance with the SDT paradigm (*Ryan & Deci, 2020*; *Ryan et al., 2021*) considering their quality. Furthermore, these results are of a great methodological utility when researchers want to study antecedents and outcomes of motivation into complex structural models.

Invariance

The results derived from the two multi-group analyses provided evidence underpinning the measurement invariance across age and sport for the 24-item, six-factor correlated model, in line with the original version of the instrument (*Lonsdale, Hodge & Rose, 2008*) and with the different adaptations to other contexts (*Hancox et al., 2015*; *Stenling et al., 2018*; *Cece et al., 2019*; *Monteiro et al., 2019*). Particularly, these findings are of great practical utility by allowing us to recommend the use of the BRSQ to more deeply study the possible differences in the level of each behavioral regulation in athletes with different age and type of sport practiced (*i.e.,* individual or team) in the Romanian domain.

Convergent and discriminant validity, and reliability

With respect to the BRSQ convergent validity, our results showed AVE scores above .50 in the six factors comprising it, indicating that every item was strongly related to the motivational factor under measurement. Our findings, although they contrasted with marginal values manifested by *Monteiro, Moutão & Cid (2018)*, were similar to

those obtained in previous studies (*Lonsdale, Hodge & Rose, 2008*; *Holland et al., 2010*; *Viladrich, Torregrosa & Cruz, 2011*; *Lonsdale et al., 2014*; *Monteiro et al., 2019*). Concerning the instrument's discriminant validity, evidence was met in support of an appropriate discrimination among the six types of behavioral regulations described by SDT (*Ryan & Deci, 2020*) and measured in the BRSQ (*Lonsdale, Hodge & Rose, 2008*). In line with previous research on the BRSQ (*Lonsdale, Hodge & Rose, 2008*; *Holland et al., 2010*; *Monteiro, Moutão & Cid, 2018*), high correlations in this study were also found between intrinsic motivation and integrated regulation ($r = .89$), between integrated and identified regulation ($r = .87$), and between introjected and external regulation ($r = .85$), although they did not suppose a discriminant validity problem by not exceeding .90 (*Kline, 2016*), not including the unity the 95% CI of each correlation and by being its score less than the unity by 1.96 times its standard error. In addition, it is important to underscore that the estimation of HTMT ratio of correlations (*Henseler, Ringle & Sarstedt, 2015*) with scores as high as .88 gathered new evidence endorsing the BRSQ discriminant validity. On the other hand, similar to the results reported both in the original version (*Lonsdale, Hodge & Rose, 2008*) and the different adaptations of the instrument (*Assor, Vansteenkiste & Kaplan, 2009*; *Holland et al., 2010*; *Viladrich, Torregrosa & Cruz, 2011*; *Hancox et al., 2015*; *Çetinkaya & Mutluer, 2018*; *Monteiro, Moutão & Cid, 2018*), a good level of reliability was obtained for each primary-order factor comprising the BRSQ with values of Cronbach's alpha, McDonald's omega and Raykov's coefficient greater than .70. Also, it should be underlined that this is the first study that provided construct reliability evidence for the hierarchical factors considered in the BRSQ.

Criterion validity

The results of the two linear regression analyses were consistent with the SDT assumptions (*Ryan & Deci, 2020*) and previous studies (*Li et al., 2013*; *Clancy et al., 2016*; *Trigueros et al., 2020*), supporting, therefore, criterion validity of the BRSQ. As expected, the three autonomous forms of motivation (*i.e.,* intrinsic motivation, integrated regulation and identified regulation) positively predicted resilience among professional athletes. A plausible explanation would rest on the fact that athletes tend to optimally develop a stronger sense of adaptation, resistance and recovery from stressing events when they engage in their sport for a combination of reasons based on enjoyment and seeking out optimal challenges, incorporation of their sport into their identity and the recognition of the its benefits. Thus, fostering the autonomous forms of motivation among athletes seems to be a promising strategy to optimally develop their resilience. The results also displayed a positive prediction effect of the two controlled forms of motivation (*i.e.,* introjected and external regulation) and, mainly, amotivation on burnout in professional athletes. This may be explained because athletes who participate in their sport guided by externally (*e.g.*, winning a tournament) and internally (*e.g.*, to gain self-esteem) controlled reasons, and perceptions of incompetence and a passive engagement, they will be prone to experience a reduced sense of accomplishment, emotional and physical exhaustion and devaluation when they failure to their set sports goals.

Limitations

Given the complexity of the cognitive processes, validation of any measure of psychological variables should be understood as an ongoing process over time. Therefore, a series of limitations should be taken into account for the present study. Firstly, the purposive sampling method used in this research does not allow us to generalize the obtained results to the general population. Thus, new research could take into account more heterogeneous samples of athletes depending on their previous sports experience, performance level, gender, injuries, religion or ethical background. Secondly, the adoption of a cross-sectional design has not permitted to establish casual-effect relationships among the variables under study. Hence, it is not possible to ascertain if behavioral regulation is an antecedent of resilience and burnout in sport or vice-versa. Additional longitudinal studies are therefore needed to examine this issue.

Practical Implications

The adaptation of the BRSQ to the Romanian sport domain allows us to assess athletes' perceptions of the six types of behavioral regulation in this setting, implying a set of implications for practice. Methodologically, the Romanian version of the BRSQ constitutes the first well-validated measure of behavioral regulation toward sport under the SDT framework in Romania. Theoretically, our results gather a consistent body of evidence in support of the self-determination *continuum* advocated by SDT. In addition, the assessment of the quality of motivation might contribute to provide a better insight into the Romanian athletes' motivational processes involved in sport. Practically, these results open the manner for implementing potentially effective interventions, positing that increased athletes' levels of the autonomous forms of motivation may enhance their performance-related outcomes. Additionally, the Romanian version of the BRSQ could be used both to analyze changes in athletes' behavioral regulation throughout a single season, and to examine their motivational trajectories in the course of their sports careers. Furthermore, this tool will allow coaches to conducted a more accurate detection of those athletes who might be at a motivational risk at any point of the season. Taken together, this information will help coaches implement more adapted motivational strategies in order to effectively develop adaptive motivational patterns among athletes.

CONCLUSIONS

The present research shows that the BRSQ can be utilized to assess both the six types of behavioral regulation and the three general qualities of motivation toward sport with Romanian athletes. Specifically, this study gathered a substantial basis of evidence to support both validity (*i.e.,* internal structure, convergent, discriminant, and criterion) and reliability of this instrument. Thus, it is noteworthy that now the scale is available as a Romanian measurement instrument of motivation underlying to the SDT framework in the sport domain, as it contributed to filling an existing gap until now in Romania.

ADDITIONAL INFORMATION AND DECLARATIONS

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Competing Interests

The authors declare there are no competing interests.

Author Contributions

- Cristina Ioana Alexe and Ioan Turcu conceived and designed the experiments, performed the experiments, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the paper, contact Romanian professional athletes, and approved the final draft.
- Dan Iulian Alexe conceived and designed the experiments, performed the experiments, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the paper, contact differennt Romanian sports federations, and approved the final draft.
- Gabriel Mareş conceived and designed the experiments, performed the experiments, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the paper, prepare the online questionnaire survey and database, and approved the final draft.
- Dragoş Ioan Tohănean conceived and designed the experiments, performed the experiments, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the paper, prepare database, and approved the final draft.
- Rafael Burgueño conceived and designed the experiments, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the paper, prepare database, and approved the final draft.

Human Ethics

The following information was supplied relating to ethical approvals (i.e., approving body and any reference numbers):

Ethics Committee of the Vasile Alecsandri University of Bacau (Romania).

Data Availability

The following information was supplied regarding data availability:

The raw measurement are available in the Supplementary Files.

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Article

Analysis of the Physiognomy of Unique Sets in the Maximum Number of Repetitions Strategy—The Case of One-Arm Scott Machine Seated Bicep Curls

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Abstract: The aim of this paper is to analyze the physiognomy of unique sets in the maximum number of repetitions (MNR) strategy and different correlations between the maximal forces, duration and volume for a relevant exercise in the case of a small muscle group. The research methodology proposes testing, in two phases, a total of 30 male students, for bicep curl exercises carried out on a bicep Scott machine. The obtained results showed that there were significant differences between the maximum forces (Fmax) developed during the initial and final repetitions of the exercise sets or for different machine loads. There was a large correlation between the load and Fmax and an inverse correlation between the load and MNR or between the MNR and Fmax. The deterioration of the execution mode, represented by the profile of the final repetition of high-duration sets, was also tested and analyzed. We concluded that the study of the physiognomy of cycles and comparisons at the level of relevant repetitions have revealed new perspectives for the design of periodization strategies, for the possibility of manipulating adapted muscular response or compensatory acceleration training for small muscle groups or the MNR strategy.

Keywords: maximum number of repetitions strategy; Scott machine seated bicep curl; maximal forces; compensatory acceleration training

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1. Introduction

Building muscle endurance takes time and consistency in training in a context in which muscles adapt quickly to exercises and the way they are performed. The way the muscle adapts to resistance training depends on several variables such as the load, volume, frequency of training, speed of contraction, work-to-rest ratios and time under tension [1]. In training, one approach is to base the prescription on the number of repetitions. The number of repetitions left in reserve in a training set is correlated with the level of effort [2]. However, some studies show that there are difficulties in predicting the proximity of momentary task failure [3] or the number of repetitions in reserve [4].

The maximum number of repetition is obtained and maintained due to the intensity, volume and metabolic response to a workload [1,5]. According to [6–8], the numbers of possible repetitions prior to failure at the same relative intensity (%1RM) vary between exercises and individuals.

Training to failure and the maximum number of repetitions (MNR) strategy, according to [9,10], are not optimal for maximizing performance. Additionally, it is difficult to determine the exact number of repetitions left in reserve. So, understanding the physiognomy of the sets can be useful for predicting the number of repetitions left in reserve in a training set.

The factors that influence the maximum number of repetitions in the case of bicep curls were analyzed by Iglesias et al. There is an inverse relationship between MNR and relative intensity, defined by the load ratio per maximum one-repetition attempt, 1RM [11].

Related to the influence of the training experience upon the MNR, studies that have evaluated the MNR between individuals with different training experience shows little [12] or no influence [13] on this variable.

Some strategies were developed in order to increase the MNR and training intensity. Pedrosa et al. [14] showed that a greater number of repetitions with a shorter mean repetition duration were performed in the barbell bench press exercise with an elastic device named the Sling Shot than without it, regardless of the individuals' training experience.

The literature also presents special programs dedicated to increasing training intensity: the method of reducing rest periods between sets (e.g., Nubret), based on the traditional training objective which manages the ability to recover between sets [15,16]; superset training, based on muscle pairs, takes advantage of the contraction of antagonistic muscles and the reduction in rest-on periods, offering very good results for short training times [17–19]; compound-set training, which is similar to superset training with the exception that it refers to exercises for the same muscle group, reducing the duration of training and high-intensity training, which produces a dramatic increase in intensity (i.e., beyond the point of muscle failure) in terms of volume reduction and training duration reduction [20–22].

It also seems intuitive to suggest that there may be differences between the repetitions during the entire cycle, in the case of the MNR strategy.

Reiser et al. presents the problem of morphological differences between the beginning and the end of a repetition, highlighting factors that influence the intensity of a conventional bicep curl; in this case, the critical role of acceleration is highlighted for the first time [23].

Nolte et al. presented a three-dimensional musculoskeletal model of the seated bicep curl resistance training exercise in which the influence of small deviations from the ideal trajectory is highlighted [24]. In the literature, there are also references to the models of kinematics, kinetics and muscle activation during explosive upper body movements, focusing on large muscle groups, but in this case, no reference is made to small groups.

Based on the literature review, some gaps have been found in this field. Different studies have focused on the analysis of the MNR and 1RM in subjects with different training backgrounds [11,25,26]; however, there are a small number of contributions focused on the physiognomy of the repetitions in an execution to the point of refusal with light weights, as well as the MNR impact on the performance of subjects after long periods of physical inactivity.

Another very little-studied problem in the case of small muscle groups is understanding the major differences between the physiognomy of repetitions during the entire cycle, in the case of the MNR strategy, starting from comparisons of the pairs of the first and last repetitions. The interest was in analyzing the mechanisms of developing muscular endurance in a small group, based on high-volume training. The main objective was to analyze the correlations between Scott machine load and the dynamics of force over the entire set, but also the concentric phase of the relevant repetition considering the strategy of maximum number of repetitions (i.e., typically at 30–40 %1RM relative intensity) and the impact of the initial stage of resuming strength training.

The analysis of the correlations between the maximal forces, volume and duration of an MNR set in the case of one-arm Scott machine seated bicep curls represents a novelty in the field of strength training, especially in the context of the difficulty in evaluating performances, generally expressed by relative intensity (%1RM) and the correlation with MNR, respectively.

We hypothesized that: (i) there is a relationship between the MNR, maximum force (Fmax) and the machine load; (ii) there are differences between the maximum forces developed during the initial and final repetitions of the exercise sets or for the different machine loads; (iii) the duration of the MNR strategy set increases while the machine load is reduced and (iv) the deterioration of the execution mode is different for the initial and final repetitions.

2. Materials and Methods

2.1. Participants

In this research, we proposed the research of a specific exercise for a small muscle group, on a relatively large sample of young people with relatively similar abilities (students at the Transilvania University of Brasov). GPower software (version 3.1.9.4, University of Düsseldorf, Düsseldorf, Germany) was used to calculate the sample size, considering an effect size of 0.4 for a recreationally trained population [27], power (1–β) of 0.8 and an α level of 0.05. Accordingly, 34 participants would be required as a necessary sample size.

As such, 35 participants, male students at the Transilvania University of Brașov, were recruited to participate in this study. The inclusion and exclusion criteria for participation in the study were: (a) having at least one year of experience in weightlifting, as a hobby; (b) spending a minimum of 2 days per week training and (c) having no previous injuries which may interfere with the study.

Five participants were excluded due to a loss of interest and personal issues, and the final sample included 30 participants (20.1 $\pm$ 1.6 years; 80 $\pm$ 3.5 kg) with experience of 23.8 $\pm$ 7.2 months and a frequency of 3 $\pm$ 1.1 times/week.

The subjects were informed of the research procedure and gave their consent. The experimental procedure was approved by the local ethics committee of the Transilvania University. The muscle testing was performed in the Department of Motor Performance of the Transilvania University of Brașov.

2.2. Components of Experimental Setup

The experimental setup used for determining the forces developed at muscle contraction, in the cases of 10 and 5 kg load, consisted of several components, as presented in Figure 1.

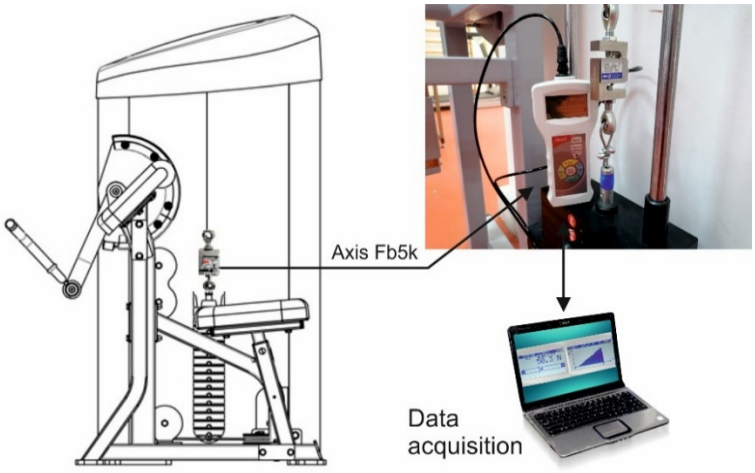


Figure 1. Experimental setup.

The machine used for the experiment was the Scott machine for seated bicep curls (SM-SBCs), supporting standard weights of 10 × 8 kg + 5 × 5 kg. The dynamometer used for determining the forces developed during the exercise was manufactured by AXIS FM, and was model Fb5k. The capacity of the dynamometer was 5000 N and the accuracy was ±0.1%. The measurement speed was from 10 to 40 measurements/second. The values were obtained by means of Axis FM software. Axis FM software allows the following operations to take place: reading device information; reading the information on the display, in real time; recording measurements on the computer while the dynamometer is connected to the PC and the program is working; downloading data saved in the device memory; viewing measurements with diagrams and statistics; saving measurements and diagrams in files; controlling the dynamometer functions from the computer keyboard and changing the working settings of the device in the program.

2.3. The Selection of Bicep Curl Exercise

Bicep curls (BC) involve the biceps brachii, one of the main muscles of the upper arm which acts on both the shoulder joint and the elbow joint. In this type of exercise, there are differences in the implementation (e.g., free weight lifting vs. machines) and the involved muscle groups also depend on the grip (e.g., supination vs. pronation).

Regardless of the bicep curl type, the execution requires that the elbow flexion range of motion be performed completely. The isolation or elimination of the contribution of the shoulders and back must be taken in consideration. By selecting the exercise, the correct execution was required as well as the elimination of the contribution of adjacent muscle groups, a particularly important aspect in testing small muscle groups. We opted for one-arm SM-SBCs due to the fact that the machine offers faster measurement possibilities, avoiding errors due to the 3D movements, and those introduced by specific free-weight BC, which could be affected by small cheats. The machine also offers the possibility of more accurate execution and at a more uniform rhythm.

Preliminary discussions with the participants showed that regardless of the selection of exercises in these routines, there is a distinct place for the arm exercises, especially the biceps (e.g., dumbbell/barbell curls standing/seated/incline/preacher curls); this is due to the simplicity of these exercises, but also to the visibility and the ability to quickly evaluate the first results. These exercises are suitable for light load–high repetition training in which the use of slow-twitch muscle fibers is highlighted, and for specific endurance training for small muscle groups such as the biceps.

The used strategy for the research was one set of training to failure, which can provide a quick boost after a period of inactivity because it creates a critical amount of metabolic stress and muscular damage to further endurance development.

2.4. The Procedure of Testing the Subjects

The methodology of the research was adapted to the ambitious objectives of this research, and the particularities of the exercise. It is innovative and it started from the calibration of the subjects for maximum repetition (i.e., 1RM one-arm SM-SBCs), followed by a set of repetitions to the point of refusal with light weights.

Step 1: The first step was to perform a one-repetition-maximum test in order to calibrate the subjects, which was performed 48–72 h before. 1RM measurement refers to the maximum force on the concentric phase of a single repetition. The subjects had the opportunity to select their best performance from successive attempts with 5 min of rest between them.

Step 2: The subjects continued to use one-arm SM-SBCs with one set of training to failure with two different types of load on the Scott machine: 10 kg and 5 kg.

In Step 2, the experiment was performed as follows:

1. The participant sat down on the bicep Scott machine.
2. The machine load of 10 kg/5 kg was chosen, according to the MNR strategy, and the machine set to a typical 30–40% relative intensity.
3. The starting position was set, with the subject positioning the triceps of the dominant hand on the preacher pad and grasping the handle.
4. The exercise was performed, with the subject lifting the hand and contracting the biceps.
5. At each repetition, the forces was measured by means of the dynamometer.
6. The execution was performed to the point of refusal. The maximum number of repetitions was counted.

After the exercise was performed, 48–72 h of rest was allowed in order for the muscle to stabilize. The subjects were monitored for execution mode, with the hand-to-shoulder starting position of the dominant hand, the wrist joint following the forearm, with complete movement.

The measurements were repeated for each subject and mediation of the results was conducted, in order to understand the dynamics of a set using the MNR strategy and analyze the first/last relevant repetition. The expected results refer to the execution mode: the durations of the phases in a repetition cycle, the equation of the dynamics of the force

on the concentric phase, the developed impulse and other useful elements in the in-depth understanding of the MNR strategy.

The research design was adapted to the sample of relatively homogeneous subjects and to the characteristics of the selected exercise. The methodology combines several work procedures, among which was 1RM testing, the performance averaging method (i.e., allowed by the experimental setting specific to the selected exercise), the comparative analysis of the force evolution depending on the duration of the prolonged sets, with the study of the major differences at the level of the initial versus the final repetitions using the MNR strategy.

Figure 2 presents a flow chart of the experimental test procedure and shows the particularities of the experimental methodology, adapted to the MNR strategy, to the specific characteristics of the muscle group and to the selected exercise.

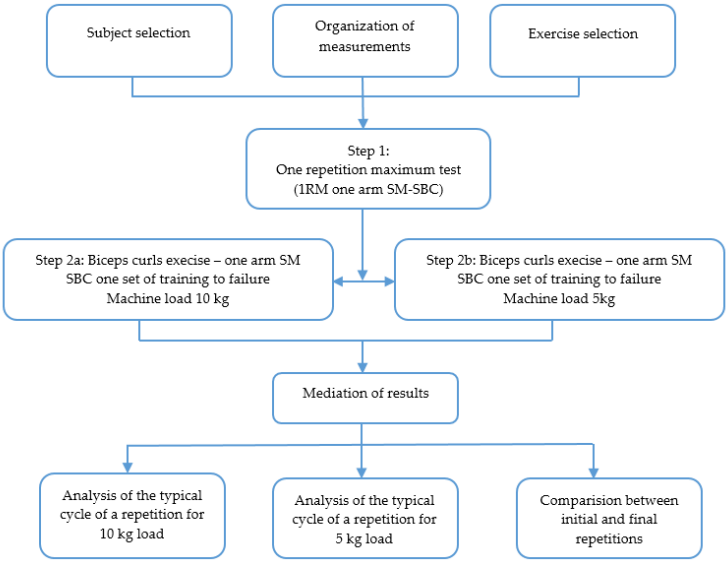


Figure 2. The flow chart of the experimental methodology based on two steps.

2.5. Data Analysis

The data analysis was performed using IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY, USA). The associations between the variables were analyzed using independent *t*-test samples. Some correlations between the variables were determined. A correlational value above 0.5 was considered to be strong, values between 0.3 and 0.49 were considered moderate, and any value less than 0.29 was considered to be poor [28].

A paired *t*-test was conducted in order to compare the maximum forces developed during the initial and final repetitions of the exercise set, or for the different machine loads. Data analysis was carried out at a 0.05 significance level (p), which means a 95% confidence level. The Cohen's d effect sizes were calculated for each repetition pair (i.e., initial and final) and defined as trivial (<0.2), small ($\geq$0.2), moderate ($\geq$0.5) or large ($\geq$0.8) [28].

3. Results

The first testing phase considered the establishment of 1RM in the participants and 1RM in relation to the body mass of the subjects. The obtained values for 1RM were 0.24 $\pm$ 0.02 kN. In this case, the 1RM/body-mass rate was also calculated (0.31 $\pm$ 0.03).

In the second phase of testing, SM-SBCs for single-arm exercises were performed, using two machine loads of 10 kg and 5 kg, respectively. Table 1 presents the descriptive statistics of the MNR and the maximum forces developed during the repetitions for the sample. At a low machine load, the maximum number of repetitions was increased.

Table 1. Descriptive statistics of MNR and maximum forces.

