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Analysis of relative age effect in muscular strength of adolescent swimmers

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: The aim of this study is to analyse the effect of relative age in anthropometric measurements, muscular strength of adolescent swimmers.

Material: The study sample was composed of 40 volunteers adolescent well-trained swimmers. Participants were grouped as swimmers born in the first quarter (January, February and March) and in the last quarter (October, November and December) of the same year. Anthropometric measurements were taken from each participant, and body mass index of participants were calculated. To determine performance parameters, handgrip, back and leg strength tests were performed on participants. The level of statistical significance was set at $p < .05$.

Results: Statistical analysis showed that there were statistically significant differences in the body height and BMI ($p < .05$), but body weight differences were not statistically significant between swimmers who are born first and last quarter of the same year ($p > .05$). There were significant differences in the means of absolute leg and handgrip strength between relative age groups. There were statistically significant differences in the means of relative back, leg and handgrip strength between groups ($p < .05$). All mean relative strength values of participants significantly differed in favour of the group born in the first quarter of the year.

Conclusions: As a result of this study, it is determined that relative age has an effect on the measured anthropometric and muscular strength parameters of adolescent well-trained swimmers. The findings of this study revealed that relative age is an important factor to be considered in swimming performance in adolescent swimmers.

Keywords: adolescent, age, relative age, swimming.

Introduction

In many kinds of sports such as basketball, handball, soccer, volleyball, tennis, have been grouped the child and young participants in the competitions according to chronological age. In these sports, child and young athletes who were born on January 1 are grouped with their peers who were born on December 31 of the same year [1, 2]. However, scientific findings have shown that physical growth and biological maturation during childhood and adolescent period can vary even among teenagers of the same age. Grouping according to chronological age in sports provides to produce a competitive environment that may provide advantages for relatively older children and young athletes while disadvantaging other athletes in the same category. Herein, relative age effect (RAE) is considered as a major factor caused this situation [3, 4].

Relative age is calculated based on the month when the individuals were born in the same calendar year. Numerous researchers have indicated that relatively older athletes in the teenagers and childhood period have a higher physical performance than younger peers [5, 6]. These findings have been revealed that the early maturing teenagers may have potential athletic advantages in terms of body size, strength, endurance, and speed, especially in the teenage period [7]. Therefore, relatively older children and young athletes have a lot more opportunity to take part in sports competitions and, consequently, can improve their psychological, technical, and tactical skills, supporting higher athletic performance [8]. In this context, RAE is commonly defined as differences in cognitive or physical performance by chronological age among young athletes who have grouped in the same competition category [9, 10].

Adolescence period is the period of most rapid physical growth due to hormonal and metabolic changes in the body. Especially, the most rapid growth occurs in the limbs and muscles. During the rapid growth phase of adolescence, the muscle strength increases and peaks at around 20-25 age [11-13]. Differences in muscle strength depend on age, gender, nutrition, the level of physical activity and muscle functions [14-16]. Age is an important indicator of physical development and muscle strength of children and young people. In this regard, the relative age is to be considered a major parameter in terms of muscle strength development. Existing studies published on this matter have focused on the effect of relative age on the athletic performance of players in team sports such as; basketball, football and hockey. [1, 17]. Swimming is a sport discipline which muscle strength and body size are highly effective on athletic performance [12, 19]. Therefore, the RAE

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may have a significant impact on athlete development in swimming. In this regard, the investigation of the effect of relative age on muscular strength in adolescent well-trained swimmers may provide important findings. To this end, the aim of this study was to analysis of RAE in muscular strength of adolescent swimmers.

Materials and Methods

Subjects

A total of 40 male swimmers who was born out in the first quarter (January, February and March) and in the last quarter (October, November and December) of 2004 participate in this study. The participants did not have a serious disability in the last 6 months and they had regular swimming training for least 5 years. The birth dates of the participants were calculated by taking into account the information on their national identification cards. Both participants and their parents were informed about the purpose and the test protocols of the study. Written informed consent forms were obtained from the parents of the adolescent swimmers who agreed to participate voluntarily in this study. This research was conducted in accordance with the Helsinki Declaration.

Data Collection

The data for this research was obtained from a standardized data extraction form, anthropometric measurements, and muscular strength tests. The standardized data extraction form was used to record age, training age and self-reported injury history. Anthropometric measurements included body weight and height. Body mass index (BMI) of the participants were calculated using the following formula: body mass (kg) / height^2 (m). Back, leg and handgrip muscle strengths of the participants in the study were measured with a 1 kg sensitivity Takei digital handgrip and back/leg dynamometers. No specific advice on dietary habits was given any of the participants during the study period. All anthropometric measurements and performance tests of participants were measured after an overnight fast. All tests for each participant were performed under the same environmental conditions (at air temperature 22°C and with 55% relative humidity) in an indoor performance lab.

Relative Age

Dates of birth in national identity card were used to determine the relative age of the participants. Relative ages of participants were calculated from the months of birth on their cards. Participants were grouped as swimmers born in the first quarter (January, February and March) and in the last quarter (October, November and December) of the same year.

Anthropometric Measurements

Anthropometric measurements were taken from each swimmer in line with the techniques set forth by the International Society for the Advancement of Kinanthropometry. Body weight of participants was measured them with in light clothes and without shoes by using a digital scale (TANITA, Japan) to the nearest 0.1 kg and their body height was measured without shoes, standing in the upright position, looking straight forward by using SECA stadiometer (SECA, Germany) device. All measurements were measured by experienced researchers [20].

Performance Tests

Leg strength

All participants were allowed to 5-10 min warm-up and stretching before the strength tests. Leg strength test was carried out using a leg dynamometer (Takei, Japan). They were requested stood on dynamometer table in their knees bent position at approximately 100 degrees and their hands grabbed the dynamometer bar in arm stretched position. For the inactivation of back muscles, the hips were positioned directly over the ankle joints and the back kept straight. In this position, the participant pulled the bar in front of the body upwards as much as possible. The test was repeated three times with a 2 min rest between each trial and recorded the maximum pull out of three trials.

Back Strength

Participants were similarly positioned as in the leg strength test, but with the legs straight and the back flexed from the hip with fully extended elbows, until the tips of the index fingers reached the patellae. The pull bar of the device was placed in the hands and the chain length was adjusted. The test was performed three times with a 2 min rest between each trial, and the best score was recorded.

Handgrip Strength

Handgrip strength test was performed by using a hand dynamometer. This dynamometer was calibrated and adjusted to suit each participant before the test was performed. They were requested seat in a chair without arm support, and with their hips flexed at 90° and feet resting on the floor. Their elbow of the test arm was flexed to 90°, the forearm in neutral, and the wrist positioned at 15–30° of extension and 0–15° of ulnar deviation. They were asked to squeeze the handle with as much force as possible for three seconds. The test was repeated three times with a 2 min rest for each participant. The highest score was recorded and used for statistical analysis.

Statistical Analysis

Data analysis was performed with the SPSS (V 15.0, SPSS Inc., Chicago, IL, USA) statistical package. Results were presented as mean (M) and standard deviations (SD). A normality analysis was performed by using Kolmogorov Smirnov tests. As variances showed a normal distribution "Independent-samples t-test" were used to determine whether the participants' physical characteristic and muscular strength performances varied according to relative age groups. The significance level was fixed at 0.05.

Results

An independent-samples t-test was conducted to compare the physical characteristics for the first and last quarter groups. The comparison of relative age groups was given in Table 1.

According to results of the *t*-test, there were statistically significance differences in the body height ($t(38) = -3.46$, $p = .001$) and BMI ($t(38) = 3.32$, $p = .002$) between first and last quarter groups. However, body weight differences were not statistically significant ($p > .05$). The mean body height of first quarter group was higher than last quarter group while the mean BMI of last quarter group was higher than the first quarter group.

The results of muscular strength performance tests of relative age groups were compared and presented in Table 2. Independent sample t-test analysis showed that there were statistically significant differences in the means of absolute leg and handgrip strength between groups ($t(38) = 2.70$, p = .010; $t(38) = 3.35$, p = .002 respectively). The means of absolute leg and handgrip strength significantly differed in favour of the group born in the first quarter of the year. However, the means of absolute back muscular strength did not differ statistically between the groups (t (38) = 1.88, p = .068).

The results of relative muscular strength performance of the groups were compared and presented in Table 3. Independent sample t-test analysis revealed that there were statistically significant differences in the means of relative back, leg and handgrip strength between groups ($t(38) = 3.64$, p = .001; $t(38) = 3.76$, p = .001; $t(38) = 3.82$, p = .001 respectively). All mean relative strength values of participants significantly differed in favour of the group born in the first quarter of the year.

Discussion

In this research, we investigated the effect of relative age on the handgrip, back and leg muscular strength in adolescent well-trained swimmers who was born in the first and last quarter of the same year. The present study revealed that the RAE brings about significant differences in body height, BMI, relative back strength and both absolute and relative handgrip and leg strength parameters of adolescent swimmers. Our study shown that relative age is an important variable which might make differences in the physical performance of adolescent swimmers due to make differences in some anthropometrics and muscular strength. Previous research reported that children who are born in first months had better cognitive and physical development than their peers who are born in the last months of same year. This means that child and adolescent athletes who are born in the first quarter of the year tend to outperform those who are born in the last quarter of same year.

Table 1. The comparison of physical characteristics between the relative age groups.

Variables	Group	n	M	SD	*t*(38)	*p*
Height (cm)	First Quarter	20	155.8	0.25	3.460	.001*
	Last Quarter	20	152.9	0,26		
Weight (kg)	First Quarter	20	46.5	2.52	0.825	.414
	Last Quarter	20	47.1	1.59		
BMI (kg/m^2)	First Quarter	20	19.2	1.11	-3.323	.002*
	Last Quarter	20	20.1	0.71		

*Note. *: p < .05*

Table 2. The comparison of absolute muscular strength performance between the relative age groups.

Variables	Group	n	M	SD	*t*(38)	*p*
Back Stregth (kg)	First Quarter	20	36.20	2.63	1.878	.068
	Last Quarter	20	34.86	1.80		
Leg Strength (kg)	First Quarter	20	42.55	2.18	2.704	.010*
	Last Quarter	20	40.35	2.91		
Hand Grip Strength (kg)	First Quarter	20	16.36	1.38	3.352	.002*
	Last Quarter	20	14.95	1.28		

Note. *: p < .05

Table 3. The comparison of relative muscular strength performance between the relative age groups.

Variables	Group	N	M	SD	t (38)	p
Back Stregth (kg/body mass)	First Quarter	20	0.78	0.04	3.643	.001*
	Last Quarter	20	0.74	0.03		
Leg Strength (kg/body mass)	First Quarter	20	0.91	0.03	3.759	.001*
	Last Quarter	20	0.86	0.06		
Hand Grip Strength (kg/body mass)	First Quarter	20	0.35	0.03	3.818	.001*
	Last Quarter	20	0.32	0.02		

Note. *: p < .05

Body composition and anthropometric characteristics are considered as important variables affecting performance in many sports. In literature, it is often stated that elite swimmers tend to tall and ecto-mesomorphic body type [21]. The results of our study indicated that adolescent well-trained swimmers who were born in the first quarter significantly taller than their peers who are born in the last quarter of 2004. In this respect, elite adolescent swimmers who are born in the first quarter of year are more likely to perform better performance in swimming competitions.

Comparison of body weight of the adolescent swimmers who are born in first and last quarter shows no statistically significant difference. However, comparison of their BMI values indicated the BMI score of swimmers who are born in the first quarter was significantly lower than swimmers who are born in the last quarter. Previous researchers have reported that smaller body mass could provide an advantage for swimmers because the metabolic cost of horizontal forward motion would in principle increase with mass [21]. Also, they suggested that BMI was associated with athletic performance and physical fitness components in young swimmers [22]. In this respect, this result indicates that adolescent swimmers who are born in the first quarter may be more advantageous in terms of the body structure in swimming.

Previous study reported that individual strength or power activities including both individual sports, such as tennis, skiing swimming, wrestling, taekwondo and team sports, such as rugby, soccer, and hockey have shown to be particularly susceptible to RAE [2, 5, 23, 24]. The present study shown that there were statistically significant differences in the absolute leg and handgrip strength parameters and relative back, leg and handgrip strength parameters between swimmers who were born first and last quarter of the same year. These differences were in favour of swimmers who were born in the first quarter. These results indicate the greater muscle growth in adolescent swimmers who are born in the first quarter. Muscular strength/power plays an important role in the swimmer to achieve swimming performance success. Moreover, arm, leg and back muscular strength are considered as important determinants of swimming performance [19, 21]. Therefore, adolescent swimmers who are born in the first quarter may be more advantageous in terms of physical performance in swimming competitions.

Conclusion

As a result of this study, it is determined the relative age have been effects on the measured anthropometric and muscular strength parameters of adolescent well-trained swimmers. Athletic performance in swimming is influenced by many factors such as; physical capacity, age (year), training level, motivation, health, genetic, and personal behaviors (physical activity level and eating habits). Additionally, our findings revealed that relative age is an important factor to be considered in swimming performance in adolescent swimmers. Therefore, the development and performance differences between adolescent swimmers who are born first quarter of the same year and their peers who are born last quarter of the same year should be taken into consideration by trainers and sports experts in swimming events and training. Future research should examine not only the effect of relative age on the physical parameters of swimmers but also their swimming performance in different swimming distance and style.

Acknowledgement

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Conflict of interests

The authors state that there is no conflict of interest.

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The influence of cardiac rehabilitation according to the C model on exercise tolerance and hemodynamic indices in patients after cardiac incident

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: Cardiovascular diseases are currently classified as civilization diseases. The number of cases since the 20th century has dramatically increased. Currently, as many as 46% of all deaths in Poland are caused by diseases of the circulatory system. The aim of the study is to assess the impact of cardiac rehabilitation according to the C model on exercise tolerance and hemodynamic indices in patients after a cardiac incident.

Material: The research was carried out in the Department of Cardiac Rehabilitation in Szymbark. The study group consisted of 32 patients who, after physical examination at admission, were qualified for the preliminary assessment of physical fitness on the basis of 6MWT. The test was carried out the day after the admission, according to current standards. Subsequently, the examined persons underwent a 28-day cycle of early cardiac rehabilitation according to the C model.

Results: As a result of a 4-week cardiac rehabilitation, a statistically significant improvement in physical performance was obtained, with a distance increase of 68.34 m on average. A statistically significant change in the level of fatigue according to Skala Borga after the completion of the rehabilitation cycle was demonstrated. Patients with normal body weight, overweight and obesity received a similar increase in 6MWT results due to the rehabilitation cycle.

Conclusions: The results of this study indicate the urgent need to educate patients in the prevention and prevention of cardiovascular disease and to increase the availability of rehabilitation for all people after a cardiological incident.

Keywords: cardiac rehabilitation, 6-minute walk test, diseases of civilization, hemodynamic, cardiovascular.

Introduction

Cardiovascular diseases are currently classified as civilization diseases. The number of cases since the 20th century has dramatically increased. Currently, as many as 46% of all deaths in Poland are caused by diseases of the circulatory system [1]. In addition, it is the most common reason for hospitalization. The highest percentage of all certificates issued by the Social Insurance Institution for incapacity for work is caused by diseases of the cardiovascular system (23.4%). In Poland, about 1.1-1.5 million people suffer from coronary heart disease [2]. In the case of cardiovascular diseases factors related to lifestyle in up to 54% determine deaths of people [3]. The goals of secondary prevention relate to the prevention of relapse and reemission [4]. Systematic physical effort is aimed at reducing the risk of acute cardiac events and shortening the treatment time of incidents already occurring [5, 6].

In order to assess the tolerance of effort, as well as the effectiveness of the rehabilitation process, many tools are used, among others electrographic stress test and spiroergometric test. In the clinical setting, a six-minute walk test is commonly used - 6MWT (6 Minute Walk Test) [7]. The test is most often used to determine exercise tolerance in patients with respiratory diseases, and to determine the level of exercise in people with cardiovascular disease [8]. 6 MWT is one of the methods of objective evaluation of the functional efficiency of the patient. It allows for a comprehensive assessment of the work of all organs and systems of the human body involved in performing physical activity (respiratory, cardiovascular, blood, peripheral circulation, neuromuscular units and muscle metabolism) [7]. In patients with chronic heart failure, this test has prognostic value regarding the severity of the disease and mortality, especially at distances below 300 m [9–11]. 6MWT in 1993 was recognized by the European Society of Cardiology Working Group as a test useful in a cardiological clinic [12]. Langenfeld et al. [13] used the march test to assess the performance of patients with pacemaker, compared its results with studies on the cycloergometer and treadmill, obtaining a good correlation of results.

Aim of study. The aim of the study is to assess the impact of cardiac rehabilitation according to the C model on exercise tolerance and hemodynamic indices in patients after a cardiac incident.

Material and Methods

Participants: The research was carried out in the Department of Cardiac Rehabilitation in Szymbark. The study group consisted of 32 patients who, after physical examination at admission, were qualified for the preliminary assessment of physical fitness on the basis of 6MWT.