Characteristics	MNR_10 kg	MNR_5 kg	Fmax_10 kg (kN)	Fmax _5 kg (kN)
Mean	24.93	39.97	0.142	0.105
Median	25	40	0.14	0.105
Standard deviation	2.85	2.18	0.008	0.01

MNR—maximum number of repetitions.

The first hypothesis was confirmed by the correlation determined between the load, MNR and Fmax, respectively. There was a large correlation between load and maximum force ($p < 0.01$; r = 0.896) and an inverse correlation between load and MNR ($p < 0.01$; r = −0.949) and between MNR and Fmax ($p < 0.01$; r = −0.840).

The experimental research and the obtained results followed three directions. The first direction aimed to analyze two cycles of repetitions: one at the beginning of the exercise and one at the end, with the human carrying out a machine load of 10 kg.

The second direction followed the same methodology, for a machine load of 5 kg.

The purpose of the third direction was to make a comparison between the repetitions.

3.1. Detailed Analysis of the Typical Cycle of a Repetition for a 10 kg Load

For the analysis of a cycle of a repetition, a mediation of the obtained results was performed, due to the large number of records. The purpose of mediating the recordings was to understand the physiognomy of the relevant set using the MNR strategy.

The results are presented in the following lines, considering a machine load of 10 kg applied to the Scott machine.

As seen in Figure 3, the MNR is 25 and the average duration of the repetitions is 2.26 s, considering the method of execution to the point of refusal, with a total duration of the set of 56.64 s. It is also noted that the maximum value of the recording force during the set did not deposit 0.142 kN, recorded at the seventh repetition (i.e., under the conditions of the average manner of execution of the relevant set, it was 34–42% higher than the static force of the Scott machine). This indicates the role of the accelerators in the case of a medium load for a small muscle group, with the subjects having the possibility to manage the effort. Regarding the problem of the relevance of the repetitions, the fact that the last repetition was canceled due to its incorrect execution was taken into account.

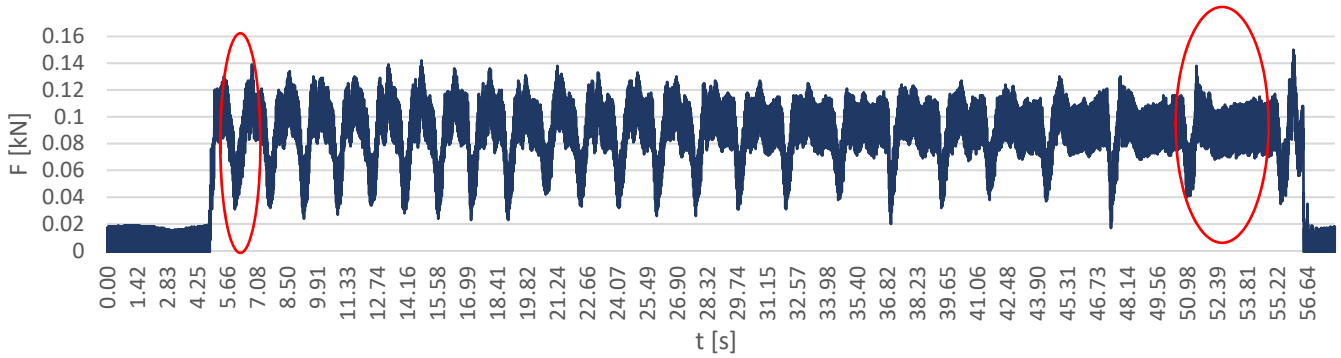


Figure 3. Evolution of forces versus time with execution to the point of refusal—10 kg load.

As seen in Table 2, the forces reached a maximum point at each repetition, for the entire cycle. The average value of the maximum forces related to 1RM led us to obtain the relative intensity (%1RM).

Table 2. Maximum forces per repetition—10 kg load.

Repetition	Fmax (kN)	t (s)	Repetition	Fmax (kN)	t (s)
R1	0.127	5.64	R13	0.131	25.08
R2	0.139	6.84	R14	0.128	26.84
R3	0.134	8.62	R15	0.127	28.70
R4	0.127	9.78	R16	0.125	30.78
R5	0.128	11.70	R17	0.125	33.08
R6	0.136	13.32	R18	0.121	34.92
R7	0.142	14.84	R19	0.124	37.51
R8	0.136	16.39	R20	0.127	40.33
R9	0.134	18.03	R21	0.124	42.41
R10	0.128	19.73	R22	0.13	44.96
R11	0.138	21.25	R23	0.129	47.8
R12	0.133	23.17	R24	0.138	51.42
Fmax (kN)			0.13		
1RM (kN)			0.242		
%1RM			54%		

1RM—maximum one-repetition, %1RM—relative intensity, Fmax—maximum force.

The obtained value of the %1RM was 54%. This value may seem quite high, but the explanation also depends on the fact that the test procedure was aimed at a small muscle group and an exercise performed on a cable machine, and not with free-load.

The evolution of the maximum forces, in time, at each repetition, is shown in Figure 4.

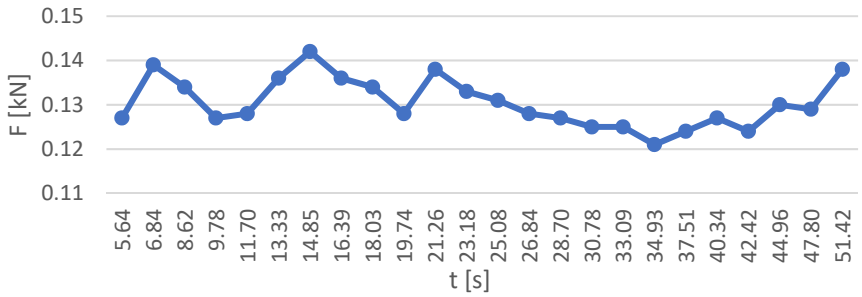
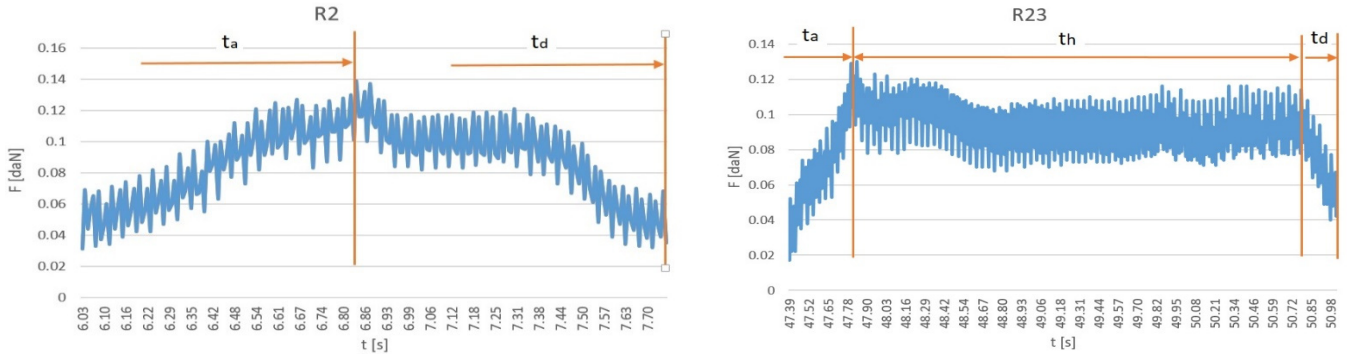


Figure 4. Evolution of maximum forces per cycle—10 kg load.

It can be observed that, in the first half of the set, there was a good regularity of frequency and amplitude; after that, the maximum force had a decrease followed by a return near the end of the set, in which the subjects tried to add an additional repetition by forcing the speed of execution.

3.1.1. Evaluation of the Cycle of One Repetition—Initial and Final

For an initial repetition, the evolution of the force for a cycle of one repetition is presented in Figure 5a. The second repetition (R2) was analyzed, being more relevant than the first one; in this case, considering that the number of repetitions was high, it can be considered that this was the relevant initial repetition. There was an interesting physiognomy of R2, with a concentric phase with reduced oscillations around the trend and an eccentric phase with a long bearing around the reference.



(**a**) (**b**)

Figure 5. Evolution of forces versus time—10 kg load for cycle of an initial repetition (**a**) and of a final repetition (**b**).

It can also be observed in Figure 5a that the ascending time (t_a) and the descending time (t_d) had very close values. The duration of R2 was 1.72 s, with t_a being 0.81 s.

For a final repetition (R24), the evolution of the force for a cycle of one repetition is presented in Figure 5b. In this case, interesting mechanisms were observed. First, the duration of R24 was 4.38 s, with t_a being 0.41. A short t_d of 0.24 s was followed by a holding time (t_h) of 3.34 s. A sudden decrease of 0.39 s ended the final repetition cycle.

This result, observed and measured at R24 whereby the subjects maintained muscle contraction for a longer period, was surprising because there is energy consumption and the natural tendency would have been exactly the opposite. The explanation lies in the psychological pressure related to the failure to add a new repetition to the MNR set. However, there was an interesting implication of maintaining the muscle contraction in the proximal area of the maximum force (i.e., 85–90%) related to the execution of the exercise through which the MNR strategy determines this surprising behavior.

The amplitude of the oscillations on this level was higher, which confirms the effect of the subject's fatigue, close to the exhaustion of the set.

3.1.2. Evaluation of the Superposition of the Relevant Repetitions

The idea of overlapping the concentric phase of R2 and R24 allowed us to understand how the bicep muscle adapted during exertion in a typical extended set, with MNR = 25. Figure 6 presents the superposition of the forces' evolution for the initial and final repetition in the case of the 10 kg machine load.

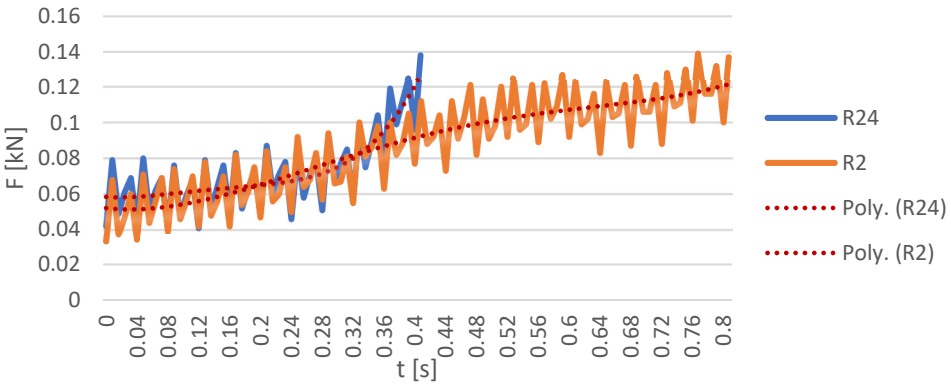


Figure 6. Superposition of the forces' evolution at the initial and final repetitions—10 kg load.

In the case of a 10 kg load, we can observe some differences between the first and last relevant repetitions. It can be seen that the time taken to reach the maximum value of the force was longer at the beginning. Additionally, the slope of the ascending curve (i.e., the geometric place of the mean values of the micro cycles) was less inclined in R2,

which proves that, towards the end, a fatigue threshold was reached, which causes an increase in the execution speed on the concentric phase of the repetition cycle. Hence, the third hypothesis was validated.

A polynomial regression was found that presents the evolution of the forces in time, for each initial and final repetition. In Figure 6, those regressions are represented by a red line. Identifying one type of regression could lead to the identification of different strategies for changing the way the exercise is performed. For the initial repetition, the regression that best fits the average values of the forces is presented in Equation (1). The coefficient of determination (R square) is 0.729 and interprets, as a percentage, how representative the regression line is for the investigated data (72%).

$$F_{R2} = 0.052 - 0.0005 \cdot t + 6 \times 10^{-5} \cdot t^2 - 8 \times 10^{-7} \cdot t^3 + 3 \times 10^{-9} \cdot t^4 \quad (1)$$

Based on the polynomial regression developed, the impulse was calculated by integration. For the period of reaching the highest force (i.e., 0.8 s), in the case of an initial repetition, the impulse was 0.041 kN·s.

The polynomial regression that best fits the measured average values for the final repetition is presented in Equation (2). R square for this regression is 0.607.

$$F_{R24} = 0.058 - 0.0004 \cdot t + 7 \times 10^{-5} \cdot t^2 - 3 \times 10^{-6} \cdot t^3 + 4 \times 10^{-8} \cdot t^4 \quad (2)$$

Based on Equation (2), the impulse developed at a final repetition, in 0.41 s, decreased at 0.023 kN·s. It can be observed that the impulse was 50% lower in the case of the final repetition.

Table 3 presents the results obtained from the paired *t*-test application. It can be observed that, for the first relevant repetition, the mean of the maximum force values was 0.127 ± 0.004 kN, an 8% lower value than the mean of the final repetition of the exercise set, which was 0.138 ± 0.006 kN.

Table 3. Paired-samples test: pair R24_Fmax–R2_Fmax.

	M	**N**		**SD**	
R24_Fmax	0.138	30		0.006	
R2_Fmax	0.127	30		0.004	
	M	**SD**	*t*	**df**	*p*
Pair R24_Fmax–R2_Fmax	0.011	0.007	8.14	29	≤0.001

M—mean; N—number of subjects; SD—standard deviation; *t*—*t*-value; df—degrees of freedom; *p*—level of significance; R24—final repetition; R2—initial repetition.

There was a significant average difference between R2_Fmax and R24_Fmax ($t_{29} = 8.14$, $p \leq 0.001$), and R2_Fmax was 0.011 points lower than R24_Fmax. The second hypothesis was validated; there was a statistically significant difference between the maximum forces developed during the initial and final repetitions of the exercise set.

Cohen's d was calculated in order to find the size of the difference between the means. The value was, in this case, −2.15, meaning a large effect size and a practical significance.

3.2. Detailed Analysis of the Cycle of a Repetition for a 5 kg Machine Load

In Section 3.2 the procedure from Section 3.1 and the execution mode of the reference set was repeated, with a machine load of 5 kg. As seen in Figure 7, the medium duration of a typical repetition was 1.53 s, according to MNR = 40, and the total duration of a set was 61.49 s. Comparing to the duration of a typical cycle of repetitions of 2.26 s, in this case, the duration was reduced by 32%. The frequency of the repetitions was increased, which highlights that, due to the aim of obtaining as high an MNR value as possible, there was a tendency to increase the speed of execution. This translated into higher accelerations and values of the maximum force, which exceeded 0.105 kN, more than twice the load of the Scott machine.

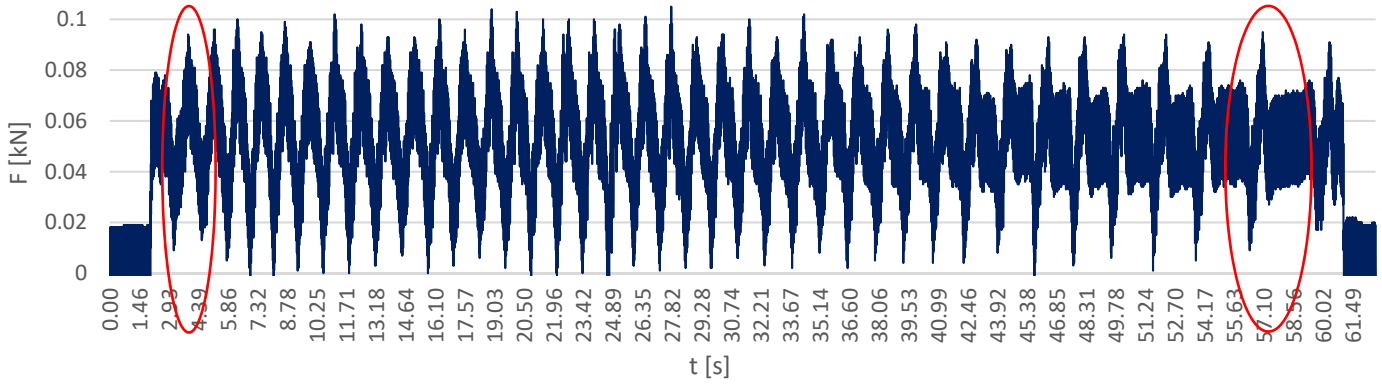


Figure 7. Evolution of forces versus time for execution to the point of refusal—5 kg load.

Hence, the first important conclusion for this loading case was the tendency of subjects to increase the execution speed; this allowed an increase in the acceleration, transposed in the maximum double force compared to the loading of the machine, compared to an increase of only 35% in the case of loading in Section 3.1. This observation also takes into account the 8.4% longer duration of the set, so a higher time-under-tension of the bicep muscle (i.e., 61.49 s vs. 56.64 s).

Although the load of the machine was reduced by half, the maximum force during the set was reduced by 22.2% (i.e., 0.105 kN vs. 0.142 kN), and the duration of the set, and therefore, the time under tension, increased by only 8.4%.

The intensity of %1RM was, in this case, 39%, which, for a number of 40 repetitions seems a high value. The explanations for the higher load are, thus, reconfirmed, with a special role of compensatory acceleration in the case of bicep curls, through which the subjects tried to pass quickly over the critical points in the concentric phase.

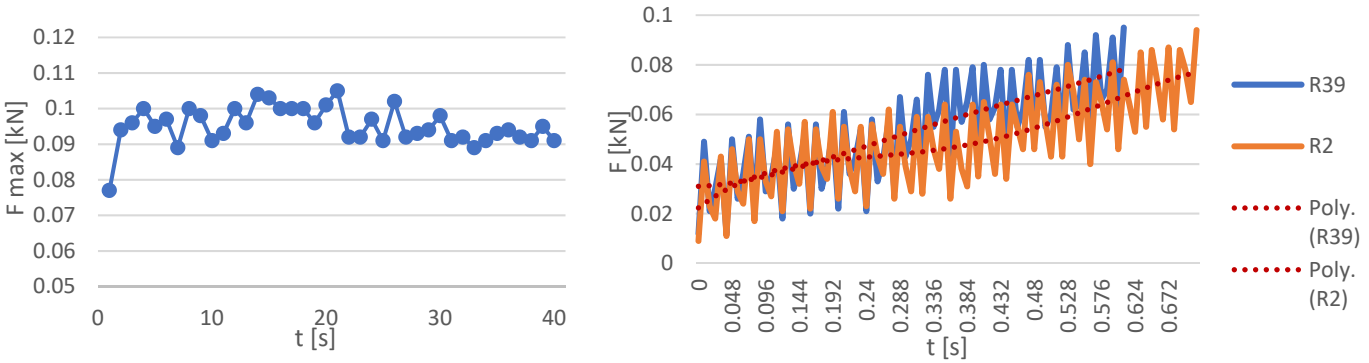
Table 4 presents the maximum values of the force for the execution cycle.

Table 4. Maximum forces per repetition—5 kg machine load.

Repetition	Fmax (kN)	t (s)	Repetition	Fmax (kN)	t (s)
R1	0.077	2.25	R21	0.105	27.78
R2	0.094	3.88	R22	0.092	29.00
R3	0.096	5.16	R23	0.092	30.30
R4	0.1	6.32	R24	0.097	31.68
R5	0.095	7.5	R25	0.091	32.96
R6	0.097	8.7	R26	0.102	34.35
R7	0.089	9.86	R27	0.092	35.71
R8	0.1	11.17	R28	0.093	37.11
R9	0.098	12.44	R29	0.094	38.53
R10	0.091	13.76	R30	0.098	39.89
R11	0.093	15.07	R31	0.091	41.37
R12	0.1	16.31	R32	0.092	42.88
R13	0.096	17.57	R33	0.089	44.56
R14	0.104	18.89	R34	0.091	46.48
R15	0.103	20.13	R35	0.093	48.24
R16	0.1	21.44	R36	0.094	50.18
R17	0.1	22.72	R37	0.092	52.22
R18	0.1	23.96	R38	0.091	54.36
R19	0.096	25	R39	0.095	57.04
R20	0.101	26.504	R40	0.091	60.35
Fmax (kN)			0.095		
1RM (kN)			0.242		
%1RM			39%		

1RM—maximum one-repetition, %1RM—relative intensity, Fmax—maximum force.

The evolution of the maximum forces for the entire cycle is presented in Figure 8a. The dynamics of the maximum forces per cycle demonstrate much better regularity than in the case of the higher loading of the Scott machine, suggesting better execution accuracy. The % 1RM load of 39% becomes reasonable for training with bicep curls and emphasizes the proposal to include sub-periods dedicated to MNR strategy.



(**a**) (**b**)

Figure 8. (**a**) Evolution of maximum forces per cycle—5 kg load. (**b**) Superposition of the forces' evolution at initial and final repetition—5 kg load.

The graph in Figure 8b presents the comparison via superposition of the force dynamics for an initial (R2) and final (R39) repetition.

It can be observed that the time taken to reach the maximum force in the case of the first repetition was about 0.71 s. Compared to the value of 0.8 s in Section 3.1, it resulted in a reduction of 11% in the duration of the concentric phase. Additionally, the dynamics of the force during this phase changed significantly.

The time taken to reach the maximum force for R39 was 0.61 s. Compared to the value of 0.71 s for R2, there was a 14% decrease in the duration of the concentric phase, a smaller decrease than in Section 3.1. in which the duration decreased from 0.8 s to 0.41 s.

This result was also interesting because it highlights the role of compensatory acceleration for the two different Scott machine loads; additionally, there were dynamics and mechanisms for adjusting the execution by subjects with significantly different nonlinearities. Compensatory acceleration training is a strategy for executing concentric motion as quickly as possible for the capitalization of the leverage zones.

The dynamics of the force during the concentric phase of the repetition was also dramatically changed, highlighting a change in the mechanisms specific to the use of the bicep muscles.

Elements of nonlinearity were anticipated in the sense that the 50% reduced load was not transposed with proportional evolutions at the level of the maximum value of the forces on the relevant repetitions.

For the initial repetition, the regression that best fits the average values of the forces is presented in Equation (3). R square is 0.505.

$$F_{R2} = 0.02 + 0.0019 \cdot t - 6 \times 10^{-5} \cdot t^2 + 9 \times 10^{-7} \cdot t^3 - 4 \times 10^{-9} \cdot t^4 \quad (3)$$

Based on Equation (3), for an initial repetition, the impulse developed in 0.71 s was 0.014 kN·s.

The polynomial regression that best fits the measured average values for the final repetition is presented in Equation (4). R square for this regression is 0.526.

$$F_{R39} = 0.031 + 3 \times 10^{-5} \cdot t + 3 \times 10^{-5} \cdot t^2 - 4 \times 10^{-7} \cdot t^3 + 2 \times 10^{-9} \cdot t^4 \quad (4)$$

Based on Equation (4), for the final repetition, the impulse developed in 0.61 s was 0.018 kN·s. It is an anomaly in this case, demonstrating that for reduced intensities within

small muscle groups, the subjects forced an additional repetition with the help of other muscle groups. This surprising result refers strictly to the exercise of one-arm Scott machine seated bicep curls at very low intensities.