Characteristics of the studied group:

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• 32 women aged: M = 77 years, δ ± 6.8

• Inclusion criteria: cardiac surgery (CABG, AVR), percutaneous coronary intervention (PCI)

• left ventricular ejection fraction ranging from 30% to 65% (M = 51%, δ ± 9.7)

• the BMI index was: 19 to 41 (M = 29, δ ± 5.5)

Research Design: The test was carried out the day after the admission, according to current standards. Subsequently, the examined persons underwent a 28-day cycle of early cardiac rehabilitation according to the C model [14] (people with a metabolic rate below 5 MET). The day before the discharge, 6MWT was repeated.

6MWT was made on the corridor with a length of 30 m; the distance of the march was marked with posts, and on the route, every 3 meters there were distance markers. During the test, a stopwatch and a blood pressure gauge were used. Before starting the test, the subject rested in a sitting position for 10 minutes. Patients were advised not to make intense efforts 2 hours before the start of the test. At the same time, the respondents were instructed to walk their own pace during the test with the option of being released or stopped. The test consists in walking along the longest possible distance in the course of 6 minutes. The degree of patient fatigue, experienced just after the end of the test, was also assessed. For this purpose, a subjective, modified Borga scale was used, in which 0 points means the feeling of "total lack of effort", and 10 points means the feeling of "maximum effort".

Statistical Analysis: Statistical analysis of the results was performed by means of: Wilcoxon matched pairs test and Kruksal-Wallis test. The level of statistical significance was assumed at $p < 0.05$.

Results

The basic criterion for the 6MWT assessment is the length of the distance travelled within 6 minutes. In the study before the beginning of the rehabilitation cycle, the distance was from 84 to 420 meters - an average of 219,5 meters (δ ± 65.47). However, in the study after completion of the rehabilitation cycle, the result was from 126 to 462 meters, on average 288 meters (δ ± 77.52) (Table 1). The resulting difference in the distance covered was from 42 meters to 126 meters, on average 68.34 meters (δ ± 21.34) and this value is statistically significant at $p < 0.05$ (Table 2). The above results indicate the value of the conducted rehabilitation - despite a relatively short duration (4 weeks), a significant increase in efficiency and shaping the mechanisms responsible for adapting the body to the effort is evident. The characteristics of the results obtained

Table 1. 6MWT results before and after the rehabilitation cycle

	Statistical indicators			
Study:	**M**	**δ ±**	**Min.**	**Max.**
Distance 6MWT PRE	219,5	65,47	84	420
Distance 6MWT POST	288	77,52	126	462
Borg scale PRE	3,55	1,12	2	7
Borg scale POST	2,87	0,68	2	5

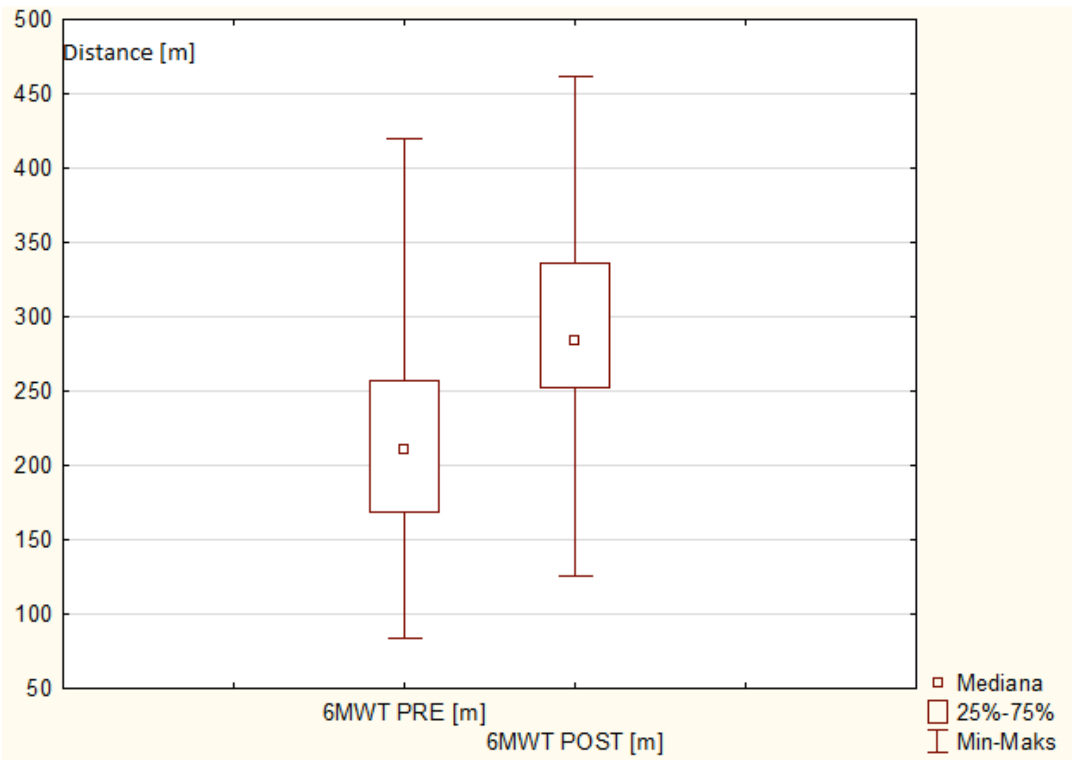

Figure 1. Distribution of results in 6MWT before and after a cycle of rehabilitation

Table 2. Differences in 6MWT and Borg scale before and after the rehabilitation cycle

Variable	M	δ ±	Significance (p) Wilcoxon test
Difference 6MWT [PRE -POST}	68,34	21,34	0,000001
Difference skali Borga [PRE-POST}	-0,75	0,68	0,00001

Table 3. 6MWT results before and after rehabilitation depending on the BMI value

Body mass index BMI [kg/m²]	Medium difference 6MWT [m] (PRE-POST)		
	N	M	δ ±
BMI: 18.5 – 24.99 Normal range	10	68	21.61
BMI: 25.0–29.99 Overweight	9	70	48.85
BMI ≥30 Obesity	13	72	53.83
P value (Kruskal - Wallis test)	0 .85		

Table 4. Changes in haemodynamic indices 6MWT (before and after the rehabilitation cycle)

Study:	Statistical indicators M	δ ±	Significance (Test t)
HR exercise PRE	82.22	12.99	0.91
HR exercise POST	82.41	11.23	
SBP exercise PRE	141.47	26.97	0.23
SBP exercise POST	147.06	22.18	
RPP exercise PRE	11645.63	2879.27	0.26
RPP exercise POST	12105.69	2443.50	

in 6MWT are presented in Fig. 1.

Each patient, both before the beginning of the rehabilitation cycle and after its completion, assessed the level of fatigue using the modified Borga scale. Before starting the rehabilitation, patients assessed their fatigue on average at 3.55 (δ ± 1.12), and after rehabilitation, at 2.87 (δ ± 0.68). The difference in the results is statistically significant at $p < 0.05$ (Table 2).

The next aim of the analysis was to find the answer to the question: what is the level of efficiency in terms of the categories of patients with normal body weight, overweight and obesity. Analyzing the results obtained in 6MWT against the BMI body mass index no statistically significant differences were found (Table 3). Patients with normal body mass, overweight and obesity obtained similar results 6MWT (H = 0.85).

One of the parameters describing the intensity of effort in 6MWT is the product of the maximum heart rate (HR) and maximal systolic blood pressure (SBP), i.e. rate pressure product (RPP) [15]. This index correlates very well with the oxygen consumption of the heart muscle during dynamic exercise. Analyzing the data contained in Table 4, statistically insignificant differences between the results before and after the hemodynamic cycle were found (t = 0.23-0.91), although higher blood pressure tolerance was observed at the end of the cycle, which may indicate directional adaptation mechanisms for effort. The study participants obtained statistically significant: increase in the distance in 6MWT with simultaneous lower heart rate and with less energy expenditure.

Discussion

The distance covered in 6MWT predicts cardiovascular events in cardiac patients with similar accuracy as the MET value assessed during the exercise test. The addition of a simple to measure distance in 6MWT to traditional risk factors improves the risk assessment in this group of patients [16]. The six-minute walk test is an easy test with simultaneous safety [17]. The obtained results indicate statistically significant increase in the distance obtained during 6MWT. Similar results were obtained by other authors [18, 19], which proves the effectiveness of the performed rehabilitation.

Convergent results with other authors were also demonstrated by analyzing the distance obtained in relation to the BMI index. Differences between individual BMI penalties are not statistically significant. It should also be noted that many scientific reports indicate postoperative complications in cardiac patients [20] and longer hospital stays [21]. Excessive body weight may also be a contraindication for performing cardiac surgery [22]. Hemodynamic indicators also did not change statistically significant with simultaneous increase in the distance length in 6MWT. The adaptive changes of the circulatory system to increased physical effort have also been described earlier in the literature [23, 24].

The 6-minute walk test is a test based on simple equipment and minimal costs. The test is easy to understand and be performed by older people. In addition, its advantage is safety, because the risk is not greater than during moderate physical activity.

Currently, there are no statistical standards for the Polish population. According to American authors, overcoming a distance of less than 320 m means finding yourself in the so-called The "risk zone", and sets a very low level of physical fitness [25]. The mean initial distance of the studied group was 219,5 m, while the final one was 288 m, which may mean an increase in efficiency under the influence of cardiac rehabilitation, which reduces the risk of another cardiovascular event.

Conclusions

1. As a result of a 28-day cardiac rehabilitation, a statistically significant improvement in exercise tolerance was obtained, expressed in the distance increase in the 6MWT test and the reduction in the average number of points in the Borga scale.
2. The BMI index is not a factor significantly influencing the change of exercise tolerance as well as the subjective assessment of patient fatigue
3. The results of this study indicate the urgent need to educate patients in the prevention and prevention of cardiovascular disease and to increase the availability of rehabilitation for all people after a cardiological incident.

Conflict of interests

The authors declare that there is no conflict of interests.

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Anthropometric characteristics of professional football players in relation to the playing position and their significance for success in the game

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: Football is a game in which anthropometric characteristics are important factors for specific player positions, where morphological characteristics differ in relation to the competitive level and the position in the game. Body composition is an important indicator of the physical fitness and general health of athletes so today its often discussed in scientific literature. The aim of the research was to determine the differences in the anthropometric characteristics of the professional football players in relation to the player's position and to determine their importance in the game.

Material: Twenty-nine male football players of the national team of Serbia participated in the research, in which the body height, weight and Body mass index were measured.

Results: The results of the study indicate that statistically significant differences in body height and body weight were recorded between goalkeepers and midfielders ($p < 0.01$) and goalkeepers and attackers ($p < 0.05$) in favor of goalkeepers, while no statistically significant differences were recorded in the Body Mass Index. The lowest height, weight and BMI were recorded in the midfielders.

Conclusions: Based on the results of the research it can be concluded that the morphological characteristics have a vital role in determining the success of athletes. Football coaches can use the results of this study as a means to better understand and interpret anthropometric characteristics and their importance in relation to the gaming position. The acquaintance of noticed differences could improve the training process as well as the selection at the early age.

Keywords: Morphological characteristics, geographical area, selection of football players.

Introduction

Football is a game in which anthropometric characteristics are important factors for specific gaming positions [1]. Morphological characteristics [2, 3] successfully distinguish footballers compared to the competitive level and the game position [4] and they are important factors in selecting players in team sports [5, 6] describing the structure of the body of the player based on a large number of anthropometric data [7], which define the longitudinal and transversal dimensionality of the skeleton, mass and volume of the body [8] and they are under great influence of endogenous and exogenous factors [9]. In many studies it has been confirmed that the morphological characteristics of athletes can influence the success in achieving sports results [10, 11]. The data on body weight and height show a great variation [12]. Insufficient height by itself is not a lack for football, although it affects the position of the team [13]. Footballers who play in different positions have specific morphological characteristics [14, 15], that is, defender players are the highest and the heaviest, as confirmed in the research [16] says that defenders are on average six centimeters higher and seven pounds heavier than attackers. Unlike defensive players, midfield players, backs and wings show a tendency for a lower height [13]. The body mass index is used to classify athletes as normal, overweight or obese [17, 18], which is used in adults as an internationally recognized indicator of overweight and obesity [19]. Body composition is an important indicator of the physical fitness and general health of athletes [20] and today it is often discussed on this topic in scientific literature. According to some authors, Claessens, et al., [21] form of the body and its morphology, in addition to physical abilities, psychological characteristics and energy capacity of the system, is one of the main factors determining sports performance. Therefore, the diagnosis of body condition is often the subject of research, based on which a real insight into the current state of the defined population and possible negative or positive trends of growth and development over a certain period of time [22, 23].

Regarding the above mentioned current research, it was realized with the aim of diagnosing differences in the anthropometric characteristics of Serbian national football players in relation to the play position and determine the relevance of these characteristics for success in the game, and it is based on the hypothesis that there is differences in anthropometric characteristics.

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Material and Methods

Participants

The study included a sample of 29 male players, members of national team of Serbia, the average age of (Mean-Std.Dev.) 26.83 ± 3.94, body height 185.76 ± 7.47 cm, body weight 77.24 ± 7.45 kg, BMI 22.43 ± 1.13 kg/m^2.

Research Design

All anthropometric variables [Body Height (cm), Body Weight (kg), Body Mass Index (kg/m^2)] were measured according to standard procedures of the International Society for the Advancement of Kinanthropometry (ISAK) [24]. To measure the body height and weight of players, a stadiometer and a calibrated scale were used with a precision of 0.1 cm and 0.1 kg, while BMI was calculated by dividing the body mass with the square height of the body in meters [25].

Statistical Analysis

All the data collected by the study were processed by descriptive and comparative statistics. From the space of descriptive statistics, for each variable, the measures of central tendency and dispersion measures were calculated: Mean, Minimum, Maximum, Range Deviation, Standard Deviation, while to calculate the distribution: Skewness and Kurtosis.

From the space of comparative statistics, a discriminative parametric procedure, a variance analysis with one factor Anova and PostHoc was used, which determined differences in relation to the player position. The statistical program for personal computers SPSS for Windows version 20.0 was applied for data processing.

Results

Table 1 shows numerical quantitative indicators of the physical status of the football players. The highest average height, weight and BMI was recorded in the goalkeeper, then with defensive players and attackers, while the lowest height, weight and BMI were recorded in the midfielders. An analysis of the symmetry of the results in the goalkeeper indicates that there are no significant deviations from the normal distribution, however, in terms of homogeneity, there is a platykurtic curve. For defensive players, attackers and midfielder, distribution of frequencies with statistically negative asymmetry in body height and weight is present, while in BMI scores there are no significant deviations from normal distribution.

With defensive footballers and midfielder, a platykurtic curve in the Body Weight variable was formed, while the leptokurtic curve was formed in the BMI variables. Unlike the defensive and midfielders, the striker has a platykurtic curve in the Body Height variant. In order to determine statistically significant differences between the player's positions, depending on the numerical parameters for the assessment of body status, a variance analysis with one factor-Anova was used (Table 2). It is evident from Table 2 that statistically significant differences were recorded in body height ($p < 0.018$) and body weight ($p < 0.019$), as opposed to BMI, where no statistically significant difference was recorded.

By analyzing the results of PostHoc Table 2, the differences in the anthropometric characteristics in relation to the player's position are shown. Statistically significant differences in body height and body weight were recorded between goalkeepers and midfielders ($p < 0.01$) and goalkeepers and attackers ($p < 0.05$) in favor of goalkeepers. Figure 1 shows the average values of the anthropometric characteristics of the football players.