Table 5 presents the results obtained from the paired *t*-test application. It can be observed that, for the first relevant repetition, the mean of the maximum force values was 0.077 ± 0.005 kN, a 15% lower value than the mean of the final repetition of the exercise set, which was 0.091 ± 0.007 kN.

Table 5. Paired-samples test: pair R39_Fmax – R2_Fmax.

	M	**N**		**SD**	
R39_Fmax	0.091	30		0.007	
R2_Fmax	0.077	30		0.005	
	M	**SD**	***t***	**df**	***p***
Pair R39_Fmax–R2_Fmax	0.014	0.006	12.71	29	≤0.001

M, mean; N, number of subjects; SD, standard deviation; *t*, *t*-value; df, degrees of freedom; *p*, level of significance.

From the results, we can say that there was a significant average difference between R2_Fmax and R39_Fmax (t_{29} = 12.71, $p \leq 0.001$), and R2_Fmax was 0.014 points lower than R39_Fmax. This result validates the second hypothesis; there is statistically significant difference between the maximum forces developed during the initial and final repetitions of the exercise set. In this case, a large effect size was also observed, and Cohen's d was −2.3.

3.3. Comparison between the Forces Developed at 10 kg and 5 kg Loads

A comparison of the physiognomy of the concentric phases of the initial and final repetitions was made for the two situations—loads of 10 kg and 5 kg, respectively.

In the case of the first relevant repetitions, as seen in Figure 9a, it can be observed that the forces were higher for the higher load. The slopes of the instantaneous forces in relation to the ascending time were related, demonstrating similar styles of repetition, with similar speeds and accelerations. Another observation is that the time taken to reach Fmax and the ascending duration on the concentric phase were lower in the case of the last relevant repetition with the load of 5 kg.

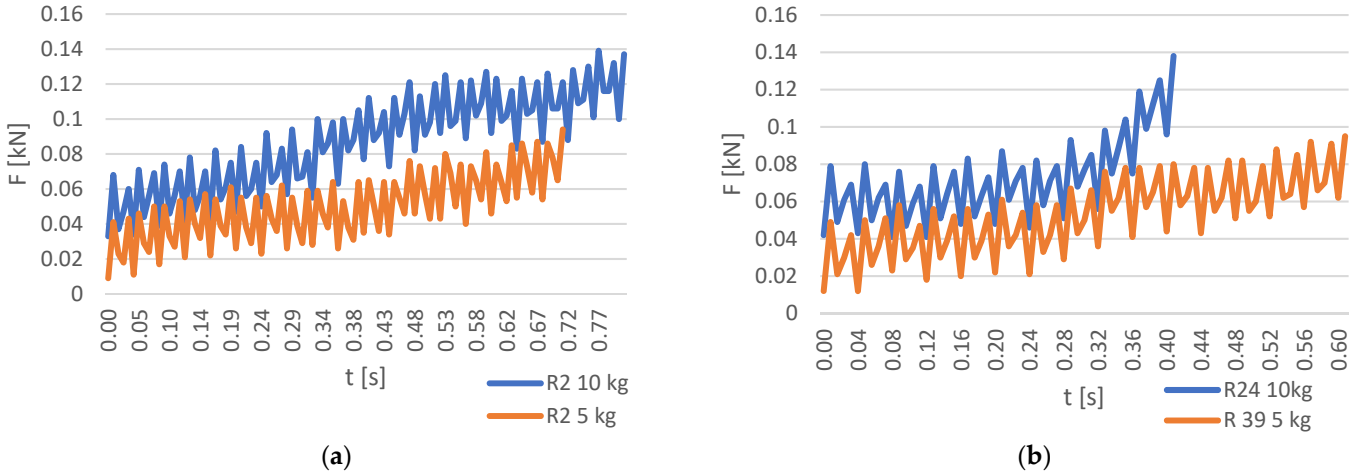


Figure 9. Comparison of initial repetition (**a**) and final repetition (**b**) for 10 kg and 5 kg, respectively.

In the situation of the final repetitions, there were differences in dynamics, with very interesting practical implications. The evolution of the forces for the concentric phase for the two machine loads can be observed in Figure 9b. The first observation is that although in the initial phase of the repetitions the forces were similar, in the case of the higher load, an increase was observed; this demonstrates the attempt to complete the repetition in a

shorter time, materialized, therefore, by the acceleration and the reduction in the duration of the ascent phase of the repetition. Additionally, the values of Fmax obtained for the considered loads were not proportional. The duration of the concentric phase of the last repetition, relevant for the low load, was approximately 25% higher than the case of the other considered load.

As seen in Table 6 there was a statistically significant difference between the maximum forces developed during the initial repetition of the exercise set at considered loads, respectively (t_{29} = 34.23 and $p \leq 0.001$). For the final repetitions, t_{29} = 23.009, $p \leq 0.001$.

Table 6. Paired-samples test for initial and final repetition for 10 kg and 5 kg, respectively.

	M	SD	*t*	df	*p*
R2_Fmax 10kg–R2_Fmax 5 kg	0.05	0.008	34.23	29	≤0.001
R24_Fmax 10kg–R39_Fmax 5 kg	0.047	0.011	23.009	29	≤0.001

M—mean; N—number of subjects; SD—standard deviation; *t*—*t*-value; df—degrees of freedom; *p*—level of significance.

The average difference between the mean of the maximum forces developed during the initial repetition in the case of each machine load was M = 0.05 ± 0.008 kN. For the final repetition, M = 0.047 ± 0.011 kN.

Figure 10 presents the relationship between %1RM and MNR for Scott machine seated bicep curls. This diagram is in line with the literature that studies the correlation between %1RM and loads in the area of 4–7 RM or 8–10 RM for other exercises performed for large muscle groups. Higher values of %1RM are highlighted; these have been explained previously and have opened the doors to new research related to possible links with high-intensity training or new periodization strategies for training macrocycles.

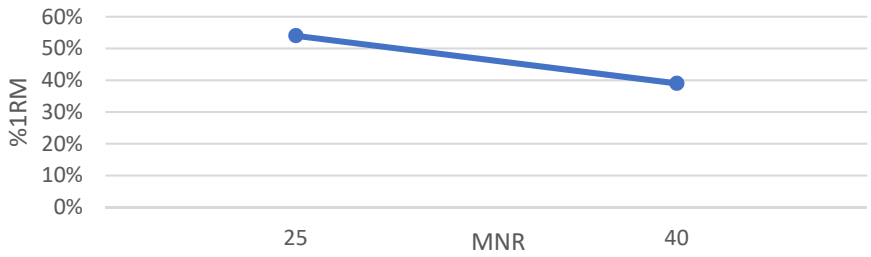


Figure 10. MNR vs. %1RM.

4. Discussion

To understand the dynamics of the force during the single set analyzed for the two Scott machine loads, a 1RM calibration was performed first, and in the second phase, the main parameters of interest were: volume/repetition range, load and manner of execution. There are very complex intercorrelations between these parameters, which depend on the training strategy and the selection of exercises.

The tests were performed for two loads on the Scott machine which, through the execution mode, offer more interesting dynamics of force evolution in the concentric phase. It turns out that when the load was reduced to 50%, a significantly higher number of repetitions was obtained but there was a slightly longer duration of the set

The evolution of the maximum forces per cycle in the case of a 10 kg load had good regularity of frequency and amplitude and, after that, the maximum force had a decrease, followed by a return near the end of the set in which the subjects tried to add an additional repetition by forcing the speed of execution. For a 50% reduced load, the dynamics of the maximum forces per cycle demonstrated much better regularity, suggesting better execution accuracy.

In the case of a 10 kg machine load, some differences can be observed between the first and last relevant repetition. It can be noticed that the time taken to reach the maximum

value of the force was longer at the beginning. Additionally, the ascending slope was less inclined in R2, which proves that, towards the end, a fatigue threshold was reached, which caused an increase in the execution speed in the concentric phase of the repetition cycle.

For a 50% reduced machine load, there was a 14% decrease in the time taken to reach the maximum force, highlighting the role of compensatory acceleration for the two different Scott machine loads.

In the case of 5 kg machine load, the frequency of the repetitions was increased, which highlights that, due to the aim of obtaining as high an MNR value as possible, there was a tendency to increase the speed of execution.

It was observed that, in the case of a reduced load, the impulse developed at the final repetition was about 29% higher than in the case of the initial repetition, demonstrating that for reduced intensities within small muscle groups the subjects forced an additional repetition with the help of other muscle groups.

Additionally, the data collection method offered a simple way to understand the correlations between the MNR and intensity %1RM in the MNR single-set strategy in the case of Scott machine bicep curls. Particularly interesting features were observed in these unique sets using the MNR strategy. A correlation between the intensity of %1RM and the MNR for the two machines was also drawn for the two machine loads, which highlighted an approximation in terms of the intensity and duration of execution, even if the MNR differed significantly.

Therefore, we confirmed that the hypotheses were validated by the analyzed results.

The analysis led to the identification of innovative strategies capable of manipulating the intensity factors and boosting the efficiency of the exercises based only on small, intelligent changes to the set-up.

The first strategy would be drop-set MNR, respectively reducing the machine load after consuming 70–75% of the MNR with the maximum load and extending the MNR with the resulting lower machine load.

The second strategy refers to the exercise technique using only the Scott machine mixed with an additional load, which can be represented by some elastic resistance bands or even some pneumatic muscles. By attaching the elastic bands, an increase in tension was obtained in the desired portions of the trajectory of the movement. In the initial sub-phase of the concentric part of the repetitions, the forces were much smaller than the maximum force. On the one hand, this allowed for a higher number of repetitions, but also resulted in a longer duration of the set using the MNR strategy. On the other hand, in this case, a significant change in the physiognomy of the last relevant repetition in the sets would be expected.

A periodization strategy can be considered, referring to the addition of a distinct 1–2-week MNR strategy phase for a training macrocycle. For example, in the case of recovery after a long period, in the initial phase (i.e., 2–3 weeks with 2 workouts per week) it is possible to use the MNR strategy with a single set to failure; in the next phase dedicated to increase strength, the subjects could follow a strategy of 5–6 sets of 3–5 repetitions, for 3–4 weeks, and then, a hypertrophy phase with 3–4 sets of 8–12 repetitions.

The research has some limitations. The first limitation is related to the need for calibration of the subjects for a maximum repetition 1RM one-arm SM-SBC. Secondly, the research was conducted on a homogeneous group. The aim was to understand the mechanisms specific to a single set extended to the point of muscle failure, for a homogeneous group—in this case, a male group. Third, the study was conducted only on university students. So, the obtained results cannot be generalized.

Future work will be focused on analyzing the effect of the MNR strategy on high-intensity training and managing these emerging strategies for efficient recovery. Research based on this methodology can also be applied to other small muscle groups. REID applications can also be considered for future work, for person re-identification, based on supervised exercise using camera views.

5. Conclusions

The presented research was focused on the study of one-arm Scott machine bicep curls using the MNR strategy, considering a relatively large representative sample of subjects with similar abilities. The selection of a relevant exercise for testing a small muscle group using the MNR strategy was harmonized with the relatively large number of subjects with homogeneous capabilities and performances and the very large volume of data required. The interest was in analyzing the sets of one-arm bicep curls using the MNR strategy with a special focus on understanding the physiognomy of microcycles for the first and last relevant concentric phases of repetitions.

In summary, the detailed analyses of sets using the MNR strategy and of the microcycles for the first and last relevant concentric phases of repetition showed that there is a correlation between the machine loads, the maximum developed forces and the MNR. Additionally, there were significant differences observed between the maximum forces of the initial and final repetitions of the exercise sets for the different machine loads. The duration of the MNR increased while the machine load was reduced and a deterioration of the execution mode was observed when the maximum number of repetitions was reached.

All the research hypotheses were demonstrated for the two different machine loads. A series of mechanisms and correlations specific to the selected exercise were demonstrated; they were explained, during the analyses of the dynamics of force, as a function of time, both for the concentric phase of the repetitions and for the entire set using the MNR strategy.

We conclude that the study of the physiognomy of cycles and comparisons at the level of relevant repetitions have revealed new research directions: establishing new test architecture for relatively large and homogeneous groups of subjects; testing the performance of small muscle groups for MNR strategies; and explaining the differences between the physiognomy of the first and the last repetition within MNR sets. These will allow researchers to highlight new strategies specific to resistance training for small muscle groups.

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

Data Availability Statement: The data used to support the findings of the current study are available from the corresponding author upon request.

Conflicts of Interest: The authors declare no conflict of interest.

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THE IMPACT OF THE BETTING INDUSTRY ON SPORTS

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Abstract: *Sports betting is the oldest form of gambling in the world. In the beginning, it was simply a leisure activity. We are currently talking about a multi-billion-euro deal. The sports betting industry has changed more in 15 years than in the last 50 years. In the 1950s, sports betting began to enter the world and almost nothing changed until the beginning of the 21st century. However, with the onset of the new millennium, online betting has changed the landscape dramatically, and is now developing at a fast pace than ever before. The future is always unpredictable, but we will try to imagine it based on current trends in sports betting. The paper "The impact of the betting industry on sports" aims to present a series of aspects regarding the history of sports games, the types of sports games existing today, a brief highlight of the Romanian sports games market and a short presentation of the positive and negative effects on sports.*

Key words: *Gambling, sports betting, sport, promotions, advertising.*

1. Introduction

Sports betting have thrived in the last decade. From a niche market to 1 billion $ industry, sports betting is now compared to traditional sports in terms of revenue. As such, sports betting is similar to traditional sports betting. Players can bet with real money on their favourite team or on other different events from the game.

Sports betting represents the anticipation of the result of a match and the bet of a sum of money on that result and if the result at the end of the match corresponds to the bettor's prediction then he will collect a sum of money directly proportional to the bet, otherwise the bettor will lose his bet.

Much of the betting change is due to the new ability to place bets during the game, which came with online bookmakers. Most bookmakers have already reported taking live bets from the market, bringing companies already a higher turnover than pre-bets.

Operators are already aware of this and are adding new doses of fun to live betting. Almost everywhere, every live match has live stats added to the site, and many companies have already started adding live videos from that site. Thus, watching sports is no longer occupied by

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the territory of television. Major betting sites have a turnover large enough to allow them to claim rights to major sporting events.

2. Literature Review

2.1. The history of sports betting

The history of sports betting is not a new issue. The origins of betting lie in ancient Greece. The first bets in history were made in Greece, more than two thousand years ago. The Greeks were known as great lovers of sports and sporting events such as the Olympic Games, where they took advantage of the opportunity and bet on their favourite competitions [4]. At that time, citizens were betting on various sports to have fun.

After becoming popular in ancient Greece, betting also attracted those from the Roman Empire.

The Romans quickly adopted these customs of the Greeks and turned it into a real business. The Romans bet a lot on gladiator's fights. But after the end of the Roman era, this practice survived and was adopted by the early medieval kingdoms. People were betting on gladiator fights and horse racing. The wrestling was one of the most popular sports in ancient Greece, the Roman Empire and the Byzantine Empire [3].

In the Middle-Ages, several European leaders tried to ban sports betting, but despite the measures taken, the bets persisted and continued to take place clandestinely. This custom has become especially popular in England, with betting enthusiasts betting heavily on horse racing. Eventually, English settlers took sports betting to the United States, where it spread rapidly and became one of the most popular pastimes for many people. Today, however, this activity is legal only in some American states.

Sports betting is made by people from all over the world, but the most popular are in Europe, where they have a long tradition and are a legal activity in most states [5]. Currently, this activity has turned into a big business, being a source of income for bookmakers and bettors.

Online sports betting

Online sports betting has been a great opportunity for betting enthusiasts. Online bookmakers have been set up in the United States and Canada to offer bettors the opportunity to bet online, from the comfort of their home or from anywhere with an Internet connection.

Sports betting experienced a massive boom after the Internet was invented and introduced. The ability to place bets directly from home has led many players to want to play more actively. Before the Internet age, bettors had to go to an offline bookmaker to place their bet, but things changed radically with its advent.

The biggest advantage of online betting is that it gives gamblers the chance to make quick decisions that can ensure them huge profits if they bet well, thanks to the live opportunity.

Tracking of the results. This type of bet is known as live betting, and has become one of the favourite bets of bettors.

Another aspect of online sports betting is the ability to place bets on virtually all types of sports on the planet and in all countries that exist. Today is possible to bet on other kinds of events, not just sports.

Bookmakers also offer free incentives for players who choose to sign up and deposit money into their account. These are called online sports betting bonuses and can even double your initial money invested if bettors decide to sign up on the main international sports betting pages [8].

Sports betting has a long history behind it and we can be sure that many other

generations will enjoy this activity. In fact, we can say that as long as there are sporting events on the planet, there will be sports betting, and on Earth there will always be human beings who will organize sports competitions.

2.2. Types of sports betting

Sports betting involves not only a passion for sports, but also a high level of knowledge designed to tip the scales in favour of the gambler [9]. The world of sports betting does not focus exclusively on luck. The advantage of betting on matches and other sports matches is that the bettor has a say, if he is familiar with the sport he is betting on.

Knowing the style of play of a team or a player, as well as the other participants in the game, it will be easier for you to place bets with higher chances of materializing in winnings.

Sports you can bet on in online casinos include football, tennis, boxing, golf, basketball, handball, but also horse racing, cycling, hockey and darts.

If we refer to the betting offer of the bookmakers that offer their services through the Internet, we can make a classification of the bets according to the ratio between the time of placing the bet and the period of the event. So, we have 'live betting' and 'classic betting'.

Live bets are those bets that are placed during the actual event. They are also called 'in-running bets', 'live betting', or 'in-play betting'. These types of sports bets have appeared on the market only in recent years and we can only find them at a few bookmakers in the world (of the order of tens). In general, for live bets, a simple prediction is chosen on which to bet. Although the term 'live' can be translated as 'happening right now', virtually no bookmaker offers 'live' bets in the true sense of the word [5].

From the moment you ask for your bet to be validated until the moment your bet is accepted by the bookmaker, a certain 'latency time' generally takes between 4 and 8 seconds.

If during this time nothing important happens during the match, the odds do not decrease or increase, you have a chance that your bet will be accepted. Some houses give the possibility to accept the bet (stake), and if the odds change, validating at the last odds (which may be different than the one you chose). During the development of different types of sporting events there are certain periods in which the odds offer is blocked by the bookmaker and no bets can be placed (e.g. tennis, football, etc.).

In general, at sporting events where a large number of points are scored, these odds blockages are rarer (e.g. basketball, handball, etc.). In the case of live betting, the bettor has the advantage of being able to watch the match on TV (or on the field). However, this advantage can never be raised at the level of bookmakers, which in addition to receiving live information about the match faster than a regular bettor (real-time broadcasts, use of terrestrial TV broadcasts instead of satellite, people seconded to matches), he also has a specialized man (bookmaker) who directs all the information received, including the stakes and odds set so far.

Classic bets are those bets that can only be placed before the actual start of the event. These types of sports bets can be placed either at an online bookmaker via the Internet, or at betting agencies where you pay with cash, receiving in return a ticket with the chosen bet [5].

The major advantage of these types of bets is given in terms of the maximum stake that can be placed for a simple bet. If in live betting, the maximum allowed bets generally do not exceed the value of a few hundred dollars, in classic bets these

maximum risky amounts can be at least 10 times higher.

If we refer to the type of bet that can be chosen, 3 types of bets are especially highlighted, namely: direct bets, handicap bets and total bets.

Direct bets are those bets by which the winner of the game or the tie at the end of the regular playing time is chosen. Each bookmaker defines its regular playing time for different sports according to its own rules. The regular playing time differs from many bookmakers in general for football, basketball and ice hockey.

Handicap bets are those bets that give a points advantage (or subunits of points) to the team considered by the bookmaker to be at a disadvantage so that the odds are balanced around the odds of 2.00[10].

This quantification of the disadvantage may depend on several factors such as: the statistical results obtained by the teams in the last period; injuries suffered by important players in teams; major imbalance in the total amounts bet on the combat teams.

In the offer of bookmakers there are offers with European handicap bets and offers with Asian handicap bets. The European Handicap is a particular case of the Asian Handicap in that it is full-fledged and with three possible variants.

Total bets are those bets that choose the number of total points scored during the regular time of the sporting event. These types of bets can be with two possible events 'below total' or 'over total' or with three possible events 'below total', 'over total' and 'exactly total'.

2.3. The sports betting market in Romania

The gambling industry is one of the most regulated and transparent in Romania, through GEO 77/2009, as well as through the creation, in 2013, of the National Office for Gambling (ONJN).

In recent years, the sports betting market has evolved significantly, according to information provided by the Ministry of Finance. In 2010 the reported revenues were approximately 354 million lei, now they exceed 1.5 billion lei. The beginning of this progress was marked by the appearance of many betting houses, but in 2014 the trend was changed and the market began to mature. Now companies are not only relying on opening new centres, but especially on optimizing profits. The Association of Employers of Betting Operators in Romania attributes the increase in turnover in this sector to the development of online betting. Massive investment in advertising by bookmakers has influenced consumer behaviour in this sector. The marketing strategy of online operators has been aimed at attracting new customers through various incentives, bonuses and exclusive offers.

The top online sports bookmakers recommended by specialists are the following:

– At the Net betoperator, you will find an extremely rich offer of live bets, which consists of numerous sporting events, but also in the betting options available for each match, such as the fast markets at 1 and 5 minutes. At the same time, here you will be able to close your bets before the deadline, on the entire amount or on the desired stake part, using the partial Cash Out function.

– Unibet offers the most competitive shares on the market. The operator covers the most important competitions in the world, from local teams to traditional sports in Europe and the rest of the world. Every day you can find over 4000 sporting events that benefit from the best betting odds. On the operator's website you can also find detailed analyses of the most

important events in the world of sports. Unibet customers have access to a platform through which live videos are transmitted in real time.

– The Fortuna operator, known for its ground agencies, also offers online sports betting. The casino welcomes its customers with a welcome bonus that can be used for sports betting. If you have imagination you can choose special bets, accessible only to this operator. On the Fortuna online platform, you can bet on the most popular exports in the world.

At Betano online bookmaker you will find a few games every day in which the operator stops his 0% winning margin, as well as a series of extremely advantageous semi-permanent offers. In addition, you will be able to place voice command bets via mobile phone and watch over 24,000 live video events annually.

The sports betting agency Unibet can boast a rich history of awards obtained in the world of the gambling industry in the last decade. One of the most interesting functions of the operator is Action Betting, an ultra-fast betting platform with immediate solution, which can keep you in suspense minute by minute. In addition, the sports offer is extremely wide and includes many types of unique bets.

The volume of online and offline sports and casino betting (wagered amounts) in Romania amounts, on average have got to the value of 4 billion euros per year, according to estimates from the profile market.

Market players explain that the value of the volume expresses the totality of the bets played and not the turnover which represents the difference between the volume of bets played and the prizes paid.