Discussion

The aim of this research was to determine the differences in the anthropometric characteristics of male footballers of the national team of Serbia in accordance with their playing positions and to determine the relevance of these characteristics for the success of the game. The results of the study confirm the hypothesis that there are statistically significant differences in anthropometric characteristics in body height and weight, while in BMI there were no statistically significant differences. The values of BMI for Serbian footballers are 22.43 ± 1.13kg/m^2, and they correspond to the values of four elite European leagues (England, Italy, Germany and Spain) and their BMI values range from 22.8 ± 1.1 kg/m^2 to 23.2±

Table 1. Descriptive parameters of the football player in relation to the player's position

Position	Variables	N	Mean	Std.Dev.	Max.	Min.	Range	Skewness	Kurtosis
	Body Height		194.25	5.31	201	190	11	.708	-2.065
Goalkeeper	Body Weight	4	85.75	7.41	94	79	15	.230	-4.517
	BMI		22.82	1.34	24.47	21.38	3.09	.358	-1.368
	Body Height		187.50	5.35	195	177	18	-.309	.459
Defender	Body Weight	10	78.90	5.38	85	70	15	-.369	-.978
	BMI		22.43	1.14	24.84	20.45	4.39	.487	2.009
	Body Height		181.73	5.35	194	165	29	-.309	.459
Midfielder	Body Weight	11	73.27	5.38	82	60	22	-.369	-.978
	BMI		22.16	1.14	23.55	21.68	1.87	.487	2.009
	Body Height		184	7.39	191	175	16	-.475	-2.716
Forward	Body Weight	4	75.50	9.88	85	62	23	-1.044	1.097
	BMI		22.43	2.19	25.58	20.24	5.34	.354	1.326

Table 2. Differences in the anthropometric characteristics of the football player - Anova, Post Hoc

Anthropometry	Position				Anova	
	GK	DF	MF	FW	F	p
Body Height	194.25±5.315*#	187.50±5.35	181.73±5.35	184±7.39	4.026	.018
Body Weight	85.75±7.41*#	78.90±5.38	73.27±5.38	75.50±9.88	3.970	.019
Body Mass Index	22.82±1.34	22.43±1.14	22.16±1.14	22.43±2.19	.457	.715

Note: Goalkeeper – GK; Defender – DF; Midfiwlder – MF; Forward – FW. * - Goalkeeper vs Midfielder; p < 0.01; # - Goalkeeper vs Forward; p < 0.05

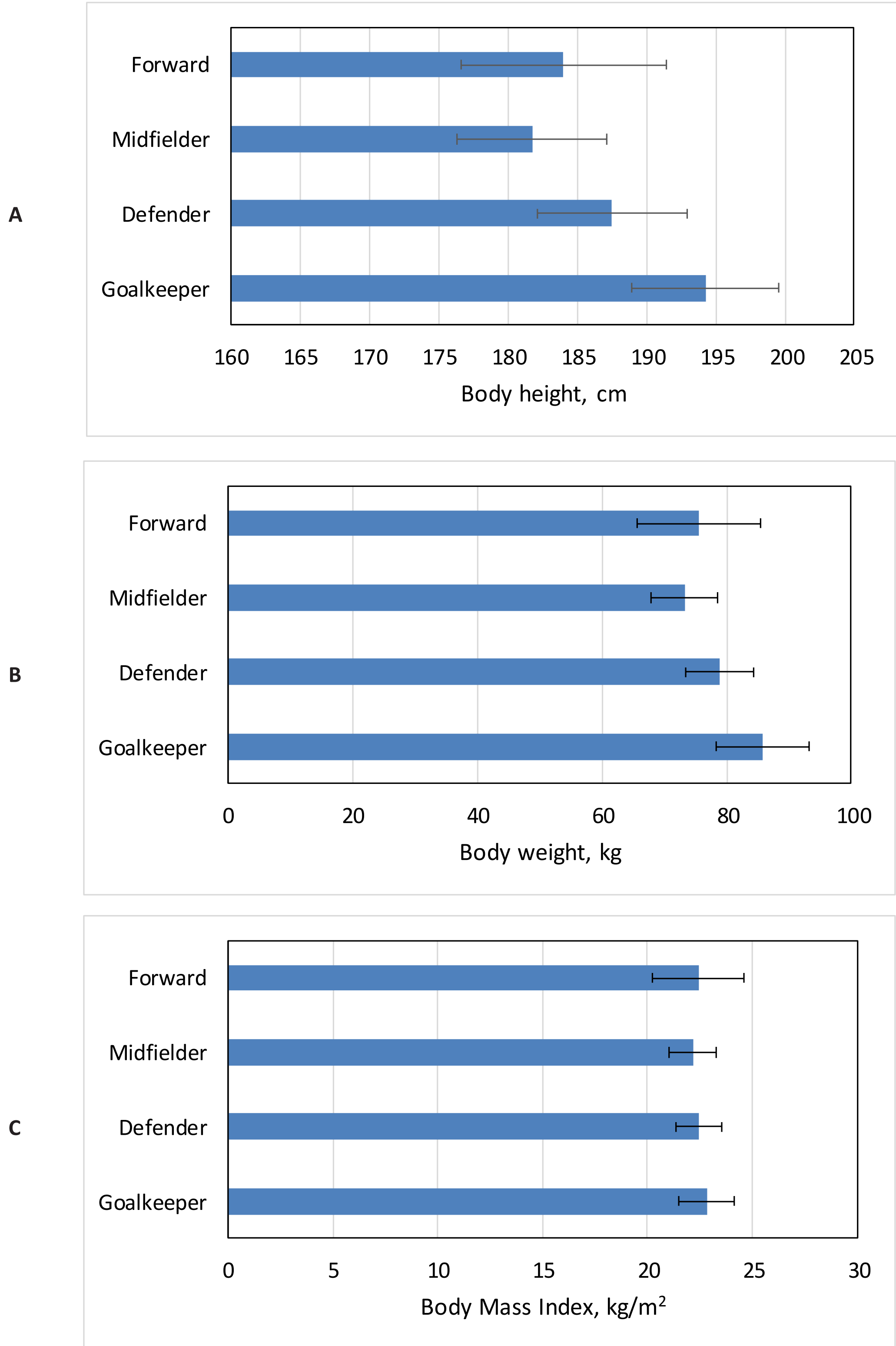

Figure 1. Antropometric characteristics of the soccer players: (**A**) Body height; (**B**) Body weight, (**C**) Body Mass Index.

1.1 kg/m^2 [15, 17]. Similar values of BMI were recorded by Bangsbo [26], with Danish footballers (23.87 kg/m^2), Bunc, & Psotta [27], with players from Czech Republic (23.58 kg/m^2), Rahkila, & Luthanen [28], football players from Finland (23.35 kg/m^2), Vanfraechem & Tomas [29], with players from Belgium (23.41 kg/m^2) and Ćorluka et al. [60], with players from Bosnia and Herzegovina (22.3-23.5 kg/m^2).

The average body weight of the Serbian football players is 77.24 ± 7.45 kg, and they are in line with the average body weight of footballers competing in the German Bundesliga 77.5kg, England Premier League 73.3kg, Italian Serie A 74.3kg and Spanish La Liga 75.0 kg [15, 30]. The identical values of body weight were recorded in Norway's players 72.2kg, 73.1kg in Saudi Arabia players, and 76.4kg in South American football players [6, 31, 32], which indicates that Serbia's footballers are in rank with world footballers. The average body height and weight for professional football players is around (180-185cm and 70-75kg) when all players are taken into account [3, 33, 34]. The highest body height is scored in goalkeepers and defenders, while the midfielders are the smallest [3, 35, 36]. Research suggests that professional players differ from their playing position in anthropometric characteristics such as body height, weight, and body mass index. In particular, the goalkeepers who took part in the FIFA World Cup (2002 and 2006) were significantly higher, heavier, and had higher BMI values than defenders, strikers and midfielders, with the midfielders having the least values of anthropometric characteristics: height and weight [37, 38]. In our research, the goalkeepers had a higher body height (194.25cm) and body weight (85.75cm) than the midfielders (181.73cm; 73.27kg) and the attackers (184cm; 75.50kg). The reason for the higher weight of the goalkeepers can be justified by the fact that goalkeepers are less likely to run in the game, therefore they consume less energy, while other players tend to be lighter and leaner in order to run a greater distances in the field [39], which is confirmed by the researches [14, 30, 40, 41, 59], which are in agreement with our results. Footballers of Serbia have a higher body height than Croatian football players [42], Portugal, Brazil and Iran [30, 43, 44].

Research shows that the geographical area as a determinant of growth has an impact on the selection of football players [45], this is confirmed by the research carried out by Popović, et al., [46] that people in Serbia are very high with an average of 181.96cm and very close to the highest nations in Europe. Observing the body height and weight of players from different geographic regions show that players differ significantly in this regard. Such differences can be the result of ethnic and cultural influences or the result of a different style of football, where teams from different countries prefer different types of players [15, 47]. Anthropometric research in footballers [3, 6, 34] have shown that body height and weight are important factors [48]. Thus, football differs from other individual sports in that there are no definite characteristics of each player [49], where the anthropometric characteristics of height and weight are necessary for good performance [1], and their relationship is equally important because of the fact that top football involves a duel game, head-ball strikes, alternate attack and defense, all of which relates to effective realization during the match [50]. Physical height is an advantage for the goalkeeper, attackers and defensive players who play the most in the game with hands and head, while midfielders, wings and back wings tend to have a lower height [12]. It is precisely this anthropometric characteristic for midfielders that allows them to move more efficiently and cover larger distances of the field [51] also, lower body height allows them to handle the ball well in order to overcome defensive players [31, 33] because a small body height keeps the center of gravity closer to the ground, and their dynamic balance is facilitated during dribbling. The average body height for goalkeepers who participated in the last World Championships was 188.9 ± 5.0 cm, and these values allow goalkeepers to stop the shots under the crossbar [52]. Thus, the height of the body at the goalkeeper is an obvious advantage which can compensate for their lower body weight. It is also necessary that the goalkeepers have a strong and muscular body, so that they can enter the air duels against the attackers [53]. For defenders, the body height is suitable when the ball wants to be hit with the head, from a jump or from the ground [14] and they are the highest and heaviest players due to frequent jumps to perform in tactical tasks [54]. Attackers with higher body height have the advantage of hitting high balls, while lower height attackers have the advantage of dribbling [3, 30]. The body height, weight, BMI ratio, as well as the percentage of fat mass in the overall body weight for trainers is important information. Optimal BMI values can result in an improvement in the general level of the physical and anaerobic strength [55-58]. In athletes whose BMI values between 18.5 and 20.0 are worsening work capabilities and VO_{2max} low-level athletes BMI may be able to perform submaximal exercise as well as athletes whose BMI values are in the normal range but they will work with a higher percentage of their VO_{2max} and have a significantly higher heart rate for the same O_2 consumption level [59].

Morphological characteristics have a vital role in determining the success of athletes [47, 60, 61], and especially for the realization of motor assignments [62-65], which confirms research that morphological characteristics in specific motor capabilities participate with 42% of variability, so that bigger players have greater strength and better precision of kickballs and headers [45]. Based on all of the above, the role of a trainer is to pay attention to these characteristics when creating a team, because it is necessary to adjust the configuration of his team and the style of play to his players who do not have adequate physical attributes of the conventional positions in the team, which are compensated by superior knowledge, skill and motivation [13].

Conclusion

Football is a game in which anthropometric characteristics are important factors for specific player positions, where morphological characteristics differ in relation to the competitive level and the position in the game. In this study, there were differences in the anthropometric characteristics between the goalkeeper and the attacker, the midfielders and the defending players. The goalkeepers were the highest and the heaviest, while the midfielders had the lowest body height and body weight. Football coaches can use the results of this study as a means to better understand and interpret anthropometric characteristics and their importance in relation to the gaming position. The acquaintance of noticed differences could improve the training process as well as the selection at the early age.

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Conflicts of Interest

The authors declare no conflict of interest.

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The relationship between self-efficacy and athlete burnout in elite volleyball players

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: The researches about the relationship between self-efficacy and athlete' burnout of elite volleyball players who playing in high level leagues is not available in the literature. The aim of this study is to investigate the relationship between self-efficacy and athletes' burnout in elite volleyball players.

Material: The study group is consisted 173 [n=61 female, n=112 male] elite volleyball players. The mean of the age of participants was 25.6 year [± 6.3]. Data was collected by personal information form, General Self-Efficacy Scale [GSE] and Athlete Burnout Questionnaire [ABQ]. SPSS 22 program was used in the analysis of the obtained data. Kolmogorov-Smirnov test was applied to determine whether the data showed normal distribution and the significance level was accepted as 0.05 in the analyses. Parametric tests were used in the analysis of the data.

Results: As a result of the research, high level negative correlation was found between effort and resistance sub-dimension [GSE] and the reduced sense of accomplishment sub-dimension [ABQ] [$p<0.01$]. In the same way, there was a negative correlation between ability and confidence sub-dimension [GSE] with reduced sense of accomplishment sub-dimension [ABQ] [$p<0.01$].

Conclusions: This result shows that athletes with high general self-efficacy level have less athlete burnout than others. Volleyball players who played in national teams have higher self-efficacy than others, while athletes have less athlete' burnout. Gender has no relation on volleyball players' self-efficacy and burnout. As the age of the participants decreased, burnout levels increased.

Keywords: self-efficacy, burnout syndrome, volleyball, player, sport, athletes.

Introduction

The level of competition and popularity of sports is increasing rapidly. There are athletes at the center of the growing sport in the sectorial feature and they perform the sport as a profession. Athletes endeavor to achieve lasting success. These efforts include that regular training and competition processes. Intense physical training and stressful competitions are forced to athletes physiologically, mentally and spiritually extreme. Besides, they conduct an intense relationship process with people due to their working environment. This strain and intense relationship process can be a factor in the drift of athletes to burnout.

Self-Efficacy

Self-efficacy is the evaluation of the skills in the context of the content to fullfill a certain task. It is stated the central of the human organism [1]. Self-efficacy is based on personal beliefs about how capable of dealing with the difficulties encountered. It is not a general feeling of self-confidence [2]. Belief of self-efficacy behavior is very important in the acquisition and regulation [3People use their abilities and self-efficacy to change or organize themselves and their environment [4]. On the other hand, self-efficacy belief brings about the expectation of result. The outcome expectations enable the individual to form a cognitive map and methods that may be necessary for the behavior. In this way, he/she determines a tactic and achieves his/her goals. Then he/she directs behavior by loading meaning to the result [5].

High self-efficacy beliefs contribute to more perseverance, desire, determination and patience [6]. In addition, he/she with high self-efficacy do not hesitate to engage in difficult tasks and activities. On the other hand, he/she with low self-efficacy exhibit an insecure attitude even in the tasks they can actually accomplish and the problems they can overcome. Such people are affected more quickly than stress and depression [6].

Burnout Syndrome

The concept of burnout was introduced by Freudenberger to literature. Freudenberger [7] has explained the burnout as a state of exhaustion in the individual's internal resources as a result of failure, wear, loss of energy and power, or unmet demands. Also it can be defined is as losing his/her power and not making efforts.

Burnout is not a temporary condition of fatigue or stress caused by excessive stress, such as cooling from his/her job, but rather a permanent condition [8]. Burnout emerges as emotional burnout, devaluation and reduction of personal success [9].

Burnout, which may occur by showing physical, emotional and mental symptoms; can affect the person physically, socially, mentally and spiritually [10]. The factors of affecting the state of burnout are examined in two areas as individual and organizational [environmental] [11]. Differences in environment and personality structures may cause burnout in individuals with different characteristics. One of the person with different personality structure can overcome or may be less affected by the negative consequences. Another

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person may be affected more negatively by the negative conditions that his/her perceives.

Burnout and Sport

According to Kaçmaz [12], burnout is a factor that directly affects motivation and productivity in the professional life. When the goals are not achieved, the frustration occurs. The physical, mental, emotional and spiritually fatigue and lack of energy can be defined as occupational burnout [13].

According to Eades [14], burnout in sports is psychophysiological syndrome. It emerges in response to chronic stress caused by training and competition of the athlete. It causes that emotional and physical exhaustion, non-human attitude towards other individuals, sense of exclusion by others, decrease in sportive success / performance, loss of meaning of sport for individual, desensitization, role complexity and role ambiguity. It may result leave from the sport.

The potential negative effects of burnout in sports are tried to be measured in a multifaceted manner. The studies that examined the effect of burnout on the level of motivation [15, 16], anxiety and self-confidence and stress level are prominent [17, 18].

Success and failure are important in the lives of athletes. In other words, athletes express themselves with success. Numerous studies have been conducted in order to examine the performance and self-efficacy relationship in many areas. Self-efficacy researches in sport: The effect of self-efficacy on team success [19], the relationship between superstitious behavior in sports [20] and the self-efficacy level of athletes according to their position are emerging [21].

According to Eades [14], athletes are exposed to excessive physical and psychological stress during long pre-season preparation periods, camps, and competition periods. Athletes may experience emotional and physical exhaustion, which is called burnout in sport, due to the potential failure situations. Also the sense of burnout in elite athletes can lead to a reduction in their academic success. It is important to determine the reasons and the way out of this situation in terms of athlete performance and health.

Behaviors are greatly influenced by self-efficacy belief [22]. Bandura [4] stated that if he/she do not believe that the power to produce solutions to a problem, he/she do not try to solve the problem. From this point of view, it is conceivable that self-efficacy level has positive effect on the elite athletes' coping with burnout syndrome and preventing them from negative effects.

The aim of this study was to investigate the relationship between the levels of self-efficacy and burnout of elite volleyball players who playing elite and to contribute to the literature.

Material and methods

Model of the Research

Correlational research method was used in the research. In the correlational research, the relationship between two or more variables and the change of variables together are examines. [23]. Relational researches are studies aimed at defining and investigating human behavior in individual and social relations. [24].

Participants:

Participants of the research formed with 173 elite volleyball players who playing volleyball in the 2018-2019 competition season in Turkey's Super League, 1st and 2nd league. The volleyball players sampled by convenience sampling method [25, 26]. Convenience sampling is a method that aims to prevent loss of time, money and labor. Convenience sampling is a frequently used sampling method in the field of sports sciences [24, 27]. The personal information of the volleyball players is presented in Table 1.