Official estimates published by the Association of Gambling Organizers, Rombet, indicated a turnover in the local gambling industry in Romania of about one billion euros. Regarding the value of a bet, it starts from 1-2 rons and reaches an average of ten rons, and field tennis is the second sport after football in which the most bets in Romania.

The biggest win in the history of sports betting comes from Bacău. Super bet paid over 300,000 euros. The bettor won in January 2018 the amount of 1,350,093.22 rons (almost 300,000 euros), the highest in the history of the prizes given by the betting house Super bet in the ten years of activity. He played no less than 42 tickets, all on football and all winners at a total odd of 11,808.61.

According to statistics, the gambling industry brings over 700 million euros to the state budget annually, through taxes and duties.

It is difficult to say what changes will bring us in the coming years, although the feeling is that at least for now the waters have calmed down and we should not have big "surprises" or technological advances like before. But at any moment we can be surprised by something new that we do not expect. Who thought that in the not too distant future we will be able to place sports bets using a mobile phone, with which we can also consult rankings from hundreds of different championships, or even watch live matches online?

3. Case Study: The Positive and Negative Effects of Sports Betting on Sports

Sport is actually a competition between people or teams that agree to compete according to the same rules [16]. Not knowing who will win is an essential part of the sport's attraction, which separates it from art and other entertainment [14].

The impact that the sport betting industry has on sports games highlights both positive and negative parts, which we will discuss further.

First of all, sports betting has attracted more and more people, some already fans of sports teams, others who later became fans, although initially they were attracted by the opportunity for financial winnings [15].

So, we can say that one of the effects of the betting industry is to increase the number of spectators of various sports matches.

Sports betting involves not only a passion for sports, but also a high level of knowledge designed to tip the scales in favour of the gambler [11].

The world of sports betting does not focus exclusively on luck. The advantage of betting on matches and other sports matches is that the bettor has a say, if he is familiar with the sport he is betting on.

Also, another effect of sports betting in recent times refers to the massive exposure that has come from sports sponsorship agreements. This is part of a major effort to link sports betting to large companies that sponsor various teams. They see the global popularity of the sport, as well as the money that comes from the live broadcast and want some of the action. Thus, we see commercials and various types of sponsorships during sports matches, stadiums, T-shirts and live broadcasts.

Gambling thus opens the door to a completely new source of sponsorship income, the one coming from the big sports betting companies. Therefore, there are many teams whose players wear sports equipment with the names of sports betting sites.

The growing presence of betting advertising during live broadcasts of sports matches is perhaps the most visible aspect of sports betting.

Sports betting advertising is fully incorporated into the match and its promotional materials. This highlights the connection between sports fans and bets related to favourite teams, being very difficult for a sports fan to avoid betting when everything around him urges him to do so.

As positive effects of this industry on sports we can list the increase in the number of fans and spectators, the improvement of the image of sports teams and the publicity around them, the appearance of more and more sports sponsorships, and last but not least the increase of sports clubs due both the increase in the number of spectators watching each match [6].

But this industry also has a number of negative aspects that affect the integrity of sports.

If the result is determined in advance, the integrity of the sport is lost and with it much of its meaning and appeal to fans.

Therefore, one of the negative aspects refers to fixing the matches which is a major threat to the sport [7].

There are two different reasons for fixing the match, both with ancient origins. First of all, sport can be fixed for sporting reasons: various opportunities offered to encourage a person or a team to lose a certain match. Second, people might try to make money through gambling in a match in which they know the outcome before it takes place because they have established the outcome [1].

Many people believe that the advent of sports gambling has increased the risk of fixing matches for financial gain. The huge scale of the global gambling industry (legal and illegal) is attractive to organized crime, and the range of types of bets available can increase the value of inside information. Globalization also plays an important role - criminals who want to establish matches can connect and meet athletes, coaches and officials from around the world.

The very nature of corruption in sports betting involves a number of sports participants (athletes and officials, but

also administrators), highly mobile corrupt, operating across various sports and national borders and betting on both legal and illegal markets.

With the advent of sports betting, clubs have developed a new method of corruption. It focuses primarily on winning money in the betting markets, but this time causing its own team to lose - which is easier than convincing another team to lose - and thus betting large sums of money on its own defeat.

This method is sometimes used by clubs that are in financial difficulty and / or have to enter competitions or matches of very little sporting importance.

Two factors favour this type of behaviour on the part of some clubs: on the one hand, especially the difficult financial situation in some sports environments, on the other hand, the organizational system of the clubs [12]. In fact, corruption has always been closely linked to gambling.

Thanks to the expansion of the Internet and the increase in the total volume of bets, operators have been able to offer new types of bets and other innovations that have them contributed to the attractiveness of bets and their growth.

The Internet has also allowed the development of "live betting", in other words the ability to bet during a match. Players can watch a match live on the Internet and bet online in real time, depending on how the match unfolds. Betting operators use "betting sets", which simultaneously track the match and bets on it and change the odds according to the events during the event.

The sports movement is essential for maintaining the integrity and honesty of the sport in various competitions.

Fixing the match is only possible if at least one of these parties plays an active role.

Combating the manipulation of sporting events, whether or not such manipulation is related to betting, is primarily a matter of ethics and values for the world of sport [13]. The manipulation of a result or any other secondary aspect of a game is the antithesis of sports values [2]. Therefore, public and private sector stakeholders need to work together to combat this threat, sometimes in different legal and sports jurisdictions, while often being limited by limited resources and restrictions on the ability to share information.

4. Conclusions

Sports betting involve not only a passion for sports, but also a high level of knowledge designed to tip the scales in favour of the gambler. The world of sports betting does not focus exclusively on luck. The advantage of betting on matches and other sports matches is that the bettor has a say, if he is familiar with the sport he is betting on.

This sports betting industry has experienced the same development as sports due to globalization and technology, the connection between the two being quite obvious.

We have seen the impact that sports betting has on sport, both positive and negative, the latter still requiring enough effort to be diminished.

It is difficult to say what changes will bring us the sports betting in the coming years, although the feeling is that at least for now the waters have calmed down and we should not have big "surprises" or technological advances like before. But at any moment we can be surprised by something new that we do not expect.

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Article

Differences between Active and Semi-Active Students Regarding the Parameters of Body Composition Using Bioimpedance and Magnetic Bioresonance Technologies

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Abstract: The aim of the study was to identify differences in obesity-related parameters between active sports students and semi-active or sedentary students, differentiated by sex, in order to optimize health. The study sample included 286 students, of which the male experimental sample consisted of 86 active sports students, age X ± SD 21.25 ± 0.32 years; height X ± SD 181.08 ± 3.52 cm; control group consisting of 89 semi-active students aged X ± SD 21.07 ± 0.1.13 years; height X ± SD 182.11 ± 1.32. The female experimental sample includes 57 active sports students, age X ± SD 21.02 ± 0.92 years; height X ± SD 167.48 ± 1.34 cm; the control group includes 54 semi-active students aged X ± SD 21.57 ± 0.1.98 years; height X ± SD 168.42 ± 1.76. The study used a thalliometer, Tanita Health Ware software and Quantum Resonance Magnetic Analyzer equipment to investigate height (cm), Body Mass Index (BMI), muscle mass (kg, %), as well as the obesity analysis report, and componential analysis of body and nourishment. The differences registered between the samples of active and semi-active sports subjects were predominantly statistically significant for $p < 0.05$. The differences registered between the samples of active and semi-active sports subjects were predominantly statistically significant for $p < 0.05$. The most important parameters regarding obesity and body composition that registered significant differences between the two male groups were in favor of the group of active athletes: triglyceride content of abnormal coefficient 0.844 (CI95% 0.590–1.099), abnormal lipid metabolism coefficient 0.798 (CI95% 1.091–0.504), obesity degree of body (ODB %) 10.290 (CI95% 6.610–13.970), BMI 2.326 (CI95% 1.527–3.126), body fat (kg) 2.042 (CI95% 0.918–3.166), muscle volume (kg) 2.565 (CI95% 1.100–4.031), Lean body weight (kg) 2.841 (CI95% 5.265–0.418). In the case of female samples, the group of active sportswomen registered the biggest differences compared to the group of students who were significantly active in the parameters: abnormal lipid metabolism coefficient 1.063 (CI95% 1.380–0.746), triglyceride content of abnormal coefficient 0.807 (CI95% 0.437–1.178), obesity degree of body (ODB%) 8.082 (CI95% 2.983–13.181), BMI 2.285 (CI95% 1.247–3.324), body fat (kg) 2.586 (CI95% 0.905–4.267), muscle volume (kg) 2.570 (CI95% 0.154–4.985), lean body weight (kg) 4.118 (CI95% 1.160–7.077). The results of the study directly facilitate the understanding of the complexity of the impact of obesity on multiple parameters of body composition and health.

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1. Introduction

Obesity at all ages is a globalized health problem with a major impact on quality of life [1–3]. Obesity management is a major desideratum of current health policies with a major impact on health and lifestyle. Obesity management, with major implications for optimizing health, is closely linked to the level of weekly physical activity, the quality and quantity of the diet and the approach to a proactive lifestyle. Health is dependent on a multitude of factors (physiological, somatic, mental, environmental, social, etc.), being a multidimensional concept aimed at the ability of social integrity and the environment, the dimensions of fitness, well-being, risk factors, etc. [4–9].

Recent studies have highlighted the major risk of lack of exercise in correlation with the increased incidence of obesity in cardiovascular disease, various cancers, diabetes and COVID-19 [10–14]. Obesity is considered a chronic disease that is caused by a number of major risk factors for human health, including genetic factor, hormonal balance, body thermogenic capacity, sensitivity of the nerve nucleus that regulates appetite or need for food, habits and behaviors related to unbalanced diet and sedentary lifestyle [15–18].

While the body mass index is the most researched obesity indicator [19], it is not sufficient to get a complete picture. Instead, a larger palette of factors should be considered while researching obesity, including phenotype, muscle mass, fat tissue level and its location, metabolism, triglyceride levels, and others [19–21]. An integrated/complete obesity study should take into account the correlation of body, tissue and metabolic parameters in order to be accurate and relevant [22,23]. The BIA approach is based on the use of recently proposed regression equations that estimate the body cell mass (BCM) and the anthropometric variables as the obesity degree of body (ODB %) and body mass index (BMI) [24,25]. Bio-resonance is a holistic biophysical method based on the recording and then on the decoding of electromagnetic frequency waves generated by unhealthy organs. The waves are influenced by DNA damage and by changes in the body's magnetic energy field [26,27]. The magnetic resonance concept uses magnetic fields created by high power magnets which force the body's protons to align with that field. A radio frequency current is then passed through the patient's body, causing the protons to rotate outside the equilibrium parameters, tensioning against the magnetic field and providing information that is useful for generating detailed images of the inside of the body [28,29]. The assessment of the parameters of body composition by BIA shows similar levels of agreement with standard reference methods and other field-based techniques. For TANITA devices, the studies provided a valid measure of body composition [30–32].

Magnetic bioresonance and bioimpedance technologies are considered an unconventional and noninvasive methods of health assessment, and their current application aims to quantitatively and qualitatively identify the parameters of body composition for inclusion in complex models with multiple components. Body composition assessment requires a separate approach to each parameter and studies show that, combining parameters that deviate to different levels of sports training does not allow for an accurate assessment of body composition [33]. In practice, three methods of evaluating body composition are used, namely direct, indirect, or double-indirect approaches [34–37]. BIA is included among the methods of double-indirect approaches [33], in which the evaluation process uses validated regression equations, with estimates derived from indirect methods. BIA is a non-invasive and unconventional method, among the advantages of the method is the fact that the cumulative accuracy is proportional to the number of repetitions of the tests, and among the disadvantages it is mentioned that it is not possible to determine the distribution of body adipose tissue [33]. The use of BIA in practice and research specific to sports activity has significantly increased in the last decade due to portability, time and cost

efficiency. The appearance of different devices with complex technologies has facilitated the extension of the possibilities of evaluating the parameters of body composition, but the comparison of the values calculated with these devices has multiple limits due to the fact that their reliability and calibration are different; aspects of electrode positioning, body position, and those related to the level of sports training, nutritional status, testing periodization, etc. are different. BIA was designed for general population samples, and the use of these technologies on specific samples, such as those of athletes, can provide relevant quantitative and qualitative information on body composition parameters, but also some inaccuracies in assessing body composition parameters, requiring readjustment of formula calculation by taking into account the specifics of sports training [38–40].

The studies have addressed the issue of obesity [2,41,42], and ways to reduce it under the influence of regular exercise [43–45]. Numerous studies reveal that degree of physical activity is associated with increased incidence of overweight and obesity, with a major impact on all age categories [46–48]. Expert recommendations stipulate at least 150 min of moderate-intensity aerobic activity or 75 min of vigorous-intensity aerobic activity, combined with two training sessions for muscle toning [49,50]. Prescribing exercise programs is based on age, physical fitness objectives of each individual, health level, preferences and motivations for certain types of physical activities, availability of time, intensity of activities, etc. [51–53].

The aim of the study was to identify differences in obesity-related parameters between active sports students and semi-active or sedentary students, differentiated by sex, in order to optimize health. The novelty of our study is to highlight a wide range of parameters associated with obesity using magnetic bioresonance and bioimpedance technologies for data collection, as well as by comparing two samples of students with different physical activity indexes, differentiated by sex.

2. Materials and Methods

2.1. Experimental Design

The study took place between October and December 2019 on a sample of 286 volunteer students. The study aimed at using the following measuring devices and software: thalliometer for investigating height (cm); Tanita Health Ware—Software [54], for the evaluation of BMI and muscle mass (kg, %); the Quantum Resonance Magnetic Analyzer equipment [55], for the investigation of three categories of parameters, namely the obesity analysis report, componential analysis of the body, and nourishment. Magnetic bioresonance and bioimpedance technologies are non-invasive and unconventional methods that complement classical methods by facilitating the evaluation of health and implicitly the parameters of body composition in an easy manner with increased cost and time efficiency. Deviant body composition parameters identified with BIA are calculated using linear mathematical methods to determine intra- and extracellular resistance values [33,56], single and multiple frequency BIAs that allow for separation into bioelectrical resistance and bioelectrical reactance [33,57,58]. The evaluations were performed in the time interval 9–11, in similar conditions for all study subjects. Each subject was evaluated once, with technologies used in the study. The evaluation of each subject was conducted in the gym with qualified staff for the registration and use of evaluation technologies. All study subjects performed the tests before performing any physical effort. For this article, all authors contributed equally; all authors have an equal contribution to the publication with the first author, too.

The obesity analysis report focused on the following parameters: abnormal lipid metabolism coefficient, brown adipose tissue abnormalities coefficient, hyperinsulinemia coefficient, nucleus of the hypothalamus abnormal coefficient, triglyceride content of abnormal coefficient [58]. The Componential Analysis of Body included parameters obesity degree of body (ODB%), body mass index (BMI), body cell mass (BCM). The obesity degree of body = weight real/Weight (kg) standard ··100, where the standard body weight, according to the World Health Organization for males is (height (cm) −80) · 70%, and for

females, (height (cm) −70) · 60%. [59–61]. The nourishment parameters were intracellular fluid (L), extracellular fluid (L), protein (kg), inorganic substance, body fat (kg), body moisture (kg), muscle volume (kg), lean body weight (kg), weight (kg). Where total fluid volume = intracellular fluid (L) + extracellular fluid (L); muscle mass = total volume of fluids + proteins (kg), usually muscle mass is 35–48% of the weight; lean body weight (kg = muscle mass + inorganic substances (kg); weight = solid body mass + adipose tissue (kg); skeletal muscle mass (kg) = [(Ht2 /R · 0.401) + (gender · 3.825) + (age · −0.071)] +15.102, where Ht is height (cm); R is BIA resistance in ohms—for gender, men 51 and women 50; age (years) [62].

2.2. Subjects

The study sample included 286 students, of which 175 (61.2%) were male and 111 (38.8%) were female. Subjects were divided according to gender into two groups: the experiment group consisting of active sports students and the control group consisting of non-sports, inactive or semi-active students. The experimental groups consisted of students of a Bachelor's degree in Physical Education and Sports, and the experimental groups from the kinetotherapy and nutrition and dietetics programs at the "George Emil Palade" University of Medicine, Pharmacy, Science and Technology from Targu Mures. The male experimental sample consisted of 86 active sports students, age X ± SD 21.25 ± 0.32 years; height X ± SD 181.08 ± 3.52 cm; control group consisting of 89 semi-active students aged X ± SD 21.07 ± 0.1.13 years; height X ± SD 182.11 ± 1.32. The female experimental sample includes 57 active sports students, age X ± SD 21.02 ± 0.92 years; height X ± SD 167.48 ± 1.34 cm; the control group includes 54 semi-active students aged X ± SD 21.57 ± 0.1.98 years; height X ± SD 168.42 ± 1.76. The male sample of the study included 87% subjects with urban residence and 13% with rural residence, and the female sample of the study had 91% urban and 9% rural origin. Inclusion criteria for students in the experimental group: age 18–25, physical and sports practitioners at least 5 times a week, duration of physical activity at least 250 min per week, no history of health problems or injuries in the last 3 months. Inclusion criteria for students in the control group: age 18–25 years, physical activity practitioners of maximum 100 min per week, with no history of health or injuries in the last 3 months.

2.3. Statistical Analyses

The research results were processed with SPSS 24 software, calculating statistical indicators: arithmetic mean (X), standard deviation (SD), Student's test (*t*), average differences between sports and non-sports students (DX), Cohen's (d) for effect size. Interpretation of effect size: small (0.2), medium (0.5) and large (0.8) [63]; the normality of distributions was assessed by using the Shapiro–Wilk test (S-W). Significance was set at $p < 0.05$ for all analyses. The specific reference values of the obesity analysis report are presented in Table 1. The total number of students was 765 and for this study we used 286; the calculated sample size must be a minimum of 211 subjects. The statistical power of study was (SP) 0.969 and the chosen level required was at least 0.8.

Table 1. Reference values of the obesity analysis report.

Testing Item	Normal Range	
	Male	Female
Abnormal lipid metabolism coefficient	1.992–3.713	1.992–3.713
Brown adipose tissue abnormalities coefficient	2.791–4.202	2.791–4.202
Hyperinsulinemia coefficient	0.097–0.215	0.097–0.215
Nucleus of the hypothalamus abnormal coefficient	0.332–0.626	0.332–0.626
Triglyceride content of abnormal coefficient	1.341–1.991	1.341–1.991

Other reference values are the body fat percentage of males: 20–25% is overweight, >25% is obesity; the body fat percentage of females: 17–24% is normal, 25–30% is overweight, >30% is obesity; the muscle volume is 35–48% body weight.

3. Results

Statistical processing of the results reveals that all differences between the two male groups were statistically significant in favor of the sports group, with the following exceptions for the brown adipose tissue abnormalities coefficient, the hyperinsulinemia coefficient and the nucleus of the hypothalamus abnormal coefficient. The results of the study groups are within the normal reference values, with the mention that those recorded by the group of athletes are closer to the lower limits of normality. The largest differences between the two groups, in favor of the group of athletes, were registered at the parameter the triglyceride content of abnormal coefficient 0.844, and the smallest difference at the parameter the nucleus of the hypothalamus abnormal coefficient −0.031. Cohen's calculation for effect size showed that the following parameters had low and medium values between 0.2 and 0.5 for both samples: brown adipose tissue abnormalities coefficient hyperinsulinemia coefficient nucleus of the hypothalamus abnormal coefficient triglyceride content of abnormal coefficient; the abnormal lipid metabolism coefficient recorded a large effect of 0.82. The distribution of the results was normal, according to the S-W results which ranged between 0.711–0.918 (Table 2).

Table 2. Statistical analysis of the obesity analysis report for the male groups.

Parameters	Groups	X	SD	DX	DDS	CI95% Lower	CI95% Uper	*t*	*p*	S-W
Abnormal lipid metabolism coefficient	Sp	1.574	1.053	−0.798	1.369	−1.091	−0.504	−5.403	0.000	0.711
	Nsp	2.372	0.987							0.802
Brown adipose tissue abnormalities coefficient	Sp	2.952	0.792	−0.218	0.953	−0.422	−0.014	−2.125	0.036	0.867
	Nsp	3.171	0.620							0.776
Hyperinsulinemia coefficient	Sp	0.140	0.039	−0.129	0.494	−0.235	−0.023	−2.431	0.017	0.791
	Nsp	0.270	0.498							0.808
Nucleus of the hypothalamus abnormal coefficient	Sp	0.462	0.082	−0.031	0.137	−0.014	0.061	−2.140	0.035	0.815
	Nsp	0.494	0.101							0.821
Triglyceride content of abnormal coefficient	Sp	3.001	1.095	0.844	1.186	0.590	1.099	6.600	0.000	0.865
	Nsp	2.157	0.602							0.918

Sp—group of sports students, Nsp—group of non-sports students, X—average, SD—standard deviation, DX—average difference, DDS—standard deviation of DX, CI—interval of confidence, *t*—value of Student's test, *p*—significant level of probability.

Regarding the statistical analysis of the parameters of the component analysis of the body, it reveals a strong statistical significance of the differences registered between the two male samples in favor of the group of athletes. At all parameters analyzed, the results

recorded by the sample of athletes were lower than those of the group of non-athletes, which reflects the impact of exercise on body development. The distribution of the results was normal, according to the S-W results which ranged between 0.845–0.921 (Table 3). The most relevant differences were registered at the body mass index (BMI) where the group of athletes had 2.3267 less than the group of non-athletes, as well as at the degree of body obesity (ODB%) where the difference was 10.290. The analysis of the results of the statistical indicator Cohen's for effect size for both male samples showed a large effect size of 0.89 and 0.82 for degree of body obesity (ODB%) and, respectively, body mass index (BMI); body cell mass (BCM) had 0.47 mean effect.

Table 3. Statistical analysis of the body composition parameters in male participants.

Parameters	Groups	X	SD	DX	DDS	CI95% Lower	CI95% Uper	*t*	*p*	S-W
Obesity degree of body(ODB %)	Sp	103.453	13.582	−10.290	17.164	6.610	13.970	5.560	0.000	0.856
	Nsp	113.744	10.448							0.903
Body mass index (BMI)	Sp	22.275	2.940	−2.326	3.729	1.527	3.126	5.786	0.000	0.876
	Nsp	24.602	2.324							0.819
Body cell mass (BCM)	Sp	23.888	3.644	−1.597	0.518	0.566	2.628	3.082	0.003	0.921
	Nsp	25.485	2.458							0.845

Sp—group of sports students, Nsp—group of non-sports students, X—average, SD—standard deviation, DX—average difference, DDS—standard deviation of DX, CI—interval of confidence, *t*—value of Student's test, *p*—significant level of probability.

With the exception of the following parameters—the inorganic substance, protein (kg), the lean body weight (kg) and the weight (kg)—all the other analyzed parameters registered statistically significant differences between the group of athletes and the non-athletes. The most important parameters that registered significant differences between the two groups were: the body fat (kg), the muscle volume (kg) and the body moisture (kg); the group of athletes having much better values than that of non-athletes, revealing the importance of systematic exercise of physical exercise on body composition. The size of the size effect for both groups was large for parameters body fat 0.91, muscle volume 0.83, lean body weight 0.081 and weight 0.82; the other parameters recorded an average level of the Cohen's for effect size statistical indicator. The distribution of the results was normal, according to the S-W results, which ranged between 0.769–0.923 (Table 4).

Statistical processing of the results reveals that all the differences between the two female groups were statistically significant in favor of the sports group, with one exception for the brown adipose tissue abnormalities coefficient. The results of the study groups are within the normal reference values, with the mention that those recorded by the group of athletes are closer to the lower limits of normality. The largest differences between the two groups, in favor of the sports group, were registered with the parameter abnormal lipid metabolism coefficient −1.063, and the smallest difference with the parameter the hyperinsulinemia coefficient −0.052. Cohen's calculation for effect size showed that the following parameters recorded small and medium values between 0.2 and 0.5 for all parameters. The distribution of the results was normal, according to the S-W results, which ranged between 0.789–0.913 (Table 5).

Table 4. Statistical analysis of the Nourishment for the male groups.

Parameters	Groups	X	SD	DX	DDS	CI95% Lower	CI95% Uper	*t*	*p*	S-W
Intracellular Fluid (L)	Sp	18.214	1.763	1.150	3.424	0.415	1.884	3.115	0.003	0.823
	Nsp	17.064	2.584							0.795
Extracellular Fluid (L)	Sp	9.327	0.901	0.583	1.764	0.205	0.962	3.068	0.003	0.789
	Nsp	8.7442	1.336							0.769
Protein (kg)	Sp	7.2228	0.696	0.381	1.352	0.091	0.671	2.618	0.010	0.923
	Nsp	6.8409	1.026							0.912
Inorganic substance	Sp	25.861	2.077	−0.300	3.803	−1.116	0.514	−0.733	0.466	0.867
	Nsp	26.162	2.820							0.827
Body fat (kg)	Sp	15.299	4.064	−2.042	5.243	0.918	3.166	3.612	0.001	0.875
	Nsp	17.341	2.893							0.792
Body moisture (kg)	Sp	25.808	3.943	−1.740	5.198	0.626	2.855	3.105	0.003	0.819
	Nsp	27.548	2.650							0.835
Muscle volume (kg)	Sp	35.179	3.801	2.565	6.834	1.100	4.031	3.482	0.001	0.917
	Nsp	32.613	4.975							0.881
Lean body weight (kg)	Sp	56.286	7.402	−2.841	11.302	−5.265	-0.418	−2.332	0.022	0.814
	Nsp	59.127	7.678							0.821
Weight (kg)	Sp	74.186	11.240	−3.790	14.770	0.623	6.957	2.380	0.020	0.827
	Nsp	77.976	7.655							0.831

Sp—group of sports students, Nsp—group of non-sports students, X—average, SD—standard deviation, DX—average difference, DDS—standard deviation of DX, CI—interval of confidence, *t*—value of Student's test, *p*—significant level of probability.

Table 5. Statistical analysis of the obesity analysis report for the female groups.

Parameters	Groups	X	SD	DX	DDS	CI95% Lower	CI95% Uper	*t*	*p*	S-W
Abnormal lipid metabolism coefficient	Sp	1.830	0.952	−1.063	1.194	−1.380	-0.746	−6.721	0.000	0.891
	Nsp	2.894	0.789							0.895
Brown adipose tissue abnormalities coefficient	Sp	2.765	0.943	−0.348	1.047	−0.626	−0.070	−2.509	0.015	0.789
	Nsp	3.114	0.474							0.906
Hyperinsulinemia coefficient	Sp	0.167	0.057	−0.052	.119	−0.083	−0.020	−3.311	0.002	0.918
	Nsp	0.219	0.097							0.913
Nucleus of the hypothalamus abnormal coefficient	Sp	0.438	0.080	−0.073	.117	−0.104	−0.042	−4.749	0.000	0.836
	Nsp	0.512	0.090							0.821
Triglyceride content of abnormal coefficient	Sp	3.118	1.345	0.807	1.395	0.437	1.178	4.371	0.000	0.847
	Nsp	2.310	0.693							0.839

Sp—group of sports students, Nsp—group of non-sports students, X—average, SD—standard deviation, DX—average difference, DDS—standard deviation of DX, CI—interval of confidence, *t*—value of Student's test, *p*—significant level of probability.

The statistical processing of the parameters of the component analysis of body highlights a strong statistical significance of the differences between the two female samples, in favor of the group of athletes, except for body cell mass (BCM). At all parameters analyzed, the results recorded by the sample of athletes were lower than those of the group of non-athletes, which reflects the impact of exercise on body development. The most relevant differences were registered at the body mass index (BMI) where the group of athletes had 2285 less than the group of non-athletes, as well as at the obesity degree of body (ODB%)

where the difference was 8082. The analysis of the results of both groups regarding the statistical indicator, Cohen's, for effect showed large effect sizes of 0.84 and 0.87 for the obesity degree of body (ODB%) and, respectively, body mass index (BMI); body cell mass (BCM) had 0.38 mean effect. The distribution of the results was normal, according to the S-W results, which ranged between 0.815–0.911 (Table 6).

Table 6. Statistical analysis of the body composition parameters in female participants.

Parameters	Groups	X	SD	DX	DDS	CI95% Lower	CI95% Uper	*t*	*p*	S-W
Obesity degree of body (ODB %)	Sp	104.140	17.581	−8.082	19.217	2.983	13.181	3.175	0.002	0.911
	Nsp	112.228	10.244							0.848
Body mass index (BMI)	Sp	21.771	3.453	−2.285	3.913	1.247	3.324	4.410	0.000	0.909
	Nsp	24.057	2.475							0.879
Body cell mass (BCM)	Sp	21.196	5.132	−1.591	5.119	0.232	2.949	2.346	0.023	0.815
	Nsp	22.787	1.675							0.845

Sp—group of sports students, Nsp—group of non-sports students, X—average, SD—standard deviation, DX—average difference, DDS—standard deviation of DX, CI—interval of confidence, *t*—value of Student's test, *p*—significant level of probability.

The results of the study on nourishment for the female groups show that only parameters: the body fat (kg), the muscle volume (kg) and the body moisture (kg) registered statistically significant differences between the two groups in favor of the sports group. The other analyzed parameters did not show significant differences as a result of systematically practicing physical exercises. The distribution of the results was normal, according to the S-W results, which ranged between 0.791–0.903 (Table 7).

Table 7. Statistical analysis of nourishment for the female groups.

Parameters	Groups	X	SD	DX	DDS	CI95% Lower	CI95% Uper	*t*	*p*	S-W
Intracellular Fluid (L)	Sp	14.588	3.399	−0.346	3.682	−1.323	0.630	−0.710	0.481	0.902
	Nsp	14.935	1.268							0.893
Extracellular Fluid(L)	Sp	7.3953	1.801	−0.324	1.858	−0.817	0.169	−1.316	0.193	0.872
	Nsp	7.7193	.600							0.791
Protein(kg)	Sp	5.6574	1.475	−0.307	1.576	−0.725	0.110	−1.472	0.146	0.810
	Nsp	5.9649	.482							0.823
Inorganic substance	Sp	18.963	3.819	1.296	4.430	0.121	2.472	2.210	0.031	0.871
	Nsp	17.666	2.071							0.849
Body fat (kg)	Sp	14.263	1.716	−2.586	6.335	0.905	4.267	3.082	0.003	0.903
	Nsp	16.849	6.248							0.793
Body moisture (kg)	Sp	22.947	5.436	0.194	5.861	−1.360	1.749	0.251	0.003	0.872
	Nsp	22.752	1.847							0.817
Muscle volume (kg)	Sp	26.434	6.157	−2.570	9.103	0.154	4.985	2.132	0.001	0.824
	Nsp	23.864	5.616							0.871
Lean body weight (kg)	Sp	43.778	6.156	−4.118	11.149	1.160	7.077	2.789	0.007	0.843
	Nsp	47.897	9.322							0.828
Weight (kg)	Sp	65.014	14.37	4.364	15.127	0.351	8.378	2.178	0.034	0.818
	Nsp	60.649	5.862							0.832

Sp—group of sports students, Nsp—group of non-sports students, X—average, SD—standard deviation, DX—average difference, DDS—standard deviation of DX, CI—interval of confidence, *t*—value of Student's test, *p*—significant level of probability.

4. Discussion

The analysis of the results contributes to the confirmation of the research purpose and facilitates the highlighting of significant differences in favor of the sample of active students, compared to the semi-active ones, analyzed and differentiated by sex. In all three categories of analyzed obesity parameters, namely the component analysis of the body, nourishment and the obesity analysis report, the female and male sample of sports students registered better values compared to those of semi-active students. The results of our study confirm previous studies that have analyzed the impact of physical activity on obesity [28–31], complementing the level of knowledge through the integrated analysis of three categories of parameters that analyze body obesity, namely the componential analysis of body, nourishment and the obesity analysis report.

The results of the male and female samples at the componential analysis of body reveal that the sample of sports students registered more optimal values compared to that of semi-active students for all parameters: obesity degree of body (ODB%), body mass index (BMI) and body cell mass (BCM). The athlete's population sample recorded lower values of the degree of body obesity (ODB%) indicator compared to the non-athlete population in both sexes. This allows us to conclude that regular physical activity has a positive effect on real weight, relative to ideal weight (standard). The impact of physical training on optimizing body weight has been highlighted in many studies, focusing on the type of workouts and specific effort [64–66]. The results of the study are in agreement with previous studies that highlight the role of physical exercise, especially on body mass index (BMI), at different age groups [67–69], by sex [70,71] and depending on lifestyle [72,73].

In the obesity analysis report category, all two male groups, as well as the two female groups, recorded values that met the reference limits, but the sports student groups recorded better values towards the lower reference limits compared to the reference groups. semi-active student who recorded higher values, towards the upper reference limits. The registered level of triglyceride content of abnormal coefficient was above normal limits in both population samples and this can be correlated with the diet. We consider the increased values obtained for the athletes' population sample are the result of using fat as an energy source. As such the results of our study are correlated with a study conducted on a sample of 235 student subjects (sports versus non-athletes) where the level of Triglyceride in both boys and girls was higher in athletes' subjects [74]. In alignment with our results, other studies show that physical exercise can have a major influence in fighting obesity and lowering total cholesterol, but it does not influence the level of triglycerides, which increases due to physical activity [75].

Studies on body composition have shown the importance of keeping body weight and obesity-associated parameters within normal limits in order to optimize health [76–78]. The most relevant parameters in the nourishment category of the male and female sports student groups, compared to the similar groups of semi-active students, are highlighted by our study. We consider that they were registered with body fat and muscle volume parameters. The low level of body fat and the high level of muscle volume, compared to the average weight of the samples, highlight the major impact that regular physical activity has on body composition and, implicitly, on health. When analyzing the body fat level in correlation with weight (kg), we noticed that, in both sample populations, the level of adipose tissue was lower in athletes than in non-athletes, while the weight was higher in athletes than in non-athletes. This testifies the impact of physical activities on the parameters of body composition. Similar studies have identified significant correlations between decreased adipose tissue levels and regular exercise [79,80].

The results of our study confirm and they are in accordance with the results of previous studies that showed a decrease in body fat [81,82] and increased muscle volume [83,84], at different age categories [85,86] and by practicing different types of physical activities [87,88]. Expert recommendations, based on complex studies, suggest that 150 min of moderate aerobic physical activity or 75 min of intense aerobic activity per week may lead to improved cardiovascular health; however, studies have not shown significant decreases in

obesity or clinical weight optimization without caloric restrictions as a result of dietary readjustments [36,87,89].

In the present study, magnetic bioresonance and bioimpedance technologies were used for reasons of cost efficiency, time, and easy applicability; the results aimed to identify differences in body composition parameters due to regular physical activity in two samples of healthy sports and non-sports subjects. The studies performed on different categories of populations have shown that, by comparison, the results of computed tomography (CT) and the BIA have statistically significant correlations in terms of assessing visceral obesity and other parameters of body composition. BIA can be used as an alternative to CT as a standard method [90–92].

After completing the study, we were able to identify some relevant limitations. The study included only subjects aged between 18 and 25 years, and the extension of the study to other age groups and to totally sedentary people would help to identify particular aspects according to the topic of the current study. Another limitation of the study was the non-identification of the volume and intensity of physical activities performed by the study sample, this aspect may have important implications on the level of physical fitness and implicitly on the parameters of body composition. A relevant limitation of the current study was that the results of the current study have not been compared with the results of other studies in which determinations are made by classical methods of investigating body composition parameters, as well the use of the magnetic bioresonance technology, which is difficult to interpret due to undefined parameters, and is difficult to relate to other studies.

The strengths of the study can be summarized in the complexity of obesity-related parameters analyzed in the study, the large number of subjects included in the study, the use of bioimpedance and magnetic bioresonance technologies to collect the results of the study, we take into consideration, for this study, two categories of subject active and semi-active students from various academic specializations.

5. Conclusions

The results of the study highlight significant differences in the correlations of obesity between the samples of active and semi-active sports students, for both sexes. The use of magnetic bioresonance and bioimpedance investigation technologies facilitated the identification of three categories of obesity-related multifactorial parameters, namely the body componential analysis, nourishment and the obesity analysis report.

The biggest differences regarding obesity and body composition were recorded between active and significant sports student samples. For both sexes, the most important parameters were abnormal lipid metabolism coefficient, triglyceride content of abnormal coefficient, degree of body obesity (ODB %), body mass index (BMI), body fat (kg), muscle volume (kg), lean body weight (kg). The results of the study highlight significant differences in all areas, noted between the sample of active athletes compared to those that are semi-active, emphasizing the impact of regular and systematic physical activity on body composition, obesity and health.

This study advances our understanding of the complex impact that physical activities have on multiple parameters of body composition and directly on the health of active students compared to semi-active or sedentary students. Regular exercise to promote active behaviors can have important benefits on body composition and can help optimize body weight and prevent obesity. Further studies are necessary to better understand how bio-resonance and magnetic resonance technologies can be optimally used in clinical practice. The health consequences of obesity can be diminished through physical activity; exercise is an effective means of managing obesity.

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The Multiplicative Effect Interaction between Outdoor Education Activities Based on the Sensory System

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Abstract: *Background:* The present paper initiates the introduction of physical education activities within the Transylvania University of Brașov, aiming at a new strategy. The purpose is identifying the level of knowledge and the level of perception regarding the extent to which outdoor activities are viewed and implemented, and the effects that the latter has on them by tracking certain variables of a sensory nature, comprised of visual, auditory, kinesthetic and digital areas. *Methods:* This research aims to analyze if the type of sensory channel is influenced by the type of sport and the environment (urban/rural) of that practiced sport. We also analyzed the benefits offered by different sports and if these benefits influence the type of activity. Data were collected using an online survey, a questionnaire, using a Likert scale, with subjects having to choose between multiple answers. In addition, data were allocated and reviewed based on a sample of 100 students who have the habit of practicing outdoor activities. *Results:* The results of the study significantly show that the objectives were met and as such it can be concluded that outdoor activities, from the point of view of perception systems, can be classified according to the method of ordering the rank of activities by the dominant kinesthetic sensory channel.

Keywords: multiplicative effects; interaction; outdoor education; sensory systems

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1. Introduction

Outdoor education as a form of education comprises, alongside the learning factor, its experiential aspect and its setting, because it is primarily conducted outside, as well as the concept of senses and how they are perceived and used in all their characteristics and domains [1]. Education effectuated outside, in a natural environment, has started to put quite a lot of emphasis on the perception of the senses, whereas this perception is made based on different feelings experienced outside or based on factual observation and the dualistic aspect of the cause-effect relationships arisen within the undertaking of different outdoor activities [2].

Referring to outdoor education activities, it is necessary to point out that the major objective, almost unique, is acknowledging and surpassing one's limits; victory, as an objective that comes from the accomplishment of each individual, is also pointed out [3]. This need represents an energizing part of the outdoor education activity, leading to obtaining a certain high level of self-esteem. The benefits of this accomplishment are first of all the ideal and then the material. If the programs of outdoor education have an organized, specific structure that the educators can provide, then the outdoor learning notion becomes not only a point of challenge for the students when undertaking different activities but also builds changes in oneself, leading to growth, personal development, and self-confidence [4]. The outdoor activities and sports are mostly practiced gaining a high level of fitness and good health. Another important motivation is having fun near

family, friends, and colleagues [1]. They love the experience of feeling excitement and adventure due to the adrenaline release. People that practice outdoor activities have the benefit of observing the scenic beauty and being close to nature. Talking about outdoor sports, the most important gain is developing specific skills, abilities and gaining a sense of self-confidence [2–4].

The need to wisely use open, free spaces is a product of the culture and education, life evolution, and contemporaneous civilizations. Today, when work becomes less and less physical and more and more intellectual, free time spent in different ways and forms, as a necessary complementarity to the routine and stressful activities from closed spaces, becomes the most valuable time asset outside productive work [5].

In the course of the contemporary development of life, within the last couple of years with the unfolding of the COVID-19 pandemic and the lockdowns, parents have started to work more from home, thus leading to children staying at home and performing activities inside. This sedentariness has meant fewer and fewer trips outside, losing the connection with nature for a while, becoming more engaged in things primarily effectuated in confined spaces, and experiencing a high level of stress for both parents and children [6–8].

The delusion of modern technological methods, such as the television or the computer, has led to a sedentary life among children and adults. Lately, a worrying increase in the number of overweight or anemic people has been registered both among adults and children who are attracted to video games and movies and forget, with their parents' consent, about outdoor games and walks in nature [9–11].

Though these are useful for the individual's intellectual development, they do not always offer everything necessary to develop a balanced and harmonious life. The specialized knowledge and situations where one refers to multi-disciplinary cooperation all can prove that a major part is played by outdoor activities, and one presumes that their effectuation makes it possible to highlight a superior age branch of the student's main sensory system. The need to develop the human personality through outdoor activities is believed to represent the broad field of human experiences dedicated to forming healthy characters; in this way, they can build, keep and transmit further along with a much cleaner, more beautiful, and healthier world [12–15].

Outdoor education activities are interactive activities that simulate real situations and involve resolving certain tasks. "An experiential way of learning that involves using all senses" takes place generally, but not exclusively, through exposure to the natural environment through outdoor education activities. They involve all three fields: physical, psychological, and emotional. Consequently, the participants assimilate a series of abilities and skills that contribute to improving personal performances; furthermore, when team members become aware of the obstacles that harden the teamwork, all of this contributes to improving the team's performance both within the exercise and in "real life" [16].

The main objective of outdoor activities is to encourage the development of certain personality traits with broad social acceptance: initiative, perseverance, optimism, willingness, organizing skills, courage, and special organizing skills. These characteristics arise from spending time performing outdoor activities and are constantly developing when they are constantly effectuated. Playing outside or engaging in different outdoor activities creates relationships, develops the social connections between peers, and develops motor skills, while also generating more learning possibilities in the natural environment and encapsulating a healthier mindset in all the upcoming challenges society might bring [17–20].

Moreover, in analyzing the personality traits, one must bear in mind the dynamics that characterize them and the sudden or gradual transformations that have taken place at their level. The dynamic character of free time activities also determines differentiated attitudes towards the effectuated activity and differentiated relationships between the group members. In other words, an individual does not manifest the same behavior or attitude in connection to the effectuated activity of each member of that respective group [21].

2. Review Research of Web of Science—Articles 2018–2020

The research design was defined by the following topics: "outdoor education and sports" (Topic) and 2018–2020 (Year Published) and Articles or Review Articles (Document Types) and all categories from (Web of Science Categories). As a result, only 360 papers were returned. We selected only 40 papers. The rest of the 320 was in another language than English, or do not offer the full text, or analyses collateral to the outdoors sports theme. Figure 1 shows the authors' high visibility of most respective papers and the link between themes, and publication year.

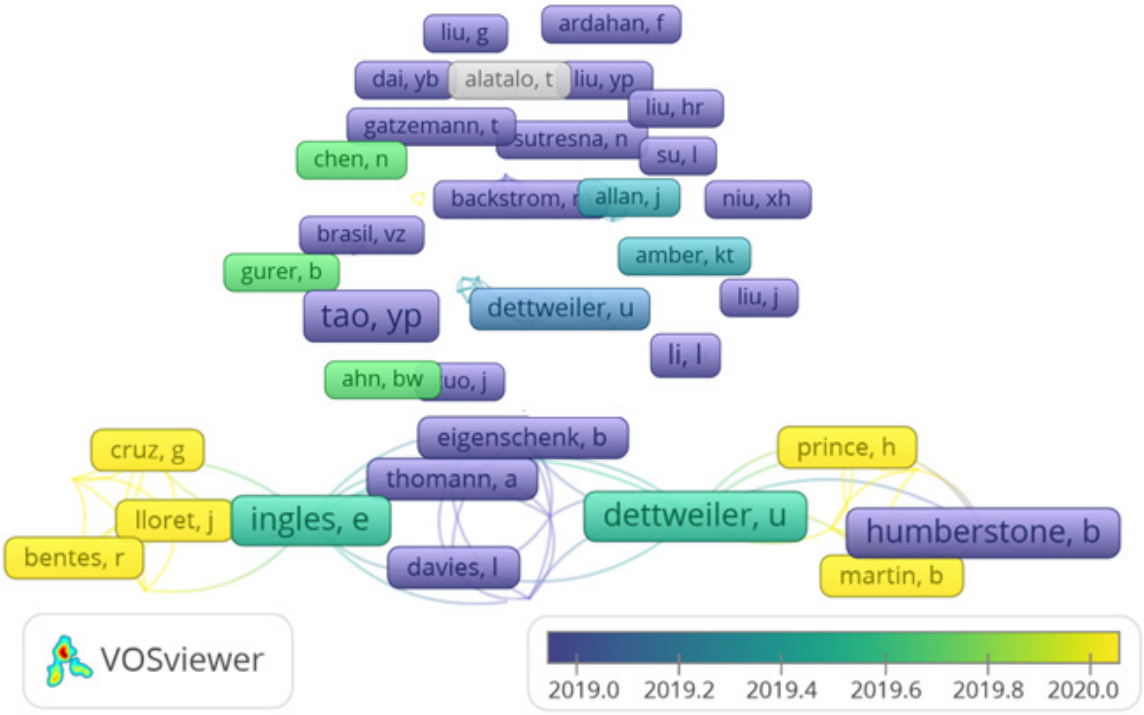

Figure 1. Clusters of papers published from 2018 to 2020 (Source: VOSviwer version 1.6.18 (May 2022).

We decided to use VOSviewer Software for a professional panorama regarding scientific papers published in the last years grouped in three main clusters. This image helps us to understand the topics discussed by the main authors, and the interrelation between them.