Table 1. The personal information of elite volleyball players

Gender	**f**	**%**
Female	61	35.3
Male	112	64.7
Total	173	100.0
Age	f	%
18-22	59	34.1
23-27	58	33.5
28-32	31	17,9
33 +	25	14.5
Total	173	100.0
Sport experience	f	%
8-12 year	72	41.6
13-17 year	62	35.8
18 year +	39	22.5
Total	173	100.0
Level of league	f	%
2^{nd} league	36	20.8
1^{st} league	89	51.4
Super league	48	27.7
Total	173	100.0
National team career	f	%
Yes	73	42.2
No	100	57.8
Total	173	100.0
Yearly training period	f	%
8 month	66	38.2
9 month	24	13.9
10 month	52	30.1
11 month	31	17.9
Total	173	100.0

According to Table 1, the research participants consisted of 61 female [35.3%] and 112 male [64.7%] elite volleyball players. Age groups of participants were 18-22 [34.1%] 23-27 [33.5%], 28-32 [17.9%] and 33+ [14.5%]. The participants are playing in the first league % 51.4, in the super league % 27.7 and in the second league % 20.8. Looking at the annual training period the rate of those who training for 8 months is 38.2% and the rate of those who train for 10 months is 30.1%.

Procedure:

''Personal Information Form'' which was created by the researcher was used in the determination of the personal information of the athletes. The personal information form includes gender, age, time of sport experience, level of league, national team career and training time throughout the year.

The general self-efficacy levels of the athletes were determined by the General Self-Efficacy Scale [GSE]. The GSE developed by Schwarzer & Jerusalem [28] and adapted to Turkish by Aypay [29] consists of 10 items and two sub-dimensions. The Cronbach Alpha value for the total of the scale is.83.

The burnout levels of the athletes were determined by the Athlete Burnout Questionnaire [ABQ] ABQ developed by Raedeke and Smith [30] and adapted to Turkish by Kelecek et al [31]. consists of 13 items and three sub-dimensions. The internal consistency coefficient was calculated to range between 0.75 and 0.87 for the scale.

Statistical Analysis:

SPSS 22 program was used in the analysis of the obtained data and Kolmogorov-Smirnov test was applied to determine whether the data showed normal distribution and the significance level was accepted as $p<0.05$ in the analyses. Data were normally distributed. In the analysis of the data, Independent Sample T Test was applied according to gender and national team career variable. One-Way ANOVA test was applied in the analysis of the variables of the age, sport experience time, league of level, and yearly training period and LSD test was used to determine the significant difference. The Pearson Correlation test was applied to determine the relationship between the general self-efficacy and athlete burnout sub-dimensions.

Results

Independent Sample T Test was used to determine the general self-efficacy and burnout level of participants according to gender.

According to Table 2, it was determined that the differences of general self-efficacy and athlete burnout status were not statistically significant by gender variable ($p>0.05$).

One Way ANOVA Test was used to determine the general self-efficacy and burnout level of participants according to age.

In Table 3, the self-efficacy levels in the effort and resistance sub-dimension [$F_{[3.169]}$= 7.383; $p<0.05$; p=.000] and in the ability and confidence sub-dimension [$F_{[3.169]}$= 3.944; $p<0.05$; p=.009] it was determined that it had a statistically significant difference by age. In order to determine the difference between the groups, LSD test was applied from post-hoc tests. As a result of LSD test, the difference between the ages of in 18-22 ages and 23-27, 28-32 years and between 23-27, 33 + ages was found to be significant in both dimensions.

The athlete burnout levels in the emotional/physical exhaustion sub-dimension [$F_{[3.169]}$= 3.119; $p<0.05$; p=.028] it was determined that it had a statistically significant difference by age. As a result of LSD test, the difference between the ages of in 18-22, 23-27 ages and 28-32, 33 + ages was found to be significant. The level of difference in reduced sense of accomplishment and devaluation dimensions was not statistically significant.

One Way ANOVA Test was used to determine the general self-efficacy and burnout level of participants according to sport experience time.

Table 4 shows that the self-efficacy levels in the effort and resistance sub-dimension [$F_{[2.170]}$= 4.555; $p<0.05$; p=.012] it was determined that it had a statistically significant difference by sport experience time. In order to determine the difference between the groups, LSD test was applied from post-hoc tests. As a result of LSD test, the difference between the 18 year + sport experience time and 8-12, 13-17 years found to be significant.

One Way ANOVA Test was used to determine the general self-efficacy and burnout level of participants according to league of level.

Table 2. Evaluation of general self-efficacy and athlete burnout level by gender.

Scale	Dimensions	Gender	n	$\bar{x}$	sd	df	t	p
General Self Efficacy	Effort and Resistance	Female	61	3.2459	.55076	171	-1.539	.126
		Male	112	3.3750	.51382			
	Ability and Confidence	Female	61	3.4672	.47098	171	-.409	.683
		Male	112	3.4978	.46920			
Athlete Burnout	Emotional/Physical Exhaustion	Female	61	2.3344	.94989	171	-1.059	.291
		Male	112	2.4857	.86856			
	Reduced Sense of Accomplishment	Female	61	2.2254	.87643	171	-.345	.731
		Male	112	2.2701	.77919			
	Devaluation	Female	61	1.9139	.96381	171	-.255	.799
		Male	112	1.9509	.88203			

Notes: *$p<0.05$

Table 3. Evaluation of general self-efficacy and athlete burnout level by age.

Scale	Dimensions	Age	n	$\bar{x}$	sd	F	p	LSD
General Self Efficacy	Effort and Resistance	18-22	59	3.1328	.56203	7.383	.000*	1<3<4 2<3<4
		23-27	58	3.3017	.51152			
		28-32	31	3.5215	.47090			
		33 +	25	3.6200	.33513			
	Ability and Confidence	18-22	59	3.3295	.52917	3.944	.009*	1<3<4 2<3<4
		23-27	58	3.3729	.53614			
		28-32	31	3.4483	.45344			
		33 +	25	3.5968	.39093			
Athlete Burnout	Emotional/Physical Exhaustion	18-22	59	3.7100	.31192	3.119	.028*	1>2>3>4 4>3
		23-27	58	3.4870	.46869			
		28-32	31	2.3695	.78417			
		33 +	25	2.5552	.96685			
	Reduced Sense of Accomplishment	18-22	59	2.6645	.83008	1.018	.386	
		23-27	58	2.0080	.95478			
		28-32	31	2.4324	.89825			
		33 +	25	2.2585	.84456			
	Devaluation	18-22	59	2.2759	.80390	.825	.482	
		23-27	58	2.3952	.78468			
		28-32	31	2.0200	.78700			
		33 +	25	2.2543	.81254			

Notes: *p<0.05

Table 4. Evaluation of general self-efficacy and athlete burnout level by sport experience

Scale	Dimensions	Sport Experience	n	$\bar{x}$	sd	F	p	LSD
General Self Efficacy	Effort and Resistance	8-12 year	72	3.2454	.52554	4.555	.012*	1<2<3
		13-17 year	62	3.2903	.54567			
		18 year +	39	3.5470	.45715			
	Ability and Confidence	8-12 year	72	3.4375	.50829	1.485	.229	
		13-17 year	62	3.4758	.46980			
		18 year +	39	3.5962	.37441			
Athlete Burnout	Emotional/ Physical Exhaustion	8-12 year	72	2.3139	.87264	1.336	.266	
		13-17 year	62	2.5677	.88202			
		18 year +	39	2.4359	.96122			
	Reduced Sense of Accomplishment	8-12 year	72	2.1632	.79740	1.007	.367	
		13-17 year	62	2.3629	.82566			
		18 year +	39	2.2500	.81918			
	Devaluation	8-12 year	72	1.7500	.85168	2.762	.066	
		13-17 year	62	2.0444	.98921			
		18 year +	39	2.1154	.83478			

Notes: *p<0.05

According to Table 5, it was determined that the differences of general self-efficacy and athlete burnout status were not statistically significant by sport experience time variable.

Independent Sample T Test was used to determine the general self-efficacy and burnout level of participants according to national team career.

Table 6 shows that the self-efficacy levels in the effort and resistance sub-dimension [$t_{[171]}$= 2.700; p<0.05; p=.005] and ability and confidence sub-dimension [$t_{[171]}$= 2.919; p<0.05; p=.005] it was determined that it had a statistically significant difference by national team career variable. In the effort and resistance sub dimension, the averages of the athletes who were previously in the national teams were higher [$\bar{x}$ = 3.4543] than those who did not [$\bar{x}$ = 3.2383]. Likewise, in the ability and confidence dimension, the averages of those with a national team career [$\bar{x}$ = 3.6062] is higher than those without [$\bar{x}$ = 3.4000].

There is a statistically significant difference in reduced sense of accomplishment dimension [$t_{[171]}$=-2.167; p<0.05; p=.005] according to career variable of burnout levels. In the reduced sense of accomplishment sub dimension the averages of the athletes who were previously in the national teams were higher [$\bar{x}$ = .81195] than those who did not [$\bar{x}$ = .79808].

One Way ANOVA Test was used to determine the general self-efficacy and burnout level of participants according to yearly training period.

Table 7 shows that the self-efficacy levels in the effort and resistance sub-dimension [$F_{[3,169]}$= 3.112; p<0.05; p=.028] it was determined that it had a statistically significant difference by yearly training period. In order to determine the difference between the groups, LSD test was applied from post-hoc tests. As a result of LSD test, the difference between the 9 month training period and 8 month, 10 month and 11 month training periods found to be significant.

Pearson Correlation test was used to evaluate the relationship between general self-efficacy and athletic burnout sub-dimensions.

According to Table 8, a negative correlation was found between sub-dimensions of self-efficacy, effort and resistance and the sub-dimensions of athlete burnout scale; reduced sense of accomplishment [r=-.225, p=.003]. In the same way, there was a negative correlation between ability and confidence sub-dimension with sub-dimensions of athlete burnout scale, reduced sense of accomplishment [r= -.265, p=.000].

Table 5. Evaluation of general self-efficacy and athlete burnout level by league of level

Scale	Dimensions	League of Level	n	$\bar{x}$	sd	F	p
General Self Efficacy	Effort and Resistance	2nd league	36	3.3380	.53967	1.020	.363
		1st league	89	3.3745	.47625		
		Super league	48	3.2396	.60914		
	Ability and Confidence	2nd league	36	3.4167	.42258	.528	.591
		1st league	89	3.5112	.44420		
		Super league	48	3.4948	.54453		
Athlete Burnout	Emotional/Physical Exhaustion	2nd league	36	2.1722	1.02221	2.632	.075
		1st league	89	2.5663	.84919		
		Super league	48	2.3792	.85775		
	Reduced Sense of Accomplishment	2nd league	36	2.1597	.83699	.629	.534
		1st league	89	2.3202	.81271		
		Super league	48	2.2031	.80003		
	Devaluation	2nd league	36	1.7083	.95525	2.326	.101
		1st league	89	1.9242	.92427		
		Super league	48	2.1354	.81534		

Notes: *p<0.0

Table 6. Evaluation of general self-efficacy and athlete burnout level by national team career

Scale	Dimensions	National Team Career	n	$\bar{x}$	sd.	df	t	p
General Self Efficacy	Effort and Resistance	Yes	73	3.4543	.49086	171	2.700	.008*
		No	100	3.2383	.53980			
	Ability and Confidence	Yes	73	3.6062	.46755	171	2.919	.004*
		No	100	3.4000	.45227			
Athlete Burnout	Emotional/Physical Exhaustion	Yes	73	2.5205	.90966	171	1.104	.271
		No	100	2.3680	.88886			
	Reduced Sense of Accomplishment	Yes	73	2.0993	.81195	171	-2.167	.032*
		No	100	2.3675	.79808			
	Devaluation	Yes	73	1.9418	.86955	171	.048	.962
		No	100	1.9350	.94121			

Notes: *p<0.05.

Table 7. Evaluation of general self-efficacy and athlete burnout level by yearly training period

Scale	Dimensions	Yearly Training Period	n	$\bar{x}$	sd	F	p	LSD
General Self Efficacy	Effort and Resistance	8 month	66	3.3333	.53669	3.112	.028*	2<1-3-4
		9 month	24	3.0486	.69761			
		10 month	52	3.3782	.43048			
		11 month	31	3.4570	.45738			
	Ability and Confidence	8 month	66	3.4924	.44065	2.248	.085	
		9 month	24	3.3021	.64260			
		10 month	52	3.4808	.45870			
		11 month	31	3.6290	.34078			
Athlete Burnout	Emotional/ Physical Exhaustion	8 month	66	2.5061	.84651	1.279	.283	
		9 month	24	2.3083	.80645			
		10 month	52	2.5385	.92845			
		11 month	31	2.1935	1.00331			
	Reduced Sense of Accomplishment	8 month	66	2.2992	.87620	2.004	.115	
		9 month	24	1.9063	.71783			
		10 month	52	2.3798	.82470			
		11 month	31	2.2177	.66377			
	Devaluation	8 month	66	1.9470	.98500	1.020	.385	
		9 month	24	1.6875	.64374			
		10 month	52	2.0721	.91600			
		11 month	31	1.8871	.89870			

Notes: *p<0.05

Table 8. Evaluation of the relationship between general self-efficacy and sub-dimensions of athlete burnout

Scales		Emotional/ Physical Exhaustion	Reduced Sense of Accomplishment	Devaluation
Effort and Resistance	r	-.029	-.225**	-.094
	p	.708	**.003**	.220
Ability and Confidence	r	-.023	-.265**	-.097
	p	.762	**.000**	.206

Notes: **p<0.01

Discussion

In this study, the relationship between general self-efficacy and athlete burnout levels among elite volleyball players were examined in Turkey. There was no significant difference between the male and female athletes in the sub-dimensions of general self-efficacy and athletes' burnout. There are studies in literature suggesting that athlete' performance may be optimal when burnout is minimal [32-34].

It was seen that the self-efficacy and burnout levels of the participants were statistically significant according to the age variable. It is seen that as the age increases, the level of general self-efficacy increases. It is observed that the level of burnout increases at an early age in the emotional/physical exhaustion dimension. This situation can be interpreted as the age factor in sports, with experience and maturation, and the fact that older athletes are able to better manage the physiological/psychological forcing and the stress experienced and they are less affected.

It has been determined that the experience of the athletes have a positive effect on the level of general self-efficacy. As the experience of athletes increases, self-efficacy level increases. The time spent in sports training brings along the development of skills. The improvement of experiences and skills can affect the level of self-confidence positively. There are studies [35-37] that indicate the effect of self-efficacy of sports experience in the literature.

There was no significant relationship between volleyball players' league of level and self-efficacy and burnout levels in this study. This situation can be interpreted as the high degree of difficulty of the league at each level.

It was determined that the self-efficacy levels of the participants who took part as athletes in national teams were higher than those who did not. A negative relationship was found between the national team career and burnout level. The burnout levels of the athletes with a national team career are lower than the other athletes in the dimension of reduced sense of accomplishment. It is likely that the knowledge, skills and experiences acquired in the elite level, such as national teams, will positively affect self-efficacy. This result can be interpreted that high-level athletes internalize their achievements and experience a decreasing sense of success less than other athletes.

It can be thought that doing training in the majority of the year and it will bring about athletes' burnout. However, in this study, the effect of annual training period on burnout has not been reached. On the other hand, the relationship between training period and effort and resistance self-efficacy were determined. Athletes who have trained for 9 months show higher effort and resistance self-efficacy than who work in 8, 10, and 11 months during year. This result shows that a 9-month training period may be more appropriate for athletes who spend most of the year training.

Conclusion

The primary purpose of this study was to examine the relationship between general self-efficacy and athlete's burnout. According to correlation analyses a negative correlation was found between effort and resistance sub-dimension and reduced sense of accomplishment sub-dimension. In the same way there was a negative correlation between ability and confidence sub-dimension with reduced sense of accomplishment sub-dimension. This result shows that athletes with high general self-efficacy level have less reduced sense of accomplishment than others. The lack of detailed studies on general self-efficacy and athletes' burnout relation in the literature makes it difficult to compare the results of the study with the literature.

Based on the results obtained, it may be suggested that athletes develop their self-efficacy in order not to be adversely affected by burnout. The relationship between general self-efficacy and athlete's burnout should be investigated in different samples with different variables.

Conflict of interest

There were no conflicts of interest.

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Application of hypoxicators in the rowers' training

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript preparation; E – Funds collection

Abstract

Purpose: Intermittent altitude exposure leads to improvements in aerobic performance and blood parameters of athletes. The variety of hypoxic devices and simulated altitude training models requires a detailed study of their effects to achieve the best results. The aim of this study was to investigate the effect of a four-week training camp at sea level conditions, combined with normobaric hypoxia, provided by hypoxicators during the night's sleep of the athletes.

Material: Sixteen rowers of the Bulgarian national team (17.13±0.83 years old) were divided into a control group (n=8) and an experimental group (n=8) subjected to hypoxia for a period of four weeks. At the beginning and end of the training camp, anthropometric and hematological data were measured. A submaximal test on the Concept II rowing ergometer was performed, and the physical work capacity and anaerobic threshold were determined.