The social benefits of practicing sport and teaching within the natural environment are detailed by Eigenschenk, in a very large study with students from six European countries. They assumed that the main benefits of outdoor education are physical health, mental equilibrium, education, citizenship abilities, attitude, crime mitigation, and anti-social behavior [22,23]. Another author conducted a similar study in Viana do Castelo (Portugal) for school-age children and adolescents that were the beneficiary of nautical activities. Besides the advantages presented above, they also discuss environmental awareness [24].

Within the non-formal educational programs, "outdoor education" represents a learning process that takes place outside. Outdoor education includes environmental education to enhance the sense of responsibility towards the natural frame of outdoor activities; adventure education by setting the scene properly from the social and cultural point of view as to engulf the needs and desires of children as well as the newly established relationships within the context of outdoor activities; the benefits of camping as a useful tool for developing new relationships and for practicing perceptive feeling during different situations; outdoor therapy activities and certain aspects of outdoor recreation; notions that have grown so much in the last decades; notions that trigger a healthier state of mind and well-being. Thus, one considers that practicing outdoor education activities can be-

come a method of teaching youngsters, these activities being elaborated with a training purpose; for example, the group cooperation activities cultivate honesty, respect for the other members' feelings and rights, care for others, and self-discipline [25–28].

Recent research has shown the importance of outdoor education on character development, collaborative social behavior, and health for all the participants in nature activities. Concurrently, the subjects get to know nature, its laws, and balance based on elements and a whole. The subjects' nature experience stimulates creativity, engaging the body and the mind and amplifying a better memory of their previous experiences and activities; these qualities are generally inhibited by the closed, artificial, and stressful environment of cities [29].

As scientific research, outdoor education drifts its education methods away from quantitative research dominated by the descriptive and the statistical characteristic to research based on hermeneutics, that is on interpreting and analyzing the experimental facts and data, thus accomplishing the link between the objective and the subject of the research as a direct link [30].

The characteristics of the motile acts are kinesthetically different, depending on the effectuated physical activity: some are extremely complex involving a thorough control of the organism and its segment, while others separately follow certain qualities, skills, or motile abilities. The optimal level of motivation for these complex motile acts requires extremely sensitive coordination and the intervention of intellectual processes. To solve complex tasks, one needs moderate motivation, while for simple tasks one needs high motivation. The ones engaging in outdoor education activities must know very well their own psychological and motile characteristics for their respective age [31].

Man is quite reasonably structured: to know the surroundings he has at his disposal a universal set of sensory organs. Everybody can hear, see, feel and understand. It is true, that few people pay attention to the fact that when someone interacts with the outside world, in most cases, they do not use all the tools provided by nature, but only the selected ones. Such a holistic approach gives man the opportunity to feel and assimilate a different kind of learning experience, an event that enhances the senses, the personality, and the motor skills of the individual [32].

The research evaluates the visual, audio, kinesthetic, and digital characteristics as one of the most important in elaborating a person's psychological portrait. Knowing his/her psychological type will not only help to get along with his /herself but will also simplify the process of interaction with other people.

For some it is more important to receive the auditory information, while for others it is more convenient to see the information with their own eyes; nevertheless, others cannot learn anything unless it is projected in their personal life, while for others a common language can be found if one speaks in the language of strict logic. This is to say that everybody has a certain specific way of perceiving information and depending on that, everybody shares visual, auditory, kinesthetic, and digital information [32].

To identify to what extent the proportion between outdoor education activities and the sensory system exists, as well as the interaction between these two elements, these relations are expressed through practical and preferential methods such as native forms as the need for movement or through preponderantly social and educational methods such as the need for self-knowledge, sense of risk and its calculation, as well as the habit of practicing movement [33].

The study also presumes that the educational formers are the ones who have the role of appreciating the harmonious social relationships of the youngsters as a result of their participation in outdoor education activities. In this context, experiential learning cannot be permanently systematic or uniform; it addresses the different characters and personalities of each participant. These skills are developed in time and with maximum attention on behalf of educators, for example, through group cooperation activities that cultivate honesty, respect for the other members' feelings and rights, care for others, and self-discipline, as ethical values. Accomplishing this educational model also requires specific strategies,

through which the students can learn to communicate with each member of the group, take responsibility, and accept the differences and the compromises within a group. The physical education teachers must know the fact that these subjects are sometimes below expectations in this area, not because they do not want to participate in these activities but because they do not know, with gradual teaching of these skills being the natural step. This happens also because some subjects are not aware of the collaborative values within a group at home or in other contexts and because these values have never been consolidated [33,34]. As a consequence, teachers must not expect the participants to learn these values at a fast and automatic pace. Learning these collaborative skills is done just like learning any other skills. If the subjects do not understand the group collaborative concepts and practice, educators must never direct them in solving their misunderstandings or disputes outside the group, but through outdoor activities that generate beneficial multiplicative effects in the individual, group, and social areas [30,35].

3. Materials and Methods

This research aims to analyze if the type of sensory channel is influenced by the type of sport and the environment (urban/rural) of that practiced sport. We also analyzed the benefits brought by different sports and if these benefits influence the type of activity (visual, auditory, kinesthesis, and digital). The data have been collected through the help of an online survey, a questionnaire, using the Likert scale with the subjects having to choose from multiple answers; therefore, a multiple-choice type of questionnaire. Furthermore, the data have been allocated and reviewed based on a sample of 100 students from the Transylvania University of Brasov, students that are in the habit of practicing outdoor activities.

The sample is representative. Data were analyzed with Microsoft Excel 365 in the first stage. In the second stage, we used SmartPLs Software version 3.0 for a factor analysis (CFA), which measures the impact of factors on the dependent explanatory construct.

3.1. Stage I—Perception Analysis Based on the Likert Scale

3.1.1. Stage I Hypothesis

Hypothesis 1 (H1). *The research hypothesis: one presumes that no matter the outdoor education program or the motives related to the sensory system for students, the degree of satisfaction in obtaining performance and surpassing their limits is important.*

3.1.2. Stage I Method

The study has as a purpose the identification of the student's preferred means of outdoor education activities through the dominant sensory system. Each student was stimulated based on his/her perceptions—visual, auditory, kinesthetic, and digital—to appreciate the effectuated outdoor education activities within a practical stage in a specialized center for these kinds of activities.

One of the methods used in the research was the Likert scale, having as an objective the appreciation of outdoor activities included in 4 modules that have been effectuated within the practical stage.

The sensory analysis method was conducted through a questionnaire that has as an appreciation system of the measurement of the student's satisfaction towards the practical stage effectuated means and methods. The scale had 5 degrees, which indicated the intensity of the agreement or disagreement of the participants to such outdoor education activities. The Likert scale had the 5 following degrees: Total agreement (+2), Agreement (+1), Indifference (0), Disagreement (−1), and Total disagreement (−2). [36]

Another method of research is the rank ordering method [37] to classify the proposed outdoor activities for the students to effectuate them based on the intensity of a single sensory characteristic that is the preferred one; the objectives were the following:

- Facilitating a more precise evaluation;
- Facilitating the appreciation through acceptance of the proposed outdoor activities.

The research used the same sample of 100 students that have been asked to express their preferences regarding the proposed outdoor activities; this is a fast and quite accurate method in evaluating certain complex characteristics such as perceiving the activities through the preferred sensory canal. The students were invited to experiment with the outdoor activities in a practical stage in a specialized center and they were asked to express their satisfaction and preferences related to this experience. The 100 students grouped in 4 clusters of 25 students have effectuated the following outdoor activities:

- Trekking and hiking;
- Mountaineering hiking;
- Orienteering and movement in different types of the field;
- Climbing a fake wall;
- Rappel;
- Zipline;
- Rope garden;
- Touristic orientation;
- Rafting, kayak canoeing;
- Mountain biking;
- Building a boat;
- Writing maps;
- Static activities based on communication.

All these activities have been proposed with the stimulation of the 4 sensory canals as a main aim:

- Activity 1 (centered on the dominant visual sensory canal)—activities that have presumed excursions and hiking in which the students were asked to contemplate nature, to effectuate activities with precise tasks such as finding a hidden treasure and orientating on the field to write a map; in these activities one presented the beauties of nature, knowing different species of plants and birds, things that required evaluating the information given, especially through the preferred sensory canal—the visual one.
- Activity 2 (centered on the dominant auditory sensory canal)—these activities presumed precise tasks without useless details; their solution also presumed communication guided mainly by the auditory sensations.
- Activity 3 (centered on the dominant kinesthetic sensory canal)—the activities have presumed to solve the tasks based on experimenting with certain physical sensations, perceiving pain, coldness, hotness, the difficulties of solving tasks in different ways, solving certain difficult motile tasks such as the rope garden, climbing rocks, rappelling and undertaking expeditions for surviving.
- Activity 4 (centered in the dominant digital sensory canal)—these activities required the management of logic and thought process with clear planning; they were stressful activities such as building a boat from different objects and experimenting this on water and building certain objects with materials from nature without affecting nature, paths or maps.

3.1.3. Stage I Results

The students' opinions regarding the 4 types of activity are presented in Table 1. The score regarding each type of activity was calculated with the formula

$$\text{An} = [\text{NoA} \times (+2) + \text{NoA} \times (+1) + \text{NoA} \times 0 + \text{NoA} \times (-1)]: 100 \quad (1)$$

where An is the name of the activity and NoA represents the number of answers for each type of activity.

Table 1. The Likert Scale the students' appreciation.

Activity	Total Agreement (+2)	Agreement (+1)	Indifference 0	Disagreement (−1)	Total Disagreement (−2)
Activity 1—sensory	72	26	1	1	0
Activity 2—auditory	70	27	1	2	0
Activity 3—kinesthetic	75	23	1	1	0
Activity 4—digital	62	29	5	4	0

The global score of this study is calculated with the formula $\frac{\sum_{i=1}^{n} An}{n}$, where n = 4 in our case, the 4 types of activities from Table 1.

On a scale from −2 to +2, the global score was 1.65 positive value, and the most appreciated module was module 3 with a score of 1.73 (Figure 2).

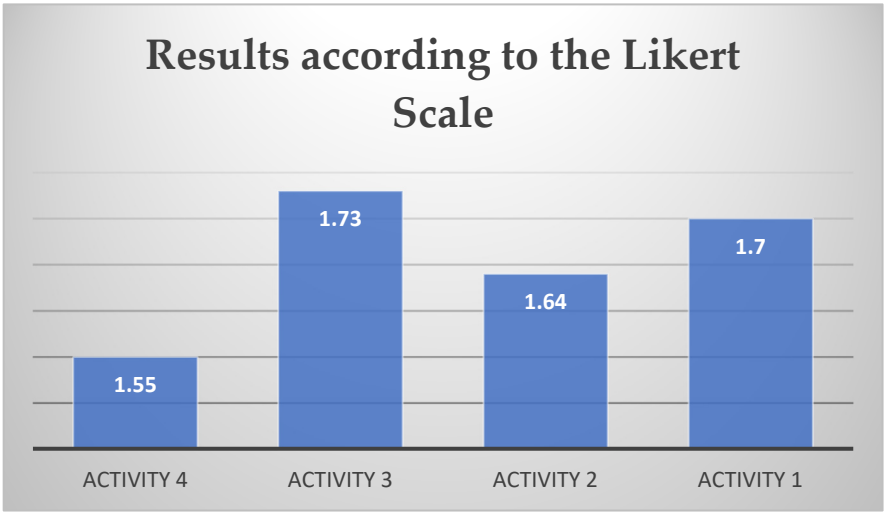

Figure 2. The research results according to the Likert Scale.

From the data research analysis, one can see that the overall image is positive, and the participant students have expressed through their options module 3 as a winner, the module centered on the dominant kinesthetic sensory canal with a score of 1.78, followed by module 2 centered on the dominant visual sensory canal with a score of 1.73.

Analyzing the research study results after the rank ordering method, one can conclude that the students preferred the activities from module 3 (centered on the kinesthetic sensory canal), with a first-place score of 1.73 followed by a tight score from module 1 activities (centered on the visual sensory canal) with 1.7. The third place was occupied by module 2 with auditory activity and a score of 1.64. The last place was occupied by module 4 with digital activity and a score of 1.55.

Thus, one can also confirm H1 by the results obtained: students' satisfaction and appreciation regarding outdoor activities are positive. The better the ability is to work with these canals the better one can communicate with oneself and those around them. A first step in training this ability is discovering the preferred sensory canal.

After closely observing the students' preferences, based on their behavior and observation charts, the ones who preferred module 3, with a score of 1.73 centered on the kinesthetic sensory canal, were aware of how they felt things and emotional reactions, and they preferred to gather information through touching, gesturing and smelling. They were willing to experiment with the emotion of the unknown and the need for movement, which contribute to improving and developing the collaborative coordination through activities that had as tasks moving on a varied field, without tracks, maintaining balance depending on the effectuated path, developing courage, the needs to affirm oneself, a

better understanding of others, and a better way of showing respect for the other's abilities and skills.

The students who marked as preference the activities from module 1 (degree score of 1.7 centered on the dominant visual sensory canal) stood out by solving tasks such as spatial orientation, using clear schemes, and often using the words "beautiful" or "ugly" in correlating the information provided by nature through images.

The ones opting for module 2, degree score of 1.64 (centered on the dominant auditory canal), resolved the tasks by hearing as a main source of information and by communicating; they also used the interior dialogue (what one says to oneself) with the very important role in consolidating the system of values; they were very sociable, centered on communication, and they did not orientate so well in space, but they were very precise in actions that did not require too many details. These students were the ones who organized evenings of radio and audiobooks.

The ones who preferred module 4, degree score of 1.55 (centered on the dominant digital sensory canal), stood out by planning tasks and analyzing each detail through their thought process without needing visual or auditory images. They perceived the information that they understood with the help of logic, being very focused and detached from the environment.

3.2. Stage II Factor Analysis

In stage II we designed a model based on Confirm Factor Analysis. The model restrictions were determined by 1 formative construct (PES = physical education and sports) and 2 reflective constructs (sensory activity; environment and sports). Our analysis measures the impact of each subitem/factor (loading factor = LF) but does not help us to establish the direction of the influence [38,39].

The SmartPLS software will estimate the model saturation based on a series of indices that enhance how well the model explains the variables and fits the hypothesis established. The relevance of the latent constructs designed was analyzed with Cronbach's alpha test, and the consistency of the model was evaluated with composite reliability, rho A, and average variance extracted (AVE). [40,41].

Our analysis is based on 3 variables (Figure 3 and Table 2):

- PES—a formative variable with 8 items, emphasizing the benefits brought by PES;
- Env Sport—a reflective variable with 2 items, emphasizing the type of sport and the environment of practice (urban/rural);
- Sensory activity—a reflective variable defined by the 4 types of activity (visual, auditory, kinesthesis, and digital) preferred by students.

Table 2. Variable analyzed.

Var Label	Var Subitems	Variable Definition	LF
Sensory activity	Visual	Activity 1 centered on the dominant visual sensory canal	0.975
	Auditory	Activity 2 centered on the dominant auditory sensory canal	1.086
	Kinesthetic	Activity 3 centered on the dominant kinesthetic sensory canal	0.941
	Digital	Activity 4 centered on the dominant digital sensory canal	0.734
Environment and Sports	Env	Environment: 1-urban or 2-rural	0.406
	Sport	Type of sports practiced by children	0.29
PES Role	Health	PES role: sanitation	0.932
	Fitness	PES role: fitness	0.774
	Body	PES role: body shaping	−0.17
	Learn	PES role: assimilation of movement concepts	−0.811
	Develop	PES role: psychosocial development	−0.882
	Relax	PES role: recreational activities	0.287
	Tolerance	PES role: promotes tolerance	0.266
	Discrim	PES role: cultural discrimination	0.42

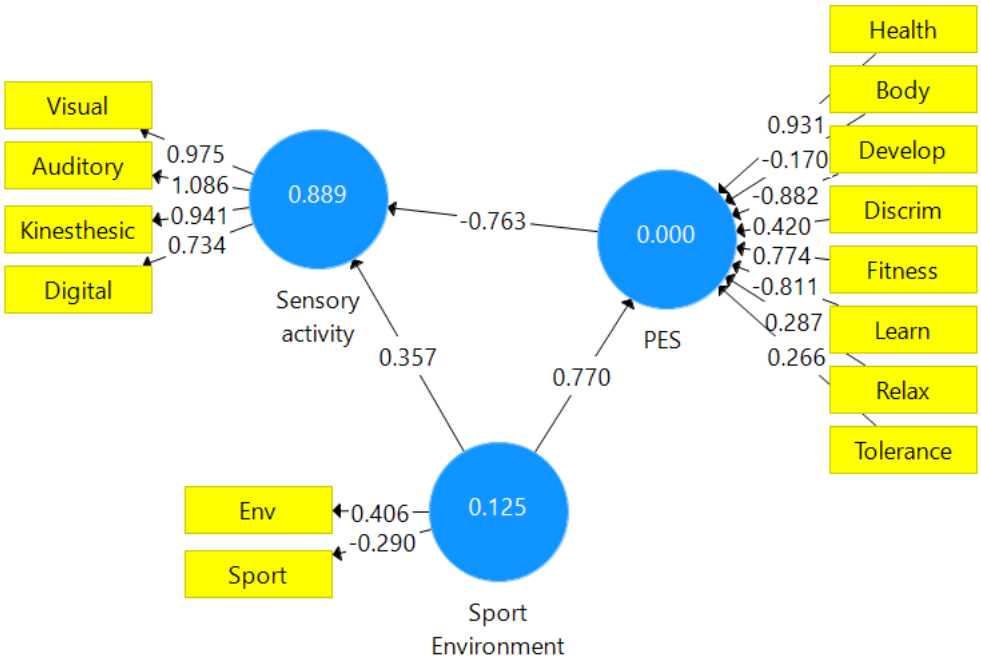

Figure 3. Cronbach's alpha coefficients and path analysis.

3.2.1. The Stage II Hypotheses of the Research Are

Hypothesis 2 (H2). *The students' preferences for the outdoor types of activity (Visual, Auditory, Kinesthesis, and Digital) do not depend on the students' environment provenience (rural or urban), but on the benefits that particular activity brings.*

Hypothesis 3 (H3). *The preference for different sports or outdoor activities has a strong and positive impact on PES outputs.*

As a result of the aforementioned questionnaire, based on the effectuated analysis, one does not see the environment the students are coming from, whether urban or rural, as a definitory factor in choosing a certain sport or a certain outdoor activity. The 4 sensory canals are a means for the students to make their choice regarding a certain outdoor activity based on their liking, their enjoyment of that particular action, and the actual perceptible feelings related to sensation [22].

Furthermore, the benefits taken out of these activities, such as communicating better, experimenting with different situations that require planning or organizational skills, experiencing different emotions through movement, etc., all have triggered needs for growth and personal development outside the routine (inside activities), actually in a new routine—that of nature [22].

It is already common knowledge that engaging in activities in the natural environment brings about quite a lot of health benefits, one of the first and most important ones being precisely the outside factor, the fresh air. Though it might be one of the most essential factors, it is completed by the students' willing to step out of their comfort zone and try different things, as the study results have provided. The students have scored very well in their sensory category, assimilating and implementing their perceptive skills in choosing their preferred outdoor activity.

3.2.2. Stage II Results

Construct Reliability and Validity—SmartPls software provides many tests that can be used to ensure a coherent analysis and interpretation of data and to assume the research outputs. For example, the consistency of our model was grounded on the validation steps provided in Table 3 [38,39]. All the considered variables present very high values for

composite reliability: Cronbach's alpha and rho_A (>0.7—the bottom value authorized), and average variance extracted (AVE) (>0.5—the bottom value approved), meaning that convergent validity can be assumed. These results empower us to believe that all our hypotheses are validated to different extents (Table 3, Figure 3).

Table 3. Validation steps/tests.

Variable	Cronbach's Alpha	Rho_A	Composite Reliability	Average Variance Extracted
	>0.7	**>0.7**	**>0.7**	**>0.5**
PES		1		
Sport and Environment	0.267	1		
Sensory Activity	0.968	0.984	0.969	0.889

The loading factors (LFs) for Sensory Activity latent constructs in Table 2 and Figure 3 enhance that all the items that form sensory activity are very well represented in the model. The visual, auditory, kinesthesis, and digital activities all have loading factors greater than 0.6, meaning that these 4 items evaluate very well student preferences for a different kind of activity.

The loading factors (LFs) for Sport and Environment latent constructs in Table 2 and Figure 3 are less than 0.6. The ENV (LF = 0.406) is important and has a positive influence on the PES role. Outdoor sports practiced in the natural environment have a greater impact on human health, fitness, and relaxation, than inside sports [39,40].

This could very well be a hypothesis proven by simple logic but based on the effectuated research and the scores the sample of 100 students have provided based on their sport or activity of choice, we can surely state that, while inside sports do also have their share of positive aspects, the outdoor activities engulf, through the 4 sensory canals experience, the best effects on human health, physical and psychological development and relaxation.

The type of sport has also a positive influence on the PES roles, but a smaller one (LF = 0.290). For a better model, the Sport and Environment latent constructs should contain some other subitems, such as: arrangements dedicated to each type of sport, integration of discoveries in the field of sports in its practice, and integration of technology facilities in sports training. These are students' suggestions to a question with an open answer. This is the reason that Cronbach's alpha has a small value (0.267) for this construct.

PES role is defined especially by Health (LF = 0.931), Fitness (LF = 0.774), Discrimination (LF = 0.420), and Tolerance (LF = 0.266). Students do not consider PES important for body shaping, personal development, and learning. We have to emphasize that this is a subjective opinion.

Discriminant Validity—Our model is statistically robust, as the Fornell–Larcker criterion and Heterotrait–Monotrait criteria are met because all values obtained are equal or less than 0.70 (Table 4) [39,40]:

Table 4. Discriminant validity.

		Fornell–Larcker Criterion		**Heterotrait–Monotrait Criterion**
Variable	**PES**	**Sport Environment**	**Sensory Activity**	**Sensory Activity**
PES				
Sport and Environment	0.700	0.353		0.398
Sensory Activity	−0.035	0.943	0.700	

The Path analysis presents the value below:

- Sports Environment → Sensory activity (0.945). The environment is important for students and has a positive influence on the PES role. Depending on the environment in which a sport is practiced, other types of senses are involved and students' preferences change.

- Sports Environment → PES (0.770). The outdoor sports, practiced in the natural environment have a greater impact on human health, fitness, and relaxation/recreation, than inside sports.
- PES → Sensory activity (−0.763). With a negative value, we may affirm that the role of PES does not influence the students' preference for a different kind of sensory activity. In other words, students consider PES important, no matter what the type of activity.

In Table 5 we may observe a strong positive correlation between the PES role and the environment, empowering H3 of our research. Outdoor sports are preferred by the students because of their positive influence on their physical and mental health. Another positive small correlation can be observed between the Sport and Environment and Sensory Activity. Outdoor sports need different sensory activities. Between PES and Sensory Activity, no correlation is presented. For students it is more important to practice sports than to choose a special type of sensory activity.

Table 5. Variable correlation.

	Latent Variable Correlation			R Square	R Square Adjusted	F Square	
Variable	**PES**	**Sport and Environment**	**Sensory Activity**			**PES**	**Sensory Activity**
Sensory Activity	−0.035	0.357	1	0.355	0.589		
Sport and Environment	0.770	1	0.357			1.456	0.572
PES	1	0.770	−0.035	0.593	0.589	0.373	

The steps presented in Tables 2–5 empower us to assume that our hypotheses are confirmed. The hypothesis tests (SRMR, d_ULS) also have higher estimates for the estimated model than for the saturated model. Thus, we may affirm that our model fits and that H1, H2, and H3 are accepted (Table 6). The standardized root means square residual (SRMR) has a value of less than 0.1, explaining a good fit [38–40]. d_ULS represents the squared Euclidean distance. Thus, our hypothesis is confirmed by a consistent model (Table 6).

Table 6. Model Fit.

Test	**Fit Summary**	
	Saturated Model	**Estimated Model**
SRMR	0.055	0.056
d_ULS	0.315	0.317

4. Discussion

After the survey results, the objectives have been fulfilled, and as such one can conclude that the outdoor activities from the perception systems point of view can be fitted according to the rank ordering method as follows: the activities included in module 3, centered on the dominant kinesthetic sensory canal, are in first place.

One notices that the majority of students favor a sensory canal, especially in stressful situations. It is important to say that they did not use exclusively a certain sensory canal, but they mainly had a preference and they identified it in selecting certain outdoor activities that would correspond to their needs. The effectuated outdoor activities proved the increase of efficacy in the functioning way of the psychological processes that depend on knowing the dominant representation system and on developing the accessibility of the representation system preferred by students. Knowing the dominant sensory system increases the possibility of knowing the students' preferences out of the four analyzed and numbered sensory systems. The practice has proved the necessity of diversifying the educational programs with outdoor education-specific activities according to the perception

mechanisms, resulting in the attraction of a higher number of students and avoiding the monotony among them.

We have also highlighted the formative potential of the outdoor activities bearing in mind the area of experimented methods ranging from using specific outdoor means to organizing activities depending on the main dominant sensory canal. Finalizing this study allows us to draft the following recommendations:

- Introducing in the curricular aria a program that offers outdoor education activities for students [41,42];
- As a particularity, the outdoor means must be selected depending on the dominant sensory canal of the student group and must be effectuated in real conditions benefiting from the best and most interesting "didactical material—the natural ecosystems or the artificial ones with their terrestrial or aquatic habitats;
- Selecting the specific means that must comprise the improvement of motile skills involved in these types of activities;
- Within the communication sessions, scientific seminars and other manifestations of this type, approaching an outdoor activity is thematic to accomplish an education from the natural value point of view at a national level.
- Sports Environment → Sensory activity (0.945) For students, the environment is crucial. the PES role, and has a favorable impact on it. Other senses may be engaged, and students' choices may change, depending on the environment in which a sport is played.
- Sports Environment → PES (0.770) In comparison to indoor sports, outdoor sports that are played in a natural environment have a stronger positive impact on a person's health, fitness, and leisure time.
- PES → Sensory activity (−0.763) With a negative result, we can state with confidence that PES's function has no influence on pupils' preferences for particular sensory activities. In other words, regardless of the activity, students think PES is important.

5. Conclusions

At the end of this research, we would like to accentuate the fundamental idea behind the chosen theme, which is that outdoor activities have a great and positive impact on students' physical and psychological development [2]. We have learned that the majority of students involved in the research have used their preferred sensory systems—visual, auditory, kinesthetic, and digital—in accordance with their correspondent needs when choosing a favorite outdoor activity [2]. Based on this, the research has proved that one needs to further diversify educational programs with outdoor education activities, to achieve a higher number of students involved in such activities and to keep away from day-to-day routine and dullness [21,26,27,30].

We also observed that the students' preferences for the outdoor types of activity do not depend on the students' environment provenience (rural or urban), but on the benefits that particular activity brings. It also depends on the student's limits in effectuating it and has a strong and positive impact on PES outputs [3].

The research has organized activities based on the dominant sensory canal by using specific outdoor means of the undertaking, using the scene in real conditions; these conditions were terrestrial or using water. This has led to a list of recommendations we think are suitable for the upcoming generations, such as implementing in the curricula a program that comprises different means of outdoor education, sorting out the best ways that motile skills can be encapsulated in the different types of activities and organizing communication sessions, seminars and other types of theoretical activities based on the notion of outdoor education, which can further extend and persuade the faculty and the students to perceive education from the natural point of view as one of the most rewarding types of education for the future [18,30].

The confirmation of the three hypotheses leads us to state that the application of the online questionnaire in the direction of the specific and relevant indicators of the research

process makes it possible to highlight the benefits provided by different sports and influence the type of activity (visual, auditory, kinesthetic, and digital).

Limitations: In this paper, there are still some limitations:

Our study employed a small number of subjects and expanding research could target many geographical areas and universities' cycles. This was preliminary research that will be further extended to national level in future research. Another objective of our next study is to evaluate what kind of abilities can be enforced and taught through different kinds of activity (visual, auditory, kinesthetic and digital).

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Informed Consent Statement: Ethical review and approval were waived for this study, due to the fact that survey was anonymous, and the respondents agreed that researchers use their answers/opinions for analysis.

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The role of chess in the development of children-parents' perspectives

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Introduction: The study examines the role of chess in the development of children from the perspectives of parents. The research focused on analyzing the parents' perceptions about chess's role in their children's development, on finding out how the perception of parents differs depending on whether they know how to play chess or not, and on outlining the profile of the parents whose children play chess.The study was conducted in Romania.

Methods: In order to conduct the study, a quantitative research method was used, while having as a research instrument a non-standardized questionnaire. The questionnaire was applied to parents of chess-playing children who are members of chess clubs from Romania. The sample of the study comprises 774 respondents.

Results: The results of our research showed that parents are of the opinion that chess helps children develop their cognitive abilities, their character and their competitive spirit. Most of the parents focused on highlighting the positive effects of chess on the development of their children. Parents also considered that chess helped their children develop positive emotions and helped them overcome negative emotions. The results revealed differences between the opinions of parents depending on whether they know how to play chess or not. Thus, parents who do know how to play chess were more likely to focus on the positive effects of the game on the development of their children, and those who know how to play chess were also more satisfied with their children's accumulated knowledge following chess lessons.

Discussion: Findings extend our understanding of how parents perceive the way chess influences the development of their children, it offered us a perspective on the perceived benefits of chess, benefits which should be further analyzed in order to identify under what circumstances chess could be introduced in the school curriculum.

KEYWORDS

chess, parents, children, benefits, development

1. Introduction

In post-modern societies, concerns for the quality of offspring are widespread among parents compared to other macrosocial contexts. Nowadays, research related to optimal child development is a traditional and yet topical, interdisciplinary field, concerned with the internal and external factors that help children develop and improve their ability to become successful youth and adults, to conduct to a successful life.

Regarding the external factors, we can underline that social environment comprises important aspects that support the understanding of child development process. Theories of human development that take into account the social-cultural influences on child development process are connected with authors like Vygotsky (1978) and Bronfenbrenner (1979). We consider that these theories are adequate to analyze our topic, because parents shape the child's first developmental environment, characterized by significant interactions and influences, over a long period of time.

According to sociocultural theory of child development of Vygotsky (1978), human learning is primarily a social process and the initiation of human intelligence takes place in society or culture. Vygotsky (1978) considers that cultural development (as opposed to natural development) is associated with language and reasoning capability. This theory focus on the interaction between individuals and the culture in their environment, interaction which exerts an important role in children's cognitive development. In perspective of Vygotsky (1978), the learning process can be synthetized as follow: in the first phase children interact with others, then they integrate the obtained data from the social interaction into their mental structure.

Chess, beyond the rules that it implies and the game strategies used, is a continuous interaction between the two players, as well as with the immediate environment in which the competition is taking place.

The ecological systems theory, developed by Bronfenbrenner (1979), focuses and underlines the importance of the environment in children's lives and development, stressing person-context interrelatedness. Child development and parent–child interactions (microsystem) are embedded in a mesosystem of a broader contexts (nuclear family, school, peers, neighborhood, and so on). Family life shapes and is shaped by the exosystem influences (extended family, workplace, mass media, health services, and neighbors). The macrosystem of culture, laws, values, and social classes shape and determine the immediate context of a child, the goals that parent have for their children, and the practices which they choose to achieve these goals.

During the process of child development, an important role is played by the parents, as agents of primary socialization. Parenting is a multidimensional concept that refers to how individuals raise their children, which includes attitudes (cognitions, feelings, and behavioral intentions) and practices regarding child-rearing. Parenting is a source of ambivalent feelings and experiences. Sometimes it is a source of deep satisfaction for both parent and child, and other times the quotidian responsibilities of being a parent generates inter-roles conflicts, stress, frustrations, and negative overwhelming emotions. But the crucial importance of parenting is widespread, parenting decisions and practices influence to a great extent the child's outcomes.

Parents' beliefs in general and their knowledge about child development in particular could guide their interactions with children and for their children. And they might be more likely to create an environment that is appropriate to develop their children's emerging abilities. The analysis of parents' perceptions about adequate activities for child development, such as chess, offers the opportunity to contour parents' thoughts about desirable outcomes for children, as well as their role as parents. Parents who consider a particular activity to be important for child development may be more likely to seek out information about that area, make decisions, and act accordingly. Furthermore, the motivation of conducting such a study also comes from the lack of research conducted in Romania regarding the effect of chess at the level of children' development. Thus, the authors believe that chess is a sport, because it manages to attract every shred of individual capacity and power, both physical and psychological, from and individual and ultimately involves competition. Moreover, chess is based on long-term research and analysis of principles that govern the process of finding deep moves that often hide complex reasoning, and chess could also be seen as an art, because it presents the intuition that it is a decision-making factor, this factor intervening when two moves have similar and sometimes contradictory assessments, being necessary for decision-making.

Parental ethnotheories are shared beliefs about the goals of child development and the socialization practices that will achieve these goals, according to Greenfield and Keller (2004). They generate specific parenting behaviors that, in turn, contribute to create the cultural adult. These ideas about childcare practices, as defined by a specific cultural environment, are related to specific developmental goals: for example, there are ethnotheories about sibling relationships (Kapısız and Sieben, 2022), about healthy eating (Srivastava et al., 2018), or about play and learning (Avornyo and Baker, 2022). Parental ethnotheories link socialization practices to cultural values and they transmit the socialization agendas of one generation to the next.

Parental ethnotheories constitute the third component of the child's developmental niche (Super and Harkness, 1986). The other dimensions are: physical and social settings, and also childcare customs and practices.

Harkness and Super (1996) consider that these culturally constructed ideas are influenced by the larger environments in which families live, and they are important in parents' decision making process regarding children's settings of daily life as well as customs of care.

As part of a system of ideas and practices that reflect wider cultural models, parents' cultural beliefs about a particular activity—such as playing chess—serve as guide to parenting practices, where playing chess messages are conveyed and experienced and, ultimately, generate children's developmental outcomes. In other words, encouraging and supporting children to learn chess is a practice that can be shaped by parental ethnotheories, with the aim of developing some specific traits especially in cognitive, socio-emotional, and moral areas.

In the scientific literature, the list of domains of child development can contain several components. For example, in the contents of the Cambridge Encyclopedia of Child Development, published by Hopkins et al. (2017), there are the following domains: physical, perceptual and cognitive, language and communication, and social, emotional, and moral development. The same areas of child development are reflected in the chapters of The Sage Handbook of Developmental Psychology and Early Childhood Education written by Whitebread et al. (2019) and in the book written by Keenan et al. (2016). In all child development domains, parents play an important role, as they transmit specific cultural beliefs, preferences, behavioral patterns, make decisions, and offer social support for different activities.

Playing games with rules begins in late preschool and develops through school, according to Vygotsky (1978), and every game with rules constructs an imaginary situation. The game of chess, in particular, creates imaginary contexts because the game is governed by certain rules (for example, each piece can only move in a specific

way) and a large number of possibilities for action are excluded. Imaginative play generates learning opportunities that could contribute to the child's further development.

Research studies on chess have considered different categories of participants in collecting data. Some researchers have aimed to study specific age groups such as: preschool children (6 year old children—Gunes and Tugrul, 2017) primary school children (Bilalić et al., 2007b), adolescents and high school players (Melamed and Berman, 1981; Atashafrouz, 2019; Afshari et al., 2022), college players (Subia et al., 2019), adults (Blanch, 2018), and elderly people (Vale et al., 2018).

Others have done research on chess players with different performance levels, with focus on amateur/novice (Blanch and Llaveria, 2021), on professional players/experts (adolescent elite chess players—De Bruin et al., 2007; adult international chess grandmaster—Fuentes-García et al., 2022) or comparative studies on these categories, that provide more convincing evidences that chess master players are different from novice players in brain functional organization of local connections and global topologies (Song et al., 2022). This type of research focuses on the analysis of the conditions that lead to chess performance, including certain psycho-social and physical characteristics of the player, which we will detail later.

The game of chess was also described in several studies as a tool used in intervention programs for improving the outcomes and the quality of life for specific categories of people, especially vulnerable ones. Some studies report the results from chess training programs implemented in educational settings (Jerrim et al., 2016; Jankovic and Novak, 2019), or the effectiveness of playing chess as a treatment option for children with ADHD (ElDaou and El-Shamieh, 2015; Blasco-Fontecilla et al., 2016). This type of intervention programs was also used with the aim of improving general cognitive status, attention, processing speed, and executive functions in a sample of semi-institutionalized and institutionalized senior people (Cibeira et al., 2021), for the elderly with dementia (Wahyu Laksono et al., 2019), or to evaluate the benefits of chess in mathematics lessons for children with learning disabilities (Scholz et al., 2008).

Some researchers have examined the subjective perspective toward the benefits of chess, such as teachers' perceptions; for example, Chitiyo et al. (2021) investigated the experiences and perceptions of teachers who used chess during the instruction process, and they found out that their participants have largely positive perception regarding chess and they perceived consistent benefits of chess among their students. Another type of perception consists in students' perceived benefits of chess, explored by Chitiyo et al. (2023), who also examined how these benefits differ by gender and grade level.

As far as it is known, no previous study has analyzed the parents' perceptions, beliefs, or ethnotheories about the role of playing chess in child development and our study aims to accomplish that.

At the level of common sense knowledge, there is a number of assumptions related to the benefits of chess on child development, such as: "Chess increases mathematical abilities"; "Chess improves academic performance"; "Playing chess makes kids smarter"; and so on. In academic literature, there are numerous studies investigating the preconditions for learning this game and the effects produced by playing chess on diverse children' and adults' development domains.

Chess is considered a sport characterized by high psychophysiological demands, because it requires long training durations, games, and tournaments (Fuentes-García et al., 2020). These could lead to mental, emotional, and physical stress, therefore, it is not a game for everyone. To answer the question what personality characteristics have children who decide to take up chess as a hobby, Bilalić et al. (2007a) have applied the Big Five Questionnaire for Children on 269 primary school children, and they discovered that" children who are less sensitive toward others, more prone to arguing and less to avoiding conflicts (Agreeableness), more energetic (Energy/extraversion), and more open to new experience (Intellect/openness) are more likely to be attracted to the game of chess" (p. 908). Personality traits seems to play an important role only in choosing the chess environment, and not in determining the extent of chess skill development.

Adult chess players have developed some specific features, such as unconventional thinking and orderliness, being more introverted, more intuitive, highly competitive, and more suspicious (Kelly, 1985; Avni et al., 1987) than the general population.

Numerous benefits of playing chess have been researched over time. Several studies are demonstrating the importance of playing chess in developing different skills. In the next section, we will synthetize these findings, accordingly with the previous presented list of child development areas (physical, perceptual and cognitive, language and communication, social, emotional, moral development).

In quotidian common knowledge, chess is considered to be a non-active sport, which needs no physical activities or training, and static chess training is associated with sedentary lifestyle. Although chess does not play a role in the physical development of children, nevertheless a connection between physical exercises and chess can be observed. More precisely, there are studies that investigate the influence that physical condition of chess players has on the performance obtained in competitions. Fornal-Urban et al. (2009) observed that being physically fit is good for chess performance and that the young chess players taking part in their study showed higher level of physical fitness in comparison to their peers from population. They suggest that in the training process of the chess players, more attention should be paid to their fitness preparation, and the tournaments organizers should provide facilities for diverse active forms of recreation. Chess skills alone are not sufficient for performing in chess tournaments, they need to be completed with an adequate physical fitness, in order to endure exhausting chess plays (Golf, 2015; Parra et al., 2020). Thus, we can conclude that combining physical and cognitive training of the chess players might result in a mutual enhancement of both aspects.

A great amount of the perceived benefits of chess underlines cognitive benefits for younger children (Mefoh Philip and Ugwu Lawrence, 2014). For example, Sagar (2020), on the blog named Mind Mentorz, has synthetized the following benefits of learning or playing chess: focus (observation and concentration), analytical observation (finding the pros and cons of various actions), visualization (imagining a sequence of actions before its implementation), foresightedness (aware of or think about the consequences before an action), analytical reasoning (logical vs. impulsive decision making), abstract thinking (consider the bigger picture), planning (develop long term goals and bring them about), and ability to handle multiple considerations simultaneously (weighing various factors at a time). This type of information source can be accessed by parents interested in the game of chess and the development of their children.

Several studies have examined if playing chess exerts a positive influence in developing cognitive abilities and academic performance,

to improved mathematical abilities, to solve problems. For example, in an experimental study, Kazemi et al. (2012) demonstrated the correlation between chess and mathematical ability, in primary-and secondary-level male students in Iran. Their results underline that those who played chess scored significantly higher on their meta-cognitive abilities and showed higher problem-solving skills in math. Tachie and Ramathe (2022) conducted a study which concludes that chess training improves both teachers' and learners' application of metacognition in supporting learners' performance in mathematics. Blanch (2022) suggests that schoolchildren who learn or play chess appear to experience a better development of cognitive abilities or bearing a larger improvement in academic performance than schoolchildren who do not learn or play chess.

Counterintuitive findings that there is no evidence that teaching children chess improved their math ability are underlined in other studies. Sala and Gobet (2017) suggest that the effects (if any) of chess instruction, when rigorously tested, appear to be minimal on mathematical abilities and certainly too limited to provide any educational advantage over the traditional instructional methods. Also, no differences were found with respect to metacognitive ability. Another study indicated no correlation between chess playing and mathematical abilities, nor within reading or science capabilities of the students (Jerrim et al., 2018). Their main criticisms regarding the studies which found positive effects of chess on cognitive outcomes consists in the idea that these empirical investigations have not employed rigorous methods in terms of their research design and statistical analyses.

The connection between intelligence and chess was analyzed by Bilalić et al. (2007b) from another perspective, examining the answer to the question whether chess requires intelligence for learning to play it. They have tested children who had recently started to play chess to see how intelligence and practice interact at the beginning of the chess skill acquisition process. Their conclusion is that the role of intelligence in the acquisition of chess skill should not be assessed separately from other relevant factors (e.g., practice, experience, age, and gender). To what extent intelligence, practice, and motivation contribute to chess performance in young children who had just started playing chess was also examined in the study of De Bruin et al. (2014). They discovered that IQ and practice independently predicted chess performance on a chess test at the end of the course. Motivation influenced performance indirectly, by moderating the amount of practice that was undertaken. They concluded that, at the early stages of expertise development, IQ, and motivation influence chess performance.

The influence of learning and practicing chess on executive functions in childhood was the topic of interest in the research designed by Grau-Pérez and Moreira (2017). Executive functions were defined as those cognitive activities that are fundamental to goal-directed behavior and appropriate social conduct, such as: decision making, concept formation, abstract reasoning, working memory, processing speed, interference control, inhibition of impulses, planning, evaluation of errors, cognitive flexibility, shifting focus, organizing, attentional and behavioral control, having access to a complex environment that includes appropriate learning materials, and stimulation in the form of experiences. They discovered that highly complex games like chess can favor the development of planning and flexibility (two executive functions) in childhood.

Waters et al. (2002) have investigated whether one component of intelligence (visual memory ability) was associated with chess skill in a sample of adult chess players. Their data show that visual memory ability did not correlate with chess skill.

Chess can also trigger the creative function in our brain. This game is a challenge to the brain and stimulates both the left and the right brain hemispheres, developing both logical and creative thinking and originality. Sigirtmac (2016) conducted a study to investigate whether chess training has any impacts on creativity and theory of mind skills of children and the results show that the scores of children who had chess training were found to be higher than scores of other children both in creative thinking and theory of mind tests, and the difference between scores of these children were also found to be statistically significant.

Benefits of playing chess have been proven in diverse dimensions of children's development. One particular are is the development of linguistic intelligence. Joseph et al. (2021) aimed to find an answer to the question: does playing chess improve reading, writing, speaking, and listening skill? And their results indicate significant improvements in verbal reasoning, which is a component of linguistic intelligence.

Gao et al. (2021) have analyzed the link between chess skills and academic performance in primary school students and ascertained that the impact of chess skill on language and mathematics achievement appears to be actually mediated by fluid intelligence. As a feature of cognitive functioning, fluid intelligence is the ability to think speedily about new situations, to solve unfamiliar problems by using critical thinking, flexibly, and logical reasoning.

The literature on benefits of playing chess has provided some useful insights into understanding the emotional development of players. Chess players have differentiated from the general population through higher emotional stability and the ability to manage emotions (Avni et al., 1987). The same idea is confirmed by Aciego et al. (2012), who found that chess improves, besides cognitive abilities, coping and problem-solving capacity, also socio-affective development of children and adolescents who practice it.

Chess training as an intervention method, used by Jamshidi (2021) in her semi-experimental research in Iran, has improved emotional intelligence and its components in fourth to sixth grade of elementary school female students with math disorders. The results showed that chess also improves trust in problem solving and personal control in the participants.

Likewise, chess training program might reduce the level of risk aversion. Islam et al. (2021) has found that children in primary school who were taught the game of chess, and played regularly, were more likely to be less risk averse than their peers. These results are explained in connection with the exposure to win/loss situations and competition, as well as with teaching children the potential benefits of strategic risk-taking. Such programs are an adequate way to help young people deal with risk and reward later in life.

Chess is also associated with emotion regulation, which is a term that consists in the ability to process, influence, and control our emotional state. Blanch and Llaveria (2021) pointed out that chess players scored higher in expressive suppression compared with the general population. Expressive suppression is a form of emotion regulation that involves conscious, voluntary inhibition of the outward manifestation of an ongoing emotional response (Gross, 2013).

Aside from developing cognitive skills, chess also develops children's social skills. A benefit for children of playing games with rules consists in developing social aspects, such as taking turns, learning fair play, self-respect and respect for others, understanding others'

perspectives, and developing empathy. Joseph et al. (2016) underline the idea that chess might serves as a bridge in educational contexts, bringing together children of different ages, races, and genders in an activity they can all enjoy. Chess might help build individual friendships and team cohesion when children compete against other schools.