Results: The results showed: 1) a lack of significant changes in the aerobic performance after training camp, both within and between groups; 2) at the end of the training camp in the experimental group a statistically significant increase in hemoglobin concentration (156.25±4.11 vs 162.75±4.11 g/L, $p<0.01$) and erythrocyte count (5.26±0.13 vs 5.49±0.10 g/L, $p<0.01$) was observed.

Conclusions: The encouraging results regarding the higher increase in blood oxygen-carrying capacity in the experimental group did not lead to an increased working capacity. Further research should be provided in the search for optimal hypoxic training parameters, allowing not only a rise in hemoglobin concentration, but also the preservation of blood rheological properties.

Keywords: aerobic power, hemoglobin, hypoxia training, hypoxicator, rowers.

Introduction

Sports' training is a complex process for improving physical qualities and developing a high level of technical efficiency. In endurance sports success in performance is mainly determined by the rate of both oxygen transportation and oxygen utilization. However, after several years of training these rates often reach a level which can be sustained, but not increased [1]. Thus, a performance improvement of about 1-2% is a great challenge. One of the most effective ways for further development of functional capacities is altitude training [2].

It is well known that the decreased oxygen saturation of hemoglobin at high altitude causes activation of Hypoxia Inducible Factor 1 (HIF-1), which targets the activation of genes encoding erythropoietin (EPO) and the vascular endothelial growth factor. EPO stimulates red blood cell production in order to increase hemoglobin saturation and oxygen delivery. In addition, HIF-1 regulates the genes encoding the glycolytic enzymes and glucose transporters [3]. Since hypoxia triggers ergogenic adaptation, it is of great interest for athletes because it has the potential to improve their performance. Hypoxic training includes three models: live high and train high, live low and train high, and the new trend - live high and train low (LHTL). Altitude training could be related to some side effects, such as mountain sickness, pulmonary edema, cardiac arrhythmias, and immune system dysfunction [4]. Many of these pathological states could be overcome [5] by using altitude simulation devices (hypoxicators), since they allow variations in simulated altitude and in hypoxic exposure duration. Substantial research has shown that intermittent altitude exposure via such devices leads to improvements in aerobic performance, ventilatory responses, and blood parameters [6] in a relatively short period of time [7]. Endurance athletes from many sports use hypoxic masks, tents, or chambers as part of their training programs. Moreover, hypoxic training is one of the few legal methods allowed by WADA to enhance physical endurance. The reduction of costs for traveling to and staying at high-altitude training sites, as well as avoidance of increased potential for illness due to chronic exposure to stress hormones [8, 9], are other benefits of implementation of this type of training.

The existence of different devices, as well as a variety of simulated altitude training models, requires the detailed study of their effects to achieve the best results in training and competition. Therefore, the aim of this study was to investigate the effect of four weeks of training camp at sea level using hypoxicators to provide normobaric hypoxia during the night's sleep of the athletes, the LHTL model.

Materials and methods

Participants

Sixteen athletes from the Bulgarian national youth team in academic rowing of mean age 17.13 ± 0.83 years

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with mean height 183.75 ± 4.61 cm and mean weight 77.79 ± 7.42 kg took part in the study. The rowers had about 4-5 years of training experience. They have been winners of national junior championships, international junior rake regattas, and the Balkan championships, and they have achieved from 6th to 12th at the European Championships for Adolescents and Youths.

All participants received detailed information about the objectives and conducting of the study, and signed an informed consent form in accordance with the Helsinki Declaration of Human Research.

Study design

The study was conducted over a one-month period at the team's training camp at a 600-meter altitude dam. The rowers were divided into two groups: eight athletes were subjected to hypoxia during their night-time sleep (experimental group), and another eight athletes were selected as a control group. The hypoxia was introduced by masks, connected to MAG-20 hypoxicators (Mountain Air Generator 20, Higher Peak, USA) that simulated 1600 m, 2000 m, 2400 m, and 2800 m altitude for a period of one week each (Figure 1).

The training program during the experiment was the same for both groups (Table 1). The rowers had three half days of rest – each Tuesday, Thursday and Sunday.

At the beginning and end of the training camp, the anthropometric data of the athletes (weight, height, and body composition) were measured and all participants performed a single submaximal test on the Concept II rowing ergometer. The test consisted of four three-minute exercise bouts separated by 30s rest periods. The starting workload was 200W, and the subsequent loads increased by 40W (240, 280 and 320W) - a modification according to Klusiewicz et al. [10]. At the end of each step, the heart rate was registered and during the rest periods the concentration of capillary blood lactate was measured. The test continued until a heart rate of 170 bpm, as well as a lactate concentration greater than 4 mmol/L were reached.

The test was used for determining PWC170 (Physical Work Capacity) and the anaerobic threshold – intensity of exercise at which lactate concentration reached 4mmol/L (AnT-4). The following calculations were made: PWC170 per kilogram of body weight (PWC170/BW), heart rate at AnT-4 (HRAnT-4), and AnT-4 per kilogram of body weight (AnT-4/BW). The absolute and relative maximum oxygen consumption (VO2max and VO2max/BW) and PWC170 were calculated by regression equations [10].

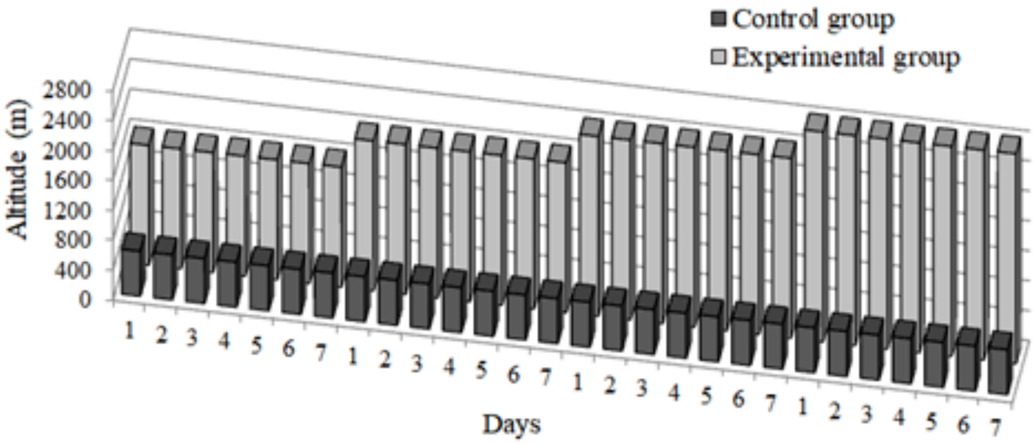

Figure 1. Experimental design. The simulated hypoxic exposure of the experimental group was eight hours every night.

Table 1. Rower's training program during experimental period

Training session character	Training session content	Part of the total training volume	One week microcycle included:
A – mixed regime training – aerobic lactic interval training	40-60 s work and 120 s rest in 3-4 series	34-35 %	4-5 building training sessions. Each training session lasted 90-100 min.
B - aerobic regime, for maintaining high level of endurance	6 x 2 min repeated and steady rowing at different distances, or 3 x 4 km rowing in the same conditions	53-55 %	3-4 maintaining training sessions for rowing technique. Each training session lasted 75-90 min.
C - aerobic regime, for maintaining high level of physical fitness and emotional recreation	Non-specific training, such as cross-country running, stretching, gymnastics exercises, and rowing ergometer training	10-12 %	4-5 general effect training sessions. Each training session lasted 30 min.

At the beginning and the end of the camp, venous blood samples were taken from the athletes.

Physical characteristics

Body Weight (BW) was measured within an accuracy of 0.05 kg, and body composition was evaluated using the bioelectrical impedance method (Tanita 418, Japan). Body Height (BH) was measured to the nearest 0.5 cm using a stadiometer. Body Mass Index (BMI) was calculated as BW (kg) divided by BH (m) squared. Hear rate was registered by the Polar H7 heart rate sensor (USA).

Biochemical analyses

Lactate concentration was measured in peripheral blood by using Lactate Pro 2, Japan.

Venous blood samples were taken by authorized medical staff, and were analyzed in a clinical laboratory for the following indicators: hemoglobin concentration, RBC count, hematocrit level, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean blood corpuscular hemoglobin concentration (MCHC), white blood cell (WBC) count and differential, platelet count and other derivatives, consisting of 22 indicators in total.

Statistical analysis

The data were analyzed statistically by using variance analysis; the reliability of the differences in the average values of the indicators was determined by Student's t-test for dependent and independent samples by SPSS statistical software (SPSS for Windows, version 16.0, 2008, SPSS Inc., Chicago, USA).

Results

Table 2 presents the basic anthropometric data of the athletes from the control and experimental groups. The average age of the rowers in the experimental group was 17.50 ± 0.58 years, while that in the control group was 16.75 ± 0.96 years. Average weight of the control group was 79.48 ± 8.22 kg and of the experimental group 76.10 ± 7.29 kg. The average stature of the control group was 183.63 ± 5.15 cm and of the experimental group 183.88 ± 4.80 cm. There were no statistically significant differences between these parameters, although some of the indexes of the rowers from the control group were higher than those of the athletes from the experimental group, as follows: weight was higher by about 3 kg, and mean fat percentage and relative muscle mass were higher by about 2-3%. Only the average BMI of the control group was about 1 kg/m^2 lower. The anthropometric indicators did not show statistically significant differences before and after the one-month training period.

Table 3 presents the results of the submaximal functional tests performed. There were no significant changes in the parameters at the beginning and at the end of the training camp both within and between groups. A very good repeatability of the achievements of the tested individuals was observed, leading to a high degree of correlation between the results of the submaximal test before and after the training camp. The calculated correlation coefficients were as follows: for AnT-4 r = 0.63311, for HRAnT-4 - r = 0.60, for PWC170 and derivative calculated VO_2max r = 0.88, and for VO_2max/BW r = 0.90.

The baseline values of the hematological parameters did not differ between both groups and were within normal limits, except for the relative lymphocyte count (LY%) (Table 4), which was significantly lower in the control group vs the experimental group ($p < 0.05$) before the training camp.

At the end of the training camp the blood indexes of the control group showed a slight, insignificant increase as the hemoglobin concentration rose from 151.00 ± 3.92 to 154.5 ± 4.20 g/L. During the period of testing the erythrocytes and hematocrit levels remained practically the same, and those of leukocytes increased slightly, albeit significantly, yet completely within the normal range (from 6.11 ± 1.04 to 6.75 ± 0.83 g/L, $p <0.05$) (Table 4).

In the experimental group at the end of the training camp a statistically significant increase in hemoglobin concentration (from 156.25 ± 4.11 to 162.75 ± 4.11 g/L,

Table 2. Anthropometric data of the athletes from the control and experimental groups.

Group		Age (years)	Height (cm)	Weight (kg)	BMI (kg/m²)	FAT% (%)	MM% (%)
Control Group	Before	16.75 ± 0.96	183.63 ± 5.15	79,48 ± 8,22	23,62 ± 2,96	14,90 ± 4,08	42,55 ± 2,31
	After			79,65 ± 8,87	23,66 ± 2,98	12,78 ± 3,68	43,63 ± 2,3
Experimental Group	Before	17.50 ± 0.58	183.88 ±4.80	76,10 ± 7,29	22,47 ± 1,29	16,38 ± 6,39	40,48 ± 4,4
	After			76,03 ± 6,74	22,46 ± 1,2	15,25 ± 3,2	40,08 ± 4,00

$p < 0.01$) and erythrocyte count (from 5.26 ± 0.13 to 5.49 ± 0.10 g/L, $p < 0.01$) were observed, and a slight but significant decrease in hematocrit levels (from 0.48 ± 0.02 to 0.47 ± 0.02, $p < 0.05$) was registered (Table 4).

At the start and the end of the training camp, in both groups, statistically significant, reciprocal changes in mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCHC) were observed. The average volume of erythrocytes measured at the beginning vs the end of the training period decreased in both groups, while the average hemoglobin concentration in erythrocytes increased.

Discussion

The anthropometric indexes of the rowers in this study are comparable to those of international standard rowers. For instance, the data for the members of the Croatian national team (2008 year) of average age 17.6 ± 0.4

Table 3. Submaximal functional test results.

Group		PWC170 (W)	PWC/BW (W/kg)	VO_2max (l/min)	VO_2max/BW (ml/kg/min)	ANT (W)	ANT-4/BW (W/kg)	HRANT-4 (bpm)
Control Group	Before	274,77 ± 59,48	3,47 ± 0,73	5,30 ± 0,45	67,14 ± 7,7	303,24 ± 13,87	3,84 ± 0,33	180,71 ± 16,12
	After	264,57 ± 41,35	3,32 ± 0,37	5,22 ± 0,31	66,01 ± 5,68	306,77 ± 38,84	3,85 ± 0,25	184,75 ± 5,69
Experimental Group	Before	252,71 ± 35,12	3,31 ± 0,21	5,13 ± 0,27	67,70 ± 3,62	288,08 ± 20,63	3,8 ± 0,27	180,23 ± 7,43
	After	253,56 ± 43,57	3,32 ± 0,34	5,14 ± 0,33	67,75 ± 2,8	274,02 ± 15,65	3,62 ± 0,23	178,05 ± 12,39

Table 4. Results of the hematological analyses of the rowers from the control and experimental group at the beginning and the end of the test period.

Group		RBC (T/L)	Hgb (g/L)	Hct	MCV (fL)	MCHC (g/L)	WBC (G/L)	LY% (%)	LY# (G/L)	Plt G/L
Control Group	Before	5,03 ± 0,30	151,00 ± 3,92	0,47 ± 0,01	93,55 ± 6,14	321,8 ± 10,21	6,11 ± 1,04	36,75 ± 3,74 eb*	2.27 ± 0.61	212,0 ± 32.83
	After	5,14 ± 0,21	154,5 ± 4,20	0,45 ± 0,01	87,5 ± 5,82 cb***	344,8 ± 10,72 cb***	6,75 ± 0,83 cb*	37,05 ± 8,50	2.54 ± 0.91	232,0 ± 25.39
Experimental Group	Before	5,26 ± 0,13	156,25 ± 4,11	0,48 ± 0,02	91,98 ± 1,9	325,0 ± 6,98	5,76 ± 0,93	45,73 ± 5,71	2.6 ± 0.33	204,0 ± 34.01
	After	5,49 ± 0,10 eb** ca*	162,75 ± 4,11 eb** ca*	0,47 ± 0,02 eb*	85,33 ± 1,65 eb***	347,5 ± 3,42 eb**	6,58 ± 1,94	46,1 ± 6,32	2.94 ± 0.45	207.2 ± 33.56

e – experimental group, c – control group, b – before, a – after, * - $p < 0.05$, ** - $p < 0.01$, *** - $p < 0.001$. Example: eb** - statistically significant vs experimental group at $p < 0.01$, before training camp.

years (n=18) showed an average body weight of 86.1 ± 4.1 kg and height average 188.9 ± 3.6 cm. Similar data were reported in the large anthropometric study of 383 (89%) rowers in the 1997 World Rowing Championship, Hazewinkel, Belgium, where the non-finalists had an average weight of 80.6 ± 5.0 kg and an average height of 186.3 ± 6.1 cm, and the finalists had an average weight of 84.8 ± 7.1 kg and an average height of 189.3 ± 5.0 cm, with an average age of 17.8 ± 0.7 years for all individuals tested [11]. Using the percentile tables of the latter study, the data of the rowers tested in this research can be evaluated as follows: the height in both groups, about 183 cm, corresponded to P25; the average weight of the control group of 79.48 ± 8.22 kg corresponded to P50, and the average weight of the experimental group of 76.10 ± 7.29 kg corresponded to P25.

According to a review of the Italian rowing federation [12], the percentage body fat of rowers is very low, with average values of 11.55 ± 2.31%.

Furthermore, the percentage body fat of the individuals tested in this study (Table 2) was slightly higher than that of the Croatian rowing champions and members of the Croatian national team (2008 year), whose athletes had 12.9 ± 2.1% of body fat [13]. However, the maximum oxygen consumption of the same group of rowers (62.5 ± 4.7 mL/kg/min), which was determined by performance of a maximum aerobic test, was a little lower in comparison to our respondents. The estimated average relative maximum oxygen consumption of the rowers tested in our study (about 67 mL/kg/min) was in accordance with the published norms for field oarsmen [14], which corresponded to the maximum score - "High".

In regards to the estimated AnT-4, the data in published literature are scanty. To the best of our knowledge only two research papers track the changes in AnT-4 in LHTL method. In a study of Polish rowers with similar to the above-mentioned anthropometric data, the average value for AnT-4 of 307 ± 41W was found [15], which is very close to our results. However, the heart rate at AnT-4 in Polish rowers was lower, 164 ± 9 bpm compared to around 180 bpm in our athletes. In the second work, volunteers were subjected to intermittent hypoxia, and although a significantly increased power output at the anaerobic threshold (228 ± 28 W to 239 ± 24 W, $p = 0.04$) was observed, there were no significant changes in VO2max and in the cycling exercise [16].