Negative aspects can also be observed in the dynamics within chess communities. For example, Puddephatt (2008) identifies some organizational mechanisms that operate in the world of chess, such as: isolation from competing social spheres; encapsulation within a symbolic status structure; a collective feeling of elite status; trials of worthiness; and prestructured ritual.

According to Mathieson (2003), moral maturity consists of seven elements: moral agency, harnessing cognitive ability, harnessing emotional resources, using social skill, using principles, respecting others, and developing a sense of meaning.

Chess players learn early that every move and decision comes with a consequence. Tanajyan et al. (2021) show, in their study, that chess promotes the ability to foresee, influencing the situation.

Dealing with adverse circumstances over time, chess players develop their maturity, patience, and composure. In their innovative study where students engaged in self-directed activity goals during their holiday, Tam et al. (2023) found that students who played chess experienced improved attitudes toward homework and perceived that learning chess resulted in improvements within their observation and patience skills.

These skills that are developed by playing chess could provide chess players a certain advantage in facing quotidian challenges.

In the literature, the studies are, rather, oriented toward the discovery of the advantages of playing chess. The negative impact on the players, on their social dynamics is less explored. Our study aims to present the parents' perception of chess as balanced as possible, investigating both the benefits and the disadvantages perceived by them.

2. Materials and methods

2.1. Research questions

In this paper, we explore parents' beliefs about the importance of playing chess in children's development. The study was conducted in Romania, and the motivation for conducting such a study is represented by the fact that research on this matter is poor in Romania and by the fact that chess has gained importance over the years and the interest for analyzing its effects on the development of children increased worldwide.

> RQ1: What are the parents' perceptions about chess's role in their children's development?
>
> RQ2: How does parents' perception differ depending on whether or not they know how to play chess?
>
> RQ3: What is the profile of the children's parents who play chess?

2.2. Data collection method

We conducted an online survey to determine parents' perceptions of the advantages and disadvantages for their children to play chess. Data were collected through an online survey through the free application Google forms in 2021. The population of the study is represented by parents of chess-playing children who are members of chess clubs from Romania (from all the counties). It was selected in a non-probabilistic way, and the questionnaire link was sent by email to all members of chess clubs, and 774 responses were collected. The survey took approximately 30 min. The research received the approval of the Ethics Commission in social research from Transilvania University of Brasov, Romania.

2.3. Sample

The questionnaire was applied to 774 respondents. The respondents have an average of 42 years (M = 41.8, SD = 7.1), and the majority of respondents are from the urban area, (87.3%), have tertiary education level (58.6%) and they know how to play chess (66.7%). Most of them have a medium-high level of income. Only a third of them are members of chess clubs (27.9%). The characteristics of the respondents are presented in Table 1.

2.4. The research instrument

A non-standardized questionnaire was used with items related to the three research questions. The questionnaire was built by the authors of this paper and it was presented to the parents in Romanian. In the present study, only a part of the data is presented. For the first research question, the following items were included: q1: The first word associated with the term chess (open-ended); q9, q10: the degree to which the chess has an impact on the players (positive and negative aspects that are presented in Table 2; 4 = very high degree, 1-very low

TABLE 1 Sociodemographic characteristic of respondents (*N*=774).

	Category	Count	Percentage
Residential environment	Rural	98	12.7%
	Urban	676	87.3%
Highest academic degree	Primary education	2	0.3%
	Secondary education	99	12.8%
	Tertiary education	451	58.3%
	Postgraduate education	218	28.2%
	NA	4	0.5
The income level-self-perception	Very low	3	0.4%
	Low	33	4.3%
	Medium	492	63.6%
	High	220	28.4%
	Very high	14	1.8%
	NA	12	1.6%
Playing chess	Yes	516	66.7%
	No	258	33.3%
Member in chess club (during the life)	Yes	216	27.9%
	No	558	72.1%

TABLE 2 Positive and negative impact on the chess–perceptions of the parents.

Positive aspects (q9; 4=very high degree, 1=very low degree)	*M*	SD	Negative aspects (q10; 4=very high degree, 1=very low degree)	*M*	SD
School performance	3.35	0.680	Withdrawal and decreased sociability	1.37	0.584
Competitive spirit	3.48	0.657	Decreased mental flexibility (difficulty thinking outside the box)	1.23	0.472
Spirit of cooperation	3.08	0.775	Decreased self-esteem as a result of setting negatives that are too high	1.40	0.582
Communication skills	3.02	0.779	Deprivation of more fun age-appropriate activities	1.79	0.777
Relationship skills	3.31	0.705	Atrophy of emotional capacities	1.20	0.459
Mental abilities	3.82	0.401	Atrophy of other senses to the negative of the visual one	1.19	0.448
Emotional capacities	3.39	0.652	Disinterest in other areas of life	1.43	0.620
Strong character	3.42	0.654	Infatuation and selfishness	1.36	0.621
Self-discipline	3.35	0.722	Mental fatigue as a result of excessive egati exposure	1.82	0.864
Ability to make quick decisions	3.25	0.825	Addiction to adrenaline and competition	1.36	0.644
High self-esteem	3.27	0.738	Robotization in social interactions	1.19	0.438
Intuition	3.38	0.747	Negative impact on mental health	1.10	0.370
			Increasing aggression	1.14	0.409
Index	3.34	0.40	Index	1.36	0.38

degree); q18: the degree to which chess can help children to pass over the negative emotions (5 = very high degree, 1-very low degree); q19: types of negative emotions that can be overcome through chess (the fear of the unknown, the fear of expressing oneself, the impatience); q20: the degree to which chess could help children to develop positive emotions (5 = very high degree, 1-very low degree); q21: if the children made new friends in chess club (yes, no); q27: the degree to which the children who play chess are different from those who do not do this (5 = very high degree, 1-very low degree); q28: the words that describe best the children who play chess (open-ended); and q41: Preconceptions regarding children who play chess (disadvantages; open-ended). The research instrument can be found in Appendix 1.

For the second research question, all the results regarding research question 1 were compared to two categories of parents: those who know to play chess and those who do not know.

For the third research question, the following items were used: q8: The reasons the children take chess lessons (open-ended); q23: If the parents made friends at the chess clubs (yes/no); q25: If they feel that they are part of a community among other parents (yes, no); q29: the degree to which they feel they are different from other parents who have children who do not play chess (5 = very high degree, 1 = very low degree); q30: Describing the parents who have children at chess classes (open-ended); q44: The degree to which the competitions are essential for them (5 = very high degree, 1 = very low degree); q51: self-perception of the parent's income level, who have children that play chess (5 = very high income, 1 = very low income); and q52: self-perception of the parent's education, who have children that play chess (intellectual, workers, and both categories) and also sociodemographic items (Table 1). Furthermore, considering the validity of the research, the authors took into account the theoretical information from the literature regarding the development of a questionnaire. The authors of the paper configured the dimensions, and operationalized the concepts in accordance with the theoretical approaches identified at the current stage of the research. Moreover, the questionnaire was pre-tested before disseminating it, in order to guarantee the validity of the instrument. Thus, the questionnaire was applied to 50 respondents in the pre-testing stage.

2.5. Data analysis

The data were analyzed using IBM SPSS Statistics (version 23). Answers to open-ended questions were analyzed using content analysis. The answers were coded and merged into some categories presented in Appendix 1. For close-ended questions were used descriptive statistics (percentages, mean, and standard deviation). Comparisons were made depending on whether parents knew or not to play chess with the Independent Samples *t*-Test. For the variables, q9: positive aspects and q10: negative aspects that were complexly measured through several indicators, indexes Mesesan-Schmitz and Coman (2020) were made to measure the information synthetically.

3. Results

3.1. RQ1: what are the parents' perceptions about chess's role in their children's development?

Parents consider there are many benefits of playing chess. At question q1, the first word associated with the term chess, most of the respondents associate chess with cognitive abilities (55.8%) as cognitive skills (e.g., mathematical skills, analysis and strategy, anticipation, training the mind, attention, self-control, mental calculation, concentration, neural connections, creativity, complexity, intuitive thinking, intelligence/high IQ, and memory). Those advantages are the main reason why parents want their children to take chess courses (Appendix 2, Table 1A). Parents believe that their children (who play chess) are talented people 4.5% and special people 3.6%, more intelligent and smarter than others (24.4%), capable of

paying attention and concentrating (6.2%), persevering people 3.6%, motivated to study, to learn new things 2.6%, good at logical games/logical skills 3.1% (Appendix 2, Table 1B). It is observed that parents pay attention to cognitive abilities. 46% declared their children are different from those who do not play chess through cognitive abilities and 31% through character traits.

These results are also confirmed by the answers for q9. At this question, the parents gave the highest score to the development of cognitive abilities (M = 3.82, SD = 4.01) as a positive aspect. In addition, they also mentioned character traits such as strong character (M = 3.42, SD = 0.65), and competitive spirit (M = 3.48, SD = 0.65).

Analyzing the answers of the q10 (Table 2), results that the parent does not perceive any risk for their children (M = 1.36, SD = 0.38). However, they only see positive aspects (M = 3.31, SD = 0.8). Only a small part of them considers that the children can sometimes suffer from the deprivation of more fun, age-appropriate activities (M = 1.79, SD = 0.77) or mental fatigue due to exposure to excessive stress (M = 1.82, SD = 0.86). At the open-ended q41, parents declared that there is some possible risk for the children, seen more as preconceptions of others (Appendix 2, Table 1C). The persons who play chess do not do sport and are predisposed to sedentarism (5%). They do not develop social abilities (7.4%) and develop arrogance and individualism. Their social life is placed in a closed circle. Chess is the sport of misfits, antisocials, "nerds," and weird/individualists/autists. They need to spend much free time preparing for competitions and do not have sufficient time for homework. In addition, chess players have no prospects after junior ageand they do not receive sufficient financial incentives. There is the risk that the children do only this (play chess) and nothing else age specific. All these results are presented in Appendix 1. Even if the parent did not associate chess with social abilities, the results of question q21, 84.6%, answered that the children succeeded in making new friends (Table 3). Also, parents perceived that chess could help their children develop positive emotions (M = 4.38, SD = 0.78) and overcome negative emotions (M = 4.20, SD = 0.84), especially impatience (41.6%; Table 3).

3.2. RQ2: how does parents' perception differ depending on whether or not they know how to play chess?

There are some differences in perception between parents who know whether to play chess or not. The parents who know chess give higher scores to the impact of chess on positive aspects [Appendix 2, Table 2A; M1 = 3.37, SD1 = 0.39; M2 = 3.20, SD2 = 0.38; $t(773) = 5.79$. $p < 0.001$], especially when it comes to the competitive spirit, spirit of cooperation, mental abilities, emotional capacities, strong character, self-discipline, ability to make quick decisions, high self-esteem, and intuition. The same parents consider in higher degree that chess helps the children to develop positive emotions [q20; $t(772) = 3.63$; $p < 0.001$] and helps the children to overcome the negative emotions (q18), [$t(772) = 2.96$; $p < 0.001$; M1 = 4.24, SD1 = 0.80; M2 = 4.38, SD2 = 0.78]. There are no differences regarding negative aspects {M1 = 1.30, SD1 = 0.41; M2 = 1.34, SD2 = 0.31; [$t(651) = 0.93$. $p < 0.001$]}. Those who know how to play chess consider to a higher degree that children can develop an addiction to adrenaline from competition (M1 = 1.41, SD1 = 0.67; M2 = 1.27, SD2 = 0.56) or that chess can have a negative impact on mental health (M1 = 1.12, SD1 = 0.41; M2 = 1.05, SD2 = 0.24). Moreover, our results also showed that compared to parents who do not know how to play chess, parents who know how to play chess believe to a greater extent that chess influences and promotes the development of strong character in children [q9; $t(761) = 5.117$, $p < 0.05$; M1 = 3.50, SD1 = 0.62; M2 = 3.25, SD2 = 0.68; Table 4].

Furthermore, our results also showed that parents who play chess are more satisfied with the amount of knowledge their children have acquired during the courses, than parents who do not know how to play chess. In other words, the average of people who know how to play and are satisfied with the knowledge their children have from chess lessons is higher than the average of people who do not know how to play chess [q11; $t(772) = 2.096$, $p < 0.05$; M1 = 4.07, SD1 = 0.85; M2 = 3.93, SD2 = 0.79; Table 5].

3.3. RQ3: what is the profile of the children's parents who play chess?

Parents are persons with a medium-high income with at least a bachelor's degree. Most of them knew to play chess, and a third was chess club members. They made friends with other club members and interacted with them. There are people for whom competition and the development of cognitive abilities are the primary concerns. Their self-perception is that they are somehow different, they are more than others involved in children's education (11.9%), pay attention to the teaching (4.4%), and they are open minded (3.6%), Willing to offer in advance and get involved in the children's activity, financially (7.2%), breathe (7.1%), intelligent (4.7%), ordinary (3.6%), and responsible 11.5% (Appendix 2, Table 1D; Table 6).

4. Discussion and conclusion

In this study, we analyzed Romanian parents' perception about the role of chess in the development of their children. The study was conducted in Romania, and during our research we were interested in finding out the parents' perspectives about the way chess influences the development of their children, in finding out if there are any differences in the parents' opinions depending on whether they know how to play chess or not, and we were interesting in gathering information about the profile of the children's parents who play chess.

The results of our research showed that parents are of the opinion that chess helps children develop their cognitive abilities, their character and their competitive spirit. From this point of view, our research is in line with a previous study (Sagar, 2020), which showed the cognitive benefits that chess has on children. Most of the parents focused on highlighting only the positive influence of chess on the development of their children, and those who also mentioned the negatives aspects of playing chess referred to the idea that children who play chess could be deprived of other fun activities, or that they could experience fatigue due to the stress created by the game.

In the context of the positive effects of chess, our research is in line with a previous study (Aciego et al., 2012) which highlighted the positive effects of chess on the socio-affective development of children and adolescents. In this regard, our results showed that, parents considered that chess helped their children develop positive emotions and helped them overcome negative emotions by teaching them how

TABLE 3 The impact of the chess—perceptions of the parents.

Positive aspects (5=very high degree, 1=very low degree)	Negative aspects (5=very high degree, 1=very low degree)
Positive aspects index	Negative aspects index
M = 3.34, SD = 0.40	M = 1.36, SD = 0.38
Q20: Chess helps the children to develop positive emotions M = 4.38, SD = 0.78	Q18: Chess helps the children to overcome the negative emotions M = 4.20, SD = 0.84
	• The fear of the unknown 27.3%
	• The fear of expressing oneself 25.6%
	• The impatience 41.6%
	• Another 5.6%
Q1. The chess is associated with the development of:	Q41: Preconceptions
55.8% cognitive abilities	• The chess community is not very visible/it is not visible in the mass media/it cannot be watched on TV because it takes too long 11.9%
	• Reduced physical abilities/predisposition to sedentarism 5.0%
	• Financial rewards reduced/not commensurate with investments 3.5%
	• Arrogance 2.3%
	• That it is the sport of misfits, antisocials, "nerds," and weird/individualists/autists 7.4%
	• That they are introverts 2.2%
	• Poor communication 1.7%
	• Individualist 1.9%
	• Lack of money 3.1%
	• Lack of horizons after finishing junior studies 1.3%
	• Takes up too much free time for preparation 1.6%
Q28: The children are different from those who do not play chess	
• Cognitive abilities	
• Good at logic games/logical skills 3.1%	
• Able to pay attention/concentrate 6.2%	
• Smarter/intelligent than the rest	
• 24.4%	
• Motivated to study, to learn new things 2.6%	
• Character traits	
• Ambitious 2.6%	
• Curious 2.2%	
• Responsible 2.3%	
• Persevering 3.6%	

to become patient. Furthermore, when discussing the perceptions of parents about the effects of playing chess, an important matter that should be taken into consideration is the matter of parental support. Thus, parents of children who play chess should receive support in order to sustain their children in the process of playing chess (Moè et al., 2020).

However, the results of the study revealed that parents perceived that children who play chess could be at risk due to the stereotypes that exist at societal level about chess players. The stereotypes mentioned most often by the parents referred to the fact that chess players do not do sports, that they do not have social abilities and might be perceived as arrogant people, or that children spend too much time playing chess and as a result, they do not have time to carry on other types of activities.

Considering the opinions of parents who play or who do not play chess, our results revealed differences between the opinions of the two categories of parents. From this perspective, our research is in line with a previous study (Horgan, 1992), which highlighted the fact that people who do not play chess can sometimes have wrong opinions about the game and its effects on children. Thus, considering parents' opinions about their children's chess performance, Horgan (1992) demonstrates that parents who are not chess players have misperceptions about their children's performance. The parents whose children have lower ratings stated that they have worse results in the first rounds because they are more stressed at the beginning of the championships, and the parents whose children have better ratings stated that the reasons why their children underperform

TABLE 4 Independent sample *t*-test for the role of chess in developing strong character and parent's knowledge of playing chess.

	t-test for equality of means										
	Group									CI4	
	Do you know to play chess	*N*	Mean	S. D.	*t*	df	*p*	Mean difference	Std. Error difference	Lower	Upper
Q9: To what extent do you think that chess can contribute to the development of strong character in children?	Yes	509	3.50	0.62	5.117	761	0.000	0.25	0.04	0.15	0.35
	No	254	3.25	0.68							

TABLE 5 Independent sample *t*-test for parents' satisfaction regarding knowledge acquired by children and parents knowledge of playing chess.

	t-test for equality of means										
	Group									CI4	
	Do you know to play chess	*N*	Mean	S. D.	*t*	df	*p*	Mean difference	Std. Error difference	Lower	Upper
Q11: To what extent are you satisfied with the amount of knowledge the child has acquired during chess training? 1 = to a very small extent; 5 = to a great extent	Yes	516	4.07	0.85	2.096	772	0.036	0.13	0.06	0.00	0.25
	No	258	3.93	0.79							

in the final rounds is represented by the fact that they are becoming tired or they lose focus. The researcher mentions that these wrong perceptions of parents are due to their lack of knowledge about chess and about the system according to which the players are assigned.

Given the results of our research, parents who do know how to play chess were more likely to focus on the positive effects of the game on the development of their children. For example, in the context of the development of strong character through chess, parents who know how to play chess and have more knowledge about the game, recognize to a greater extent than parents who do not know how to play chess, the positive influence of chess on the formation of strong character. A possible explanation for this difference of opinion may be that parents who know how to play chess have personally experienced the benefits of this sport and know better how it can contribute to strengthening the character of individuals. Moreover, according to the results, parents who know how to play chess are more satisfied with their children's accumulated knowledge following chess lessons. This may be due to the fact that parents who know the rules of the game may recognize their children's progress and development more easily and quickly than parents who do not know what the game entails.

In the context of the negative effects of chess, parents who do know how to play, were also able to recognize some of these negative effects, them mentioning that it is possible for children to become addicted the adrenaline felt during the game, and that chess could sometimes negatively impact the mental health of their children.

Given the profile of the parents of children who play chess, our study showed that these parents have high educational levels

TABLE 6 The profile of chess playing children's parents.

Q23: 70.9% made friend in chess clubs	Q44: They feel that competition is very important for them
Q8: 40.7% decided their children take chess classes because this activity is utile for children's development	(5 = very high degree, 1-very low degree)
	M = 3.79, SD = 0.99
Q25: They feel that together with the others parent belong to the community of chess club	Q51: 78.8% of parent consider that they have an income medium to high level
(5 = very high degree, 1-very low degree)	
M = 3.53, SD = 1.29	
Q29: They feel that the parents of the children who take chess courses are different	Q52: 53.1% of parents consider that the parent are intellectual and 46.6% intellectuals + workers
(5 = very high degree, 1-very low degree)	
M = 3.38, SD = 1.02	
Q30: The parents of the children who take chess classes are	
• Involved in children's education (11.9%)	
• Pay attention to the education (4.4%)	
• They are open minded(3.6%)	
• Willing to offer in advance and get involved in the children's activity, financially (7.2%)	
• Breathe (7.1%)	
• Intelligent (4.7%)	
• Ordinary (3.6%)	
• Responsible 11.5%	
• etc.	

(at least a bachelor's degree), that they are mostly people who know how to play chess, who were members of a chess club and who made friends with other parents from the chess club. The parents who participated in the study are people who put great value on the development of cognitive abilities and who are in favor of competition. They think of themselves as people who are somewhat more concerned with the development of their children and with the education of their children, they see themselves as open minded people, who invest money in the education of their children.

According to the results of the conducted research, the general opinion of the parents about the role of chess in children's development is a positive one. Similar to the results of other studies (Horgan, 1987), this research supports the idea that playing chess positively influences the development of children's mental capacity. Furthermore, by acknowledging the benefits of playing chess and by analyzing the effect of chess on the development of children, previous studies postulated the idea that that chess could be introduced in the school curriculum (Gliga and Flesner, 2014; Jankovic and Novak, 2019). Furthermore, Jankovic and Novak (2019) support its introduction into the school curriculum and emphasize the fact that one of the reasons why chess is not integrated into the educational process is due to the lack of knowledge about the multitude of benefits that chess has on children. Taking this aspect into account, through our research, we have highlighted the benefits and advantages of playing chess in the opinion of parents whose children play chess, and thus, the paper can contribute to raising awareness regarding the positive effects of playing chess.

4.1. Limitations and future research directions

Although our research provides relevant and important information regarding the benefits of chess on children's intellectual and social development, it also has certain limitations. One of the limitations of the research is shown by the fact that the participants of the study were only represented by parents, and in the future the opinion of the children who play chess, about its negative or positive effects, should also be analyzed. In this regard, the validity of the data could be tested in a future research by measuring children's opinions about chess, in order to compare their answers with the answers of the parents. Another limitation is represented by the fact that the study was conducted only in Romania, and thus its results are relevant in the Romanian context, but in order to confirm (or not) the results of our study, in a future research the opinion of parents from other countries should also be taken into consideration. Furthermore, the questionnaire was applied only to parents whose children play chess or take chess lessons, and in the future the opinion of parents whose children do not play chess should also be measured to see how they perceive the benefits of chess and how they would relate to the possibility of integrating chess as a subject in the school curriculum. Moreover, a future research could also focus on examining the opinion of other people who interact with children who play chess (e.g., teachers), about the role of chess in the development of children, and the research could focus more on the negative aspects, which are less examined in the literature. Even more, a future research should also take into consideration the matter of parental support and should focus on the process of adopting supportive practices for parents in order to favor chess play in children and adolescents.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material; further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Research Ethics Commission of Transilvania University of Brasov. The patients/participants provided their written informed consent to participate in this study.

Author contributions

CN, CC, and MB contributed to the conception and design of the study. LM-S, MG, and IA organized the database. LM-S and CN performed the statistical analysis. CN and CC wrote the first draft of the manuscript. CN, CC, MB, LM-S, MG, IA, IT, and IN wrote the sections of the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1210917/full#supplementary-material

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