It should be mentioned that the submaximal test results obtained before and after the training camp demonstrated a high correlation. It seems that the application of this test is a good opportunity for longitudinal tracking of the functional condition of rowers without disturbing their training schedule.

The changes in the red blood count during hypoxic training are logically the most intriguing and therefore the most studied. In our experiment there were no differences between the control and the experimental groups at the beginning of the training camp, except in lymphocyte counts (LY%). It is probably due to redistribution in the number of different leukocyte types as the baseline absolute lymphocyte count (LY #) is practically the same (Table 4).

When comparing the hematological parameters at the beginning and at the end of the study a statistically significant rise in erythrocyte and hemoglobin concentrations in the experimental group was observed: from 5.26 ± 0.13 to 5.49 ± 0.10 T/L, $p < 0.01$ for erythrocytes and from 156.25 ± 4.11 to 162.75 ± 4.11 g/L, $p < 0.01$ for hemoglobin. The differences in these parameters at the end of the study between the control and the experimental group were greater. Similar observations have been reported in a hypoxic training experiment of elite Nordic skiers, under the LHTL scheme, exposed to simulated hypoxia for 11 hours a day, in three stages of 6 days at 2500, 3000, and 3500 meters above sea level respectively [17]. In the quoted study there were no changes in hematological parameters in the control group, in contrast to the experimental group, where the hemoglobin concentration increased from 147 ± 8.0 to 150 ± 4.0 g/L and the red blood cell count from 4.88 ± 0.43 to 5.08 ± 0.30 T/L. However, regardless of the improvements in the blood count, no improvement in functional parameters was observed in these athletes. The VO2max in the experimental group decreased, albeit insignificantly from 61.7 ± 4.4 to 59.3 ± 2.0 mL/kg/min [17]. In another study, where two groups of highly trained athletes were subjected to 8 hours per night for two consecutive nights a week over 3 weeks under either short-term normobaric hypoxia (simulating 3636 m altitude) or in normobaric normoxia, there was no improved aerobic or anaerobic performance, although short-term normobaric hypoxia exposure increased the levels of a number of hematological parameters [18]. Our results also did not show changes in VO2max at the end of the training camp.

In addition to the blood oxygen-transporting capacity the rheological properties of the blood should also be considered. Blood fluidity has been reported previously to positively correlate with aerobic working capacity, the performance time until exhaustion, and blood lactate response [19]. In addition to hemodynamic parameters, improvements in hemorheological parameters are likely to aid better performance. Increased blood fluidity may improve oxygen delivery to muscles during exercise in well-trained individuals [20].

Among the parameters tested by us at the end of the study, compared to the beginning, we observed in the experimental group a slight but significant hematocrit reduction from 0.48 ± 0.02 to 0.47 ± 0.02, which is contrary to an increased erythrocyte count (RBC) and increased hemoglobin, and is probably due to a decrease in the average volume of erythrocytes (MCV) (Table 4). These changes in MCV could represent the physiological principle for maintenance of favorable blood viscosity [21]. However, a recent study [22] demonstrated that high MCHC and low MCV had a negative impact on the deformability of erythrocytes and correlate with their increased rigidity. In this way the rheological properties of the blood deteriorate. The lack of progress in aerobic performance against the improved blood oxygen-transporting capacity, noted by us and by other authors [18], may be due to a reciprocal deterioration in the blood rheological properties associated with MCV reduction and MCHC increase, and thus, a difficult passing of erythrocytes through microcirculation. The negative impact of hypoxia on blood viscosity has been demonstrated on experimental animals that were subjected to 5 weeks chronic and intermittent (8 hours per day) hypoxia [23]. The results suggested that intermittent hypoxia and continuous hypoxia led to increased whole blood viscosity that impairs the functions of red blood cells and promotes platelet aggregation in rats.

Conclusions

Our results suggest that: 1) the submaximal rowing specific test used by us is suitable for studying the dynamics of AnT-4 and PWC170 without disturbing training schedules; 2) one-month training at low altitude, combined with 8 hours hypoxic application per night, does not increase the physical fitness performance in rowers with very high aerobic capacity; 3) the deterioration in the blood rheological properties could be a reason for the lack of improvement in working capacity, despite the increased blood oxygen-carrying capacity in the experimental group.

Further research should be carried out in search of optimal hypoxic training parameters that lead not only to a rise in hemoglobin concentration and erythrocyte count, but also preserve the rheological properties of blood.

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Conflict of interests

The authors declare that there is no conflict of interests.

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Instruction-based selective action pattern (IBSAP): a novel method for talent identification in sports

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Abstract

Purpose: Talent identification/development programs are utilized by sports federations to select or train elite athletes. In addition to the established tests that assess perceptive and motor skills, it was deemed significant that cognitive skills should be evaluated as well. The present study was undertaken to assess the utility of Instruction-Based Selective Action Pattern (IBSAP), a novel method that we developed, in estimating perceptive, motor as well as cognitive skills of athletes in order for talent identification. We also investigated the relationship between IBSAP and auditory reaction times (ARTs).

Material: Forty-three students (average age: 12.6 years) participated in the study. Random/fixed-interval ARTs were recorded. IBSAP was applied using a table tennis robot that was set up to throw 30 balls in three different colors to different spots on the table with a frequency of 1 ball/s. The subjects were instructed to ignore the white balls, to touch the yellow balls, and to catch the pink balls before the first trial and their scores were calculated in two consecutive trials according to a scoring system.

Results: Our results showed that motor learning, adaptation and reinforcement of the participants were significantly greater in second trial compared with the first trial and that IBSAP values were correlated with ARTs.

Conclusions: We conclude that the IBSAP method reliably provides quantitative data on perception, motor as well as cognitive skills and it can be considered as a useful tool for talent identification.

Keywords: auditory reaction times, cognitive skills, motor skills, perception, table tennis, talent identification.

Introduction

Success in sports, as measured by competitive performance, is dependent upon a number of significant mental and physical components. Age, somatotype, genetic endowment, nutritional status, physiology, psychology, training level, and risk of injury are all major independent variables influencing the performance [1]. Besides the unmodifiable factors, some of which are described above, routine training, motivation and professional guidance since childhood towards a branch of sports are the most significant keys to athletic success [2, 3].

Either individualistic or a team sport, excellent perceptive and motor skills and top level cognitive skills such as intuition and decision making are required in order to achieve the level of an elite athlete in most branches of sports. During a game, an athlete should rapidly adapt to several varying conditions (the opponent, ball, environmental conditions, psychological status, etc.), implement the game plan according to her or his coach, maintain the concentration and mental endurance until the end of the game, and perform the right action at the right time even if fatigue becomes prominent [4, 5].

Perceptive, cognitive and motor skills coexist in different proportions in all branches of sports [6-8]. However, in sports branches where time is minimized to reflexes and perceptive and motor abilities reach maximum limits, mental and cognitive components become the significant determinant for the differences between athletes [9-11].

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Athletic achievement in Olympics and international competitions is an important sign of strength. Financial revenue created by sports resembles a market where more is desired everyday by clubs, sponsors and the athletes. Thus, it is of utmost importance for national athletic federations and sports clubs to select athletes with a potential for success in future. Today, many national federations select young athletes via talent identification / development programs and follow up their progress [12-14]. Most of the skill tests used in these talent identification and development programs assess perceptive and motor skills [15-17]. However, due to the fact that mental and cognitive skills play a more significant part in athletic achievement, tests that assess cognitive skills in particular has attracted significant attention recently [18-20]. Most cognitive tests are applied either desk-bound or as simulation tests and are far from the ecologic nature of sports [21, 22]. In addition, it is suggested that all skills (perceptive, motor and cognitive) must be evaluated by tests that mimic all components of performance in sports [23, 24]. However, to the best of our knowledge, no method that evaluates cognitive skills along with perception and motor skills in a single test has been published yet in the literature.

In a recent manuscript reviewing the test methods used for talent identification among young racket athletes, Faber et al [24] reported that more than 100 tools which focused on intellectual and perceptive skills were used in these tests, and that coordinative skills were determinative in identifying the future elite athletes. In accordance, the hand-eye coordination test that the authors developed was demonstrated to be a valid test for table tennis athletes [25].

We developed, in our previous studies, a method that we had named "Selective Action Array" in order to reveal the diversities in table tennis. The Selective Action Array is a useful tool for obtaining basic information on perceptive, cognitive and motor skills as well as associating such cognitive skills as attention, maintenance of concentration, learning and reinforcement with motor skills in a quantitative manner. This method allowed us to compare the differences in skill levels of table tennis athletes with non-athletes [26] or with advanced computer game players [27], and make comparisons between genders in table tennis athletes [28].

In the present study, we investigated whether our method could be utilized for talent identification in sports. In addition, we evaluated the relationship between our method and the auditory reaction time, which is an indicator of perception and motoric outcome, and generally regarded as a useful parameter for talent identification. In an attempt to express the content and purpose of the study more clearly, we have revised the name of this method as *"Instruction-Based Selective Action Pattern" (IBSAP)* since this expression is more accurate due to the fact that the participants are given solid instructions and their action patterns are quantified before and after the test, respectively.

Material and Methods

The study was conducted at Faculty of Sports Sciences at Uludag University, Bursa, Turkey, during February and March, 2014. Ethical approval was obtained from Uludag University Ethics Committee on Clinical Research.

Participants

Participants included a total of 43 students (27 females and 16 males) at a mean age of 12.6 ± 0.8 (range 11-14) years with middle and low socio-economic status from peripheral villages of Bursa province who practiced beginner level taekwondo. They participated in this study during the 2nd and 3rd weeks of taekwondo training between 10:00 – 12:00 hours. Signed informed consents were provided by themselves and their parents before the study onset.

The students were inquired about demographic and general health information, engagement in sports, and their dominant hands. They did not suffer any acute or chronic disease and nor had visual/auditory impairment either at the time of inclusion or on the day of test procedure. We determined that none of the female students was previously trained in a sports discipline under supervision of a coach while only two male students were officially trained by a coach in a summer camp or course (football and taekwondo).

Measurements of height, weight, and whole body impedance (WBI) were performed for all participants using Tanita BC-418® (TANITA Corporation, Tokyo, Japan) device. Later on, subjects' auditory reaction times (ARTs) were recorded using BioPac MP36® (BIOPAC Systems, Inc., CA, USA) system. On performing the ART, the device was set up to perform a click sound with random intervals (RIs) in the initial 10 trials and with fixed intervals (FIs) in the following 10 trials. The subjects were asked to push a button using their dominant hands when they heard the click sound in their headphones. Mean values (expressed as milliseconds; ms) for each 10 trials were determined as RI-ART and FI-ART.

Instruction-Based Selective Action Pattern (IBSAP)

IBSAP was applied with a table tennis robot (Butterfly/

Table 1. Scoring system.

Athlete's Reaction to each White Ball (initially instructed to ignore the white balls)	Points earned at each white ball
Ignored	6
Reacted but did not touch	4
Touched	2
Caught	**0**
Athlete's Reaction to each Yellow Ball (initially instructed to touch the yellow balls)	**Points earned at each yellow ball**
Touched	6
Reacted but could not touch	4
Caught	2
Ignored	**0**
Athlete's Reaction to each Pink Ball (initially instructed to catch the pink balls)	**Points earned at each pink ball**
Caught	6
Reacted but could not catch	4
Reacted but could not touch	2
Ignored	0

Amicus-3000) [Tamasu Butterfly Europa GmbH, Düsseldorf, Germany]). The robot was programmed to throw a total of 30 balls in three different colors (white, yellow and pink; 10 balls each) randomly at the same speed at a frequency of 1 ball per second that were directed to different spots on the table. The subjects were clearly instructed to ignore the white balls, touch the yellow balls, and catch the pink balls using their dominant hands after the ball bounced once on the table, but were not given a chance to observe the procedure. The instructed responses to the white, yellow and pink balls were considered to serve to the purpose of performing a minimum, moderate and maximum difficulty level, respectively. Responses of the participants to each colored ball were transferred into points on a scale of 0 to 6 (Table 1). Six points referred to ignoring the white ball, touching the yellow ball and catching the pink ball. The sum of color points for each colored ball was expressed as "color score"; the sum of color scores for all balls was expressed as "total score" and the percentage of 6-point responses of the participant to each colored ball was expressed as "% 6-point response". Two consecutive trials were conducted with a very short interval (approximately 1-2 min) covering the time spent for setting up the robot for the second trial. All trials were recorded on video camera.

Statistical Analysis

Results are presented as mean, standard deviation, and minimum and maximum values. In-group dependent variables were compared using paired t-test and Wilcoxon rank sum test for normally and abnormally distributed variables, respectively. Between-group comparisons were conducted with t-test and Mann-Whitney U-test for normally and abnormally distributed variables, respectively. Spearman test was used for correlation between reaction times, as well as for correlation between reaction times and IBSAP parameters. Significance level was set at $p<0.05$.

Results

Descriptive statistics and measurements of height, weight, body mass index (BMI), body fat percentage and fat content as well as WBI of participants obtained by using Tanita BC-418 device have been presented in Table 2. We found no significant difference in terms of age, height, weight, BMI and fat content between female and male participants, while body fat percentage and WBI of the females were significantly ($p<0.05$) higher than those of the males (Table 2).

Table 3 demonstrates RI-ART and FI-ART values for all participants as well as for females or males separately. Although the males were faster for an average of 25 ms (10%) in both RI-ART and FI-ART than females, the difference was not statistically significant (Table 3). On the other hand, FI-ART was significantly shorter for 45 ms than RI-ART, for all participants ($p<0.001$) as well as when females ($p<0.001$) and males ($p<0.01$) were considered separately (Table 3). These findings suggest that predictable auditory input decreases the reaction time of participants by about 16%, and this effect is independent of the gender.

IBSAP Results

Color scores, total scores and % 6-point response values obtained in 1st and 2nd trials in IBSAP are presented in Tables 4 and 5. Our results showed that color scores and % 6-point response values for each colored ball (Table 4) as well as total scores for all balls (Table 5) were

Table 2. Age, height, weight, body mass index (BMI), body fat percentage and fat content, and whole body impedance (WBI) of subjects.

Descriptive	Total (n=43)	Female (n=27)	Male (n=16)	p
Age (year)	12.6 ± 0.8 (11-14)	12.5 ± 0.8 (11-14)	12.8 ± 0.7 (12-14)	p>0.05
Height (cm)	153.0 ± 6.7 (133-165)	153.0 ± 5.7 (142-163)	152.0 ± 8.3 (133-165)	p>0.05
Weight (kg)	43.9 ± 9.3 (23.8-65.8)	42.8 ± 7.7 (27.0-60.5)	45.9 ± 11.5 (23.8-65.8)	p>0.05
BMI (kg/m^2)	18.7 ± 3.1 (12.0-27.2)	18.2 ± 2.6 (12.0-23.6)	19.6 ± 3.8 (13.5-27.2)	p>0.05
Body Fat%	20.2 ± 5.3 (12.1-31.9)	21.6 ± 4.1 (12.4-31.3)	17.9 ± 6.3 (12.1-31.9)	**p<0.05**
Fat (kg)	9.2 ± 3.9 (3.2-19.3)	9.5 ± 3.3 (3.4-18.9)	8.6 ± 4.8 (3.2-19.3)	p>0.05
WBI (ohm)	694.0 ± 95.3 (514-953)	721.4 ± 59.4 (630-851)	648.5 ± 125.5 (514-953)	p<0.05

Table 3. Comparison of random interval auditory reaction times (RI-ARTs) and fixed interval auditory reaction times (RI-ARTs).

Participants	RI-ARTs (ms)	FI-ARTs (ms)	p
Total (n=43)	285.3 ± 58.9 (206-551)	240.0 ± 54.8 (173-437)	**p<0.001**
Female (n=27)	294.0 ± 63.2 (222-551)	249.4 ± 58.6 (191-437)	**p<0.001**
Male (n=16)	270.6 ± 49.1 (206-370)	224.2 ± 45.1 (173-310)	**p<0.01**
p	p>0.05[a]	p>0.05[a]	

[a]: Female versus male

significantly higher in the second trial than those in the first trial. In addition, color scores and % 6-point response values of participants differed significantly between colored balls (i.e., the highest scores and success rates were obtained with responses to white balls and the lowest scores and success rates were obtained with responses to pink balls) in both the first and the second trials (Table 4). These findings suggest that the significantly greater scores obtained in the second trial are associated with adaptation of the participants to the test procedure and motor learning. Moreover, the difference in color scores and % 6-point response values between colored balls confirmed the gradual difficulty level of the IBSAP.

Comparisons of the data obtained by the IBSAP with regard to gender are presented in Table 6. No difference was detected in color scores and % 6-point response values for the white ball between the genders in either the first or the second trial. A significant difference between genders (i.e., males scored greater) for the yellow ball was detected in the first, but not the second trial, while males scored greater in both trials with the pink ball. Total scores of the males in the first trial were significantly higher than those of the females while the difference was not significant in the second trials. These findings show that there is a significant gender difference in favor of males in association with the difficulty level of the IBSAP test and suggest that this difference may derive from adaptation and motor learning capabilities as well as the readiness levels of males.

In an attempt to investigate the relationship between RI-ART and FI-ART, we found a positive correlation demonstrated by the finding that participants who had shorter RI-ARTs, had also shorter FI-ARTs (p<0.001, r=0.786) (Table 7). No relation was found between FI-ART and color scores, total scores and % 6-point response values. On the other hand, there was a significant negative correlation between RI-ART and the responses of the participants to the yellow and pink balls in the first, but not second trials. This finding shows that participants with shorter RI-ARTs scored higher during first trials with moderate and maximum difficulty levels confirming that randomness in the sound stimulus and the randomness in ball throwing overlapped. In contrast, the correlation between RI-ART and participants' responses was compromised in the second trial which is probably due to motor learning.

Table 4. Results obtained in first and second trials for each colored ball in IBSAP.

IBSAP Parameters	WHITE (n=43)		YELLOW (n=43)		PINK (n=43)	
	First Trial	Second Trial	First Trial	Second Trial	First Trial	Second Trial
Color score (max: 60 points)	54.2 ± 5.6 (28-60)	56.8 ± 5.1 [a] (28-60)	46.2 ± 9.6 [b] (19.1-60)	52.4 ± 6.9 [a, d] (30.4-60)	34.8 ± 11.2 [b, c] (11.4-55.7)	43.1 ± 9.7 [a, d, e] (16.8-57.3)
% 6-point response	79.4 ± 16.5 (16-100)	89.7 ± 14.0 [a] (20-100)	61.6 ± 21.9 [b] (18.8-100)	77.5 ± 18.4 [a, d] (35-100)	22.3 ± 23.6 [b, c] (0-78.6)	37.3 ± 25.6 [a, d, e] (0-89.5)
n of participants with 6-point response to all balls in each color	2	11	1	5	0	0
n of participants with no 6-point response to all balls in each color	0	0	0	0	12	4

[a], Compared with first trial values within same colored ball; p<0.001

[b], Compared with first trial values of the white ball; p<0.001

[c], Compared with first trial values of the yellow ball; p<0.001

[d], Compared with second trial values of the white ball; p<0.001

[e], Compared with second trial values of the yellow ball; p<0.001

Table 5. Results obtained in IBSAP with all balls in first and second trials.

IBSAP Parameters	First Trial (n=43)	Second Trial (n=43)	p
Total score (max: 180 points)	135.3 ± 19.3 (90.5-167.9)	152.4 ± 16.1 (118.8-176.3)	**p<0.001**
n of participants receiving < 100 points	2	0	
n of participants receiving > 160 points	5	16	

Table 6. Comparison of gender with regard to data obtained in IBSAP.

Color score		**Female (n=27)**	**Male (n=16)**	**p**
White	First Trial	54.3 ± 4.3 (40-58.9)	54.0 ± 7.5 (28-60)	p>0.05
	Second Trial	57.1 ± 2.9 (49.5-60)	56.4 ± 7.7 (28.4-60)	p>0.05
Yellow	First Trial	44.5 ± 8.5 (19.1-56.3)	49.1 ± 10.9 (20-60)	p<0.05
	Second Trial	51.9 ± 6.2 (37.7-60)	53.3 ± 8.0 (30.4-60)	p>0.05
Pink	First Trial	30.9 ± 9.1 (11.4-50.4)	41.4 ± 11.7 (12.5-55.7)	p<0.01
	Second Trial	40.4 ± 8.6 (16.8-54.7)	47.8 ± 9.9 (22.2-57.3)	p<0.01
Total score				
	First Trial	129.8 ± 17.8 (90.5-163.1)	144.6 ± 18.5 (101.4-167.9)	p<0.05
	Second Trial	149.4 ± 14.4 (118.8-174.7)	157.4 ± 18.0 (121.2-176.3)	p>0.05
% 6-point responses				
White	First Trial	79.0 ± 13.8 (47.4-95.7)	80.2 ± 20.8 (16-100)	p>0.05
	Second Trial	89.7 ± 10.0 (63.6-100)	89.6 ± 19.4 (20-100)	p>0.05
Yellow	First Trial	53.6 ± 18.6 (18.8-86.4)	75.0 ± 20.9 (25-100)	p<0.01
	Second Trial	74.0 ± 19.2 (35-100)	83.3 ± 15.8 (47.8-100)	p>0.05
Pink	First Trial	10.9 ± 17.1 (0-60)	41.6 ± 20.7 (3.4-78.6)	p<0.001
	Second Trial	25.6 ± 19.5 (0-73.3)	57.1 ± 22.6 (12.5-89.5)	p<0.001

Table 7. Relationships between random interval auditory reaction times (RI-ARTs), fixed interval auditory reaction times (FI-ARTs), and IBSAP values.

Reaction times ***IBSAP Parameters***		**RI-ARTs**	**FI-ARTs**
RI-ARTs			**p<0.001 r=0.786**
FI-ARTs		**p<0.001 r=0.786**	
IBSAP Color score			
White	First Trial	p>0.05	p>0.05
	Second Trial	p>0.05	p>0.05
Yellow	First Trial	**p<0.01 r=-0.408**	p>0.05
	Second Trial	p>0.05	p>0.05
Pink	First Trial	**p<0.05 r=-0.332**	p>0.05
	Second Trial	p>0.05	p>0.05
IBSAP Total score			
	First Trial	**p<0.05 r=-0.317**	p>0.05
	Second Trial	p>0.05	p>0.05
IBSAP % 6-point responses			
White	First Trial	p>0.05	p>0.05
	Second Trial	p>0.05	p>0.05
Yellow	First Trial	**p<0.01 r=-0.409**	p>0.05
	Second Trial	p>0.05	p>0.05
Pink	First Trial	**p<0.05 r=-0.323**	p>0.05
	Second Trial	p>0.05	p>0.05

Discussion

In the present study, we describe the utility of a novel method, Instruction-Based Selective Action Pattern (IBSAP), in talent identification and its relation with auditory reaction time. This method has the potential to provide a collective idea about perceptual, motor and cognitive skills. It was structured by a total of 30 balls in 3 different colors thrown at a frequency of 1 ball per second on different spots of a table by a table tennis robot. The participants were instructed to perform 3 different actions with gradually increasing difficulty levels based on the color of the balls immediately before the test. The method was performed in two consecutive trials which provided the ability to correlate cognitive concepts such as adaptation, motor learning and reinforcement with motor skill. In addition, visual perception/attention, continuity of concentration and motor coordination were assessed by testing different skill levels such as catching and releasing some of the balls (pink), touching some others (yellow), and ignoring the rest (white).

The reason for developing the IBSAP with two consecutive trials is that the method governs the potential to evaluate cognitive performances of the participants in addition to motor skills. In the first trial, the subjects attempted to perform the actions that they were instructed, but never witnessed before. In the second trial however, the participants were already experienced and the success rate was higher due to motor learning, reinforcement and adaptation (to the environment, the ball, bounce of the ball, and catching it using their hands). Therefore, it could be suggested that participants who scored higher in the first trial had a higher level of readiness, and those who had greater differences between their first and second trials experienced better learning and adaptation processes.

The fundamental logic of the IBSAP comes from the fact that a separate action was assigned to balls in different colors. Significant differences in color scores and % 6-point response values in each colored ball indicate the successful designation of gradually increasing difficulty levels in this method. In accordance, we found that scores of participants in their second trials with higher difficulty level (pink vs. yellow/white and yellow vs. white) were not achieved in their first trial with lower difficulty level (white vs. yellow/pink and yellow vs. pink) (Table 4).

We also investigated gender difference in the present study. Males scored higher in both trials at maximum difficulty level (pink balls), in only the first trial at moderate difficulty level (yellow balls) but no difference was detected between males and females at minimum difficulty level (white balls) in two trials. The difference between the genders at moderate difficulty level was not detected in the second trial due, probably, to motor learning achieved by females, while at the maximum difficulty level, even motor learning was not adequate to catch up with the males' scores. These findings suggest that the degree of difficulty among different colored balls were set up appropriately in this method and performing the test by two consecutive trials reveals positive consequences. Higher motor readiness level of males was demonstrated by the IBSAP.

The positive correlation between RI-ART and FI-ART that we showed in the present study is in good accord with previous reports [29, 30]. In addition, that FI-ART had no relationship with IBSAP parameters as shown in our study could be expected since the constant pattern of the FI-ART measurement and the internal complexity of IBSAP are two irrelevant conditions. The relationship between RI-ART and IBSAP parameters, however, is rather interesting. As demonstrated in Table 7, no relation exists between RI-ART and responses of the participants at minimum difficulty level while RI-ART is negatively correlated with participants' responses at first, but not second, trials of moderate and maximum difficulty levels. These findings show that the randomness in the time of arrival of the balls and randomness of the auditory stimuli coincide during first trial and with learning at second trial, this relationship disappears. Therefore, the relationship between RI-ART and moderate to maximum difficulty levels at first trials suggests that the IBSAP could be an efficient talent identification method.

A number of previous studies reported the significance of assessing eye-hand coordination in table tennis [25, 31]. Faber and colleagues developed an eye-hand coordination test on children at 7-12 years of age in which children needed to throw a ball against a vertical positioned table tennis table with one hand and to catch the ball correctly with the other hand as frequently as possible in 30 seconds [25]. Four different test versions were assessed varying the distance to the table (1 or 2 meter) and using a tennis or table tennis ball in this test. The authors showed that the best version for talent identification was the one which was performed by catching the table tennis ball from 1 meter and suggested that the eye-hand coordination test that they developed could be used as a skill selection test. Although the test developed by Faber and colleagues [25] is compatible with the ecological nature of table tennis, it only provides assessment for perceptiomotor skills, while cognitive skills cannot be evaluated. However, our IBSAP method enables assessment of perceptual selectivity, different motor skill levels as well as cognitive skills. In addition, the eye-hand coordination test includes a time constraint while IBSAP does not. Therefore, the process that continues until scoring a point in racquet sports can be considered to be well-reflected in the IBSAP.

In a study by Toriola and colleagues [32], the relation of initial ball-balancing and -bouncing skills of beginner-level table tennis players with their achievements in a table tennis tournament after a period of training was investigated. Interestingly, the authors reported a negative correlation between initial ball control skill scores of the participants and their rankings at end of the table tennis tournament. Therefore, assessing solely the motor skills by coordination tests may not represent an optimum method and additional procedures testing cognitive skills should be considered for a multidimensional evaluation of talent identification.

Reaction time and inhibitory control as a function of cognition were investigated using a novel method which was tested on badminton athletes [33]. However, in this test cognitive skills were investigated in association with a single motor movement while in our method cognitive skills were associated with motor skills at three gradually-increasing levels of difficulty.

The primary limitation of the present study is the lack of reliability and validity studies on the method. The student group that we included in the study was discharged from their training unexpectedly, thus preventing us to conduct the planned further tests.

However, the primary objective of the present study was to evaluate quantitatively motor and cognitive skills of participants initially and measure their relations with data obtained in the second trial using the same experimental set up. Therefore, in brief, the purpose of the method is to find the measure of how quickly a person can adapt to a situation that is encountered for the first time. The difference in points between the two trials is indicative of this adaptation. In racquet sports particularly, playing 3 to 7 sets and winning 2 to 4 of them is associated not only with motor skills but also with adaptation and learning processes and the player's chance of winning the game is higher with adaptation to opponent's style, in cases where motor skills are similar.

Conclusion

In conclusion, the method that we developed and presented in this report allows assessment of an individual's (i) visual attention/perception, (ii) cognitive skills/functions such as, motor learning ability, adaptation and reinforcement, and (iii) motor readiness levels. Therefore, in today's world where assessment of cognitive components has become significant in athlete selection, our method may provide a useful tool for predicting cognitive skills in addition to perceptual and motor skills particularly in racquet sports like table tennis due to its ecological nature both in terms of method and game process. In order to test whether our method could predict an elite athlete, it would be interesting to follow-up the best scorers in the present study for whether they would succeed in a sports branch in the future. In addition, the method could be modified in several aspects to evaluate performances of elite athletes. Hence longer-term studies, perhaps including various modifications, are warranted for this purpose.

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Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Analysis of muscle tone and strength and cerebral blood flow in kickboxers

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Abstract

Purpose: the article deals with providing a characteristic of muscle and tone status as well as precerebral and cerebral hemodynamics in kickboxers.

Material: 102 athletes with the qualification from the Second-class Athlete to the Master of Sport voluntary participated in the study. The average age of athletes at the moment of the study was 20.90±0.50. The average sports experience of participants was equal to 4.15±2.77. The control group consisted of apparently healthy young males of the same age but not involved in sports activities (n=35). The indicators of muscle tone and strength and cerebral blood flow were studied with the help of Doppler ultrasound of the main arteries of the head, electroneuromyography, and transcranial Doppler.

Results: the article provides the results of the study on the effect of muscle and tone disturbances in the spinal motion segment on the functional status of precerebral and cerebral blood flow. The disturbances in nerve conduction velocity in the symmetrical groups of trunk muscles are considered as the reason for muscle imbalance in 50% of athletes. The analysis of blood flow indicators in kickboxers with muscle imbalance revealed a typical increase in the tone of precerebral vessels and changes in the gradients of blood flow velocity in various segments of the carotid and vertebral arteries. The decrease of cerebral blood flow in athletes, in particular, the venous outflow of a dystonic nature, is the result of spasmodic and ischemic Doppler patterns against a decreased indicator of arteriovenous balance. Mild traumatic brain injuries should also be taken into account when speaking about the development of cerebrovascular dysfunction as a result of kickboxers' sparring activities and competitions.

Conclusions: Differentiated disturbances in sensory and motor conductivity result in the disturbance of afferentation and muscle imbalance intensity. Angiospasm and vascular ischemia determine the increase in the linear blood flow velocity in the carotid system and the decrease in the vessels of the vertebrobasilar system against the increase in resistivity indicators in the carotid basins and vertebrobasilar system in kickboxers. Correlation analysis revealed visceral motor correlations, which proved the influence of the functional status of the regional muscle system on cerebral hemodynamics. The analysis of tone and strength muscle characteristics and cerebral blood flow in kickboxers indicates the necessity of correcting muscle and tone asymmetry of the paravertebral area.

Keywords: electromyographic indicators, muscle imbalance, cerebral blood flow, kickboxers.

Introduction

Modern integral training for kickboxers includes the system of competitive exercises, which comprises acyclic, ballistic, and gravitational dynamic exercises of submaximal power. As a rule, competitive exercises are performed in an overcoming regime [1]. The effects of the methods aimed at forming the psychomotor characteristics of motor skills in kickboxers have been described [2, 3].

Monitoring technologies for establishing "the price" of body adaptation to training conditions have been developed. The information value of indicators (functional status of the cardiovascular and central nervous system, biomechanical and goniometric parameters) which determine a favorable prediction of sports performance has been established [4].

Many factors influencing directly and indirectly precerebral and cerebral blood flow in athletes have been described in the literature. Several scientific studies dedicated to the analysis of the athletes' brain by using non-invasive, neurophysiological, and neurovisual methods [5, 6] emphasize a dominating contribution of the central nervous system in sports achievements.

The quality of the cognitive processing of visual, auditory, and somatosensory stimulation is determined by adaptation changes in the neural chains of the athletes' brain. It was shown that reinforced neural networks and plastic changes were the result of the integration between sensorimotor coordination, stimulus discrimination, attention, and fast decision-making [7, 8].

Mild traumatic brain injuries are quite often the result of using kicking techniques in boxing and kickboxing. According to several studies [9-11], mild traumatic brain injuries result in various pathophysiological changes. These changes in brain functioning are manifested in the following symptoms: headache, dizziness, difficulties

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with attention [11] and spatial memory in athletes [12].

However, there is no sufficient coverage for the frequency of diagnosing locomotor disturbances in apparently healthy athletes, in particular, postural muscle imbalance, muscle tone and strength disturbances, functional blockades in certain regions of the spine, etc. [13].

For a better understanding of the neurobiological mechanisms of cerebral hemodynamics, as well as their role in remodeling the structure and functions of arteries in athletes [14], it is necessary to study the correlation between the symptoms of the functional disturbances of various genesis.

The issue of the effect of muscle and tone disturbances in spine segments on central and peripheral blood flow remains relevant for sports physiology and medicine. Athletes' professional activity, especially when it comes to highly skilled wrestlers, is characterized by the specific changes in motor and visceral correlations. It is established that intensive load affects both the performance of the locomotor apparatus and functions of other visceral systems [15, 16]. There are different reasons for locomotor tissue stress: training efforts above the threshold of athlete's abilities, a sharp increase in load intensity, changes in sports technique without body adaptation.

Locomotor tissue stress is manifested in the form of hypoxia, hypoxemia, muscular hypertonia, microcirculation disturbances, etc. [17-19]. Some studies reveal that multiyear muscle stress in the neck region results in the compression of the spinal artery and blood flow disturbances in the vertebrobasilar system.

In athletes with predominantly unilateral stress, the study of precerebral and cerebral blood flow is considered as the most important.

Aim: the study is aimed at establishing and estimating the correlation between electroneuromyographic indicators and blood flow in kickboxers.

Materials and methods.

Participants. 102 athletes with the qualification from the Second-class Athlete to the Master of Sport voluntary participated in the study. The average age of athletes at the moment of the study was 20.90±0.50. The average sports experience of participants was equal to 4.15±2.77. The control group consisted of apparently healthy young males of the same age but not involved in sports activities (n=35).

Research Design.

Electroneuromyography. Tone and strength characteristics, as well as the speed of excitation propagation in motor and sensory fibers, were estimated with the help of Neuromatic 2000 equipment (Dantec, Denmark). The indicators of surface electromyogram (EMG) in all participants corresponded to type I in compliance with Yusevich Yu. [20]. EMG with an amplitude of more than 300 mkV was recorded. A direct proportional dependence was registered between muscle power and the EMG amplitude of maximal voluntary effort. Qualitative and quantitative EMG assessment in various spine segments at maximal stress revealed asymmetrical amplitude indicators typical for muscle imbalance.

Doppler ultrasonography. Both the US Doppler of the main arteries of the head and transcranial Doppler were conducted by using «Smart-lite» (Rimad, Israel) equipment with color flow mapping and the automatic recording of microembolic signals. The insonation of proximal and distal segments of the common carotid artery, subclavian arteries, the internal and external carotid artery, the vertebral artery in three segments at the extracranial level was conducted with the help of transmitters with a generated frequency of US signal of 2.4 MHz. The transcranial study was accompanied by the insonation of the vessels of the carotid basin – anterior, middle, and posterior left and right brain arteries – and vertebrobasilar vessels – left and right vertebral arteries (4th segment) and the main (basilar) artery. Tables demonstrate the values of the linear blood flow velocity (LBFV), Pourcelot resistivity index (RI), and carotid gradients of the common carotid artery (CCA), internal carotid artery (ICA), external carotid artery (ECA), right and left vertebral arteries of the first and second segments (LVA1, LVA2, RVA1, RVA2), posterior, middle, and anterior brain arteries (PBA, MBA, ABA), main (basilar) artery.

Statistical Analysis. Statistical calculations were performed in the SPSS 12.1 licensed program. The data are provided in averaged values. To reveal correlations and their character, we used correlation analysis (r).

Results.

The analysis of the background ENMG muscle parameters.

In kickboxers, we revealed a decreased speed of excitation propagation in afferent and efferent fibers compared to standard values. In the majority of the athletes (90.72%), we also revealed Grade I sensory conductivity disturbances. The decrease in this indicator did not exceed 25.0% compared to standard values. Almost half of the kickboxers (45.36%) demonstrated a mild disturbance of conductivity in motor fibers. Deviations were up to 15.0% from standard values with no clinical signs. 42.27% of the sample had a simultaneous conductivity disturbance in the sensory and motor fibers of peripheral nerves. The subclinical signs of sensory polyneuropathy were registered in 37.11% of kickboxers, motor polyneuropathy – in 3.09%.

We performed a quantitative assessment of tension amplitudes in certain groups of muscles. In 20.0% of the kickboxers, we registered a homogeneous distribution of tone in posterior neck muscles (deep neck extensors). Increased muscle tone on the right side was revealed in 31.4% of the sample, on the left side – in 48.6%. The analysis of amplitude asymmetry and imbalance in the symmetrical areas of muscles on the right and the left side revealed that, in 60.0% of the athletes, the imbalance was up to 50.0%. For example, the asymmetry of tension amplitude in the trapezius muscle on the right and the left side was equal 48.0%. The same tendency was registered in the group of muscles responsible for the spine extension in the thoracic spine area. The absence of muscle imbalance was revealed only in 28.0%.

Significant quantitative changes were revealed in the area of the lumbar spine. The increased tone in the muscles on the right side was registered in 25.7% of the athletes, on the left side – in 45.7%, the absence of the pronounced asymmetry in muscle tone was established in 28.6%. The intensity of changes in the area of the lumbar spine differed compared to the areas above this region: we registered a muscle imbalance of up to 50.0% in 89.0% of the athletes and up to 70.0% in 11.0%.

Precerebral and cerebral blood flow in kickboxers. Table 1 demonstrates the linear blood flow velocity (LBFV), Pourcelot resistivity index (RI) of precerebral vessels, and the segmental assessment of vertebral arteries. The increased values of blood flow velocity in the carotid and vertebral arteries on the right and the left side are the result of an increase in systolic (LBFV syst.) and decrease in diastolic (LBFV diast.) blood flow velocity. The gradient between the common carotid and internal carotid arteries exceeded the reference values and was equal to 1.56-1.62 c.u.; the gradient between the internal and external carotid arteries was below reference values – 0.78-0.86 c.u.

To reveal latent disturbances in the hemodynamics of the vertebrobasilar system, we studied blood flow indicators in all segments of the vertebral arteries – I, II, III – at the extracranial and the intracranial level (IV) at the initial state and under contralateral rotation. Table 1 shows that the vertebral gradient in kickboxers was 73.0% higher compared to the control group.

The analysis of cerebral hemodynamics in kickboxers revealed relatively high values (by 32-45%) of the systolic linear blood flow velocity compared to the control values for all cerebral arteries (right-left). In vertebral arteries,

Table 1. Precerbral blood flow indicators in the sample studied (M±m)

Extracranial Doppler data, c.u.	Control group (n=35)	Kickboxers (n=102)
LBFV right common carotid artery, cm/s	96.02±25.10	123.20±17.50*
RI right common carotid artery, c.u.	0.72±0.06	0.89±0.05*
Carotid gradient on the right side CCA/ICA	1.32±0.12	1.56±0.29
LBFV right internal carotid artery, cm/s	66.80±17.90	75.90±15.46*
RI right internal carotid artery, c.u.	0.60±0.07	0.77±0.08*
Carotid gradient on the right side ICA/ECA	1.12±0.17	0.78±0.23*
LBFV right external carotid artery, cm/s	63.00±17.00	95.68±13.25*
RI right external carotid artery, c.u.	0.79±0.15	0.88±0.07*
LBFV right vertebral artery, segment 1, cm/s	48.00±10.00	57.91±15.53*
RI right vertebral artery, segment 1, c.u.	0.66±0.07	0.84±0.19*
LBFV right vertebral artery, segment 2, cm/s	45.10±9.11	42.51±16.35
RI right vertebral artery, segment 2, c.u.	0.64±0.06	0.78±0.20*
LBFV right vertebral artery, segment 3, cm/s	49.25±11.20	54.56±17.03*
RI right vertebral artery, segment 3, c.u.	0.58±0.05	0.78±0.13*
Carotid gradient on the right side RVA-RVA2/RVA2, %	9.66±0.05	40.41±19.46*
LBFV left common carotid artery, cm/s	96.00±17.5	131.80±16.3*
RI left common carotid artery, c.u.	0.72±0.06	0.90±0.06*
Carotid gradient on the left side CCA/ICA	1.44±0.19	1.62±0.21*
LBFV left internal carotid artery, cm/s	66.80±19.90	79.75±16.51*
RI left internal carotid artery, c.u.	0.60±0.09	0.77±0.05*
Carotid gradient on the left side ICA/ECA	1.05±0.17	0.86±0.24
LBFV left external carotid artery, cm/s	64.00±17.00	98.02±14.55*
RI left external carotid artery, c.u.	0.79±0.15	0.89±0.08*
LBFV left vertebral artery, segment 1, cm/s	50.12±10.0	59.58±13.92*
RI left vertebral artery, segment 1, c.u.	0.67±0.05	0.78±0.07*
LBFV left vertebral artery, segment 2, cm/s	46.00±10.00	40.82±13.27
RI left vertebral artery, segment 2, c.u.	0.56±0.06	0.80±0.06*
LBFV left vertebral artery, segment 3, cm/s	43.10±9.11	59.46±13.30*
RI left vertebral artery, segment 3, c.u.	0.60±0.06	0.84±0.14*
Carotid gradient on the left side LVA1-LVA2/LVA2, %	8.69±8.20	52.50±20.97*

Note: * - differences between the indicators of the groups ($p<0.05$)

we revealed a decrease in the linear blood flow by 52-75%. The resistivity index was increased in all large arteries.

We also analyzed a decrease in the linear blood flow velocity in the vessels of the brain. In general, we studied 9 cerebral vessels in each participant. Table 2 shows that, in kickboxers, approximately 22.0% of the vessels, mostly vertebral arteries, possessed the signs of a decrease in the linear blood flow velocity. In case of a unilateral lesion, the signs of a decrease in the linear blood flow velocity were mostly typical for the right vertebral artery.

We established that, in athletes, the asymmetry of blood flow in middle brain arteries was 3 times higher and 2 times exceeded the asymmetry in anterior brain arteries, 5 times – posterior brain arteries, 10 times – vertebral arteries compared to the reference values.

The most frequent patterns in athletes were spasmodic (increased LBFV, decreased RI – 28.5%) and ischemic (decreased LBFV, decreased RI – 34.4%). The third place belonged to the hyperemic pattern (increased LBFV, decreased RI – 17.6%) which preceded the spasmodic one.

In kickboxers, the blood flow velocity in the basal vein of Rosenthal exceeded the reference values by 37.0%. The arteriovenous balance indicator was lower than 1, which identifies difficulties of dystonic nature with the venous outflow (Table 3).

We studied such reserves of brain blood flow regulation as anatomic, myogenic, and metabolic. In all participants, we studied the system of arteries of the Willis' circle, which combines anatomically 2 systems of carotid arteries with each other and with the system of vertebral arteries.

The analysis of the Willis' circle revealed that, in the

Table 2. Cerebral blood flow indicators in the sample studied (M±m)

Cerebral blood flow indicators	Control group (n=35)	Kickboxers (n=102)
LBFV right middle cerebral artery, cm/s	94.7±19.5	137.4±17.9*
RI right middle cerebral artery, c.u.	0.55±0.08	0.63±0.05*
LBFV right anterior cerebral artery, cm/s	76.4±19.0	86.93±22.76*
RI right anterior cerebral artery, c.u.	0.58±0.02	0.68±0.06*
LBFV left middle cerebral artery, cm/s	95.7±19.5	125.15±18.4*
RI left middle cerebral artery, c.u.	0.54±0.16	0.74±0.05*
LBFV left anterior cerebral artery, cm/s	77.5±17.4	82.62±16.61
RI left anterior cerebral artery, c.u.	0.53±0.18	0.65±0.05**
Interhemispheric asymmetry by MBA, %	4.1±1.3	11.93±10.5*
Interhemispheric asymmetry by ABA, %	2.5±1.3	4.5±0.5*
LBFV right posterior cerebral artery, cm/s	53.2±16.2	77.85±11.6*
RI right posterior cerebral artery, c.u.	0.55±0.15	0.74±0.05*
LBFV left posterior cerebral artery, cm/s	55.4±15.1	63.12±9.99*
RI left posterior cerebral artery, c.u.	0.55±0.12	0.74±0.06*
Interhemispheric asymmetry by PBA, %	3.8±2.1	17.5±15.5*
LBFV right vertebral artery, segment 4, cm/s	56.6±7.5	32.87±11.59*
RI right vertebral artery, segment 4, c.u.	0.52±0.06	0.59±0.05
LBFV left vertebral artery, segment 4, cm/s	55.2±3.5	36.72±12.47*
RI left vertebral artery, segment 4, c.u.	0.52±0.12	0.65±0.06*
Interhemispheric asymmetry by vertebral arteries, %	1.2±1.1	12.5±8.5*
LBFV of the main (basilar) artery, cm/s	58.0±11.0	73.34±13.86
RI of the main (basilar) artery, c.u.	0.50±0.04	0.63±0.06*

Note: * - differences between the indicators of the groups ($p<0.05$)

Table 3. Regulation reserves and venous outflow of the sample (M±m)

Parameter	Control group (n=35)	Kickboxers (n=102)
Willis' circle (% disconnection)	57.10	36.20
Autoregulatory response (myogenic reserve) %	74.00±1.50	65.11±19.10*
Metabolic reserve (Cerebrovascular Reactivity Index), %	51.20±1.60	28.55±11.63
Basal vein of Rosenthal (LBFV), cm/s	19.00±1.30	26.48±5.82*
Arteriovenous balance	1.00±0.50	0.76±0.34*

Note: * - differences between the indicators of the groups ($p<0.05$)

control group, 52.6% of the students were characterized by the typical functioning of the circle when after the compression of the carotid artery all communicating arteries performed their work. In kickboxers, the same functioning was registered in 36.2% of the sample.

To reveal correlations between the main parameters determining the neuromuscular apparatus, as well as precerebral and cerebral blood flow in kickboxers, we performed correlation analysis. The most informative parameter was the carotid gradient on the right side (CCA/ICA). This parameter possessed statistically significant correlations with seven electroneuromyographic parameters. CCA/ICA, Resistivity Index (the right internal carotid artery), and the vertebral gradient on the right side (RVA1-RVA2/RVA2) demonstrated a less number of correlations. For example, the value of the vertebral gradient on the left side is connected with three parameters, while the linear blood flow velocity in the right carotid artery is connected with two parameters (Table 4).

It should be noticed that various parameters of the neuromuscular apparatus contribute differently to cerebral blood flow.

Discussion.

The disturbances established in the speed of excitation propagation (SEP) could be the reason for the muscular imbalance in kickboxers as a result of specific physical load.

The analysis of the general amplitude asymmetry and imbalance in the symmetrical areas of muscles on the left and the right side revealed that the majority of athletes was characterized by the imbalance of 50%. The subclinical signs of sensory polyneuropathy were registered in one-third of the kickboxers. There were also a few cases of motor polyneuropathy.

The study of blood flow in kickboxers with muscular imbalance revealed a typical increase in the tone of precerebral vessels and the changes in the gradients of the blood flow velocity in various segments of carotid and vertebral arteries.

Similar results have been previously described by H.B. Liu [14] in the study of precerebral hemodynamics in basketball players. The authors identify the differences in the Doppler patterns obtained in athletes and the control group both at the initial state and after dosed cyclic load. In particular, the oscillation shear index (OSI) in athletes is higher than in the control group.

The results obtained in our study prove the increase in the tone of large and small arteries as a protective mechanism for a hyperkinetic type of central hemodynamics.

In athletes, we revealed a blood flow asymmetry of a various degree in middle brain arteries. The increase in the coefficient of asymmetry in the vessels of the vertebrobasilar basin can be possibly explained by the reflectory effect of tensed muscles on the sympathetic plexus of vertebral arteries. A system vascular resistance decreases under physical load as a result of metabolism-related vasodilatation in active skeletal muscles [21]. This vasodilation provoked by physical exercises is closely connected with a decrease in oxygen tension in the muscular tissue and is characterized by a decreased response to adrenergic vasoconstrictor mechanisms [22].

The spasmodic and ischemic patterns revealed in athletes against a decreased value of arteriovenous

Table 4. Correlations between the ENMG parameters and cerebral blood flow in kickboxers

Parameter	LBFV right common carotid artery	Vertebral gradient on the left side (LVA1-LVA2/ LVA2)	Carotid gradient on the right side (CCA/ICA)	RI right internal carotid artery	Vertebral gradient on the right side (RVA1-RVA2/ RVA2)	Carotid gradient on the left side (CCA/ ICA)
SEP in motor (efferent) fibers			-0.52			
SEP in sensory (afferent) fibers		-0.43			0.73	
Total EMG amplitude m. longissimus thoracic				0.39		
Total EMG amplitude m. Trapezius			-0.42	0.37		0.57
M-response amplitude			-0.44	0.40		
M-response duration			-0.32		0.34	0.38
m. Trapezius amplitude imbalance			-0.37			0.40
T4-5 trunk erector amplitude imbalance	-0.48	0.40	-0.37	-0.30	0.35	0.43
T12 trunk erector amplitude imbalance	0.49	-0.40	-0.57	0.61	-0.37	-0.33

Note: only statistically significant correlations are given.

balance (below 1 c.u.) proved an obstructed venous outflow of dystonic nature which should be regarded as a reason of cerebral blood flow worsening. The spasmodic reaction, participating in blood flow regulation, is based on two potential mechanisms: dehydration as a result of electrolyte exhaustion and a neuromuscular mechanism [23].

The study of precerebral and cerebral hemodynamics allows estimating the mechanisms of anatomic, myogenic, and metabolic reserves in cerebral blood flow regulation [24, 25]. The literature provides the data on the effect of circulating hormones on cerebral blood flow regulation, in particular, on changes in the tone of brain vessels depending on the concentration of blood melatonin and estrogen/testosterone [26].

The study of R.M.G. Berg [27] demonstrates that metabolic feedback is faster than a myogenic one. The first one initiates a cerebral autoregulatory response, while myogenic feedback contains a relatively slower mechanism which functions for establishing basal cerebrovascular tone. Nevertheless, the myogenic factor (as well as metabolic and baroreflexive) is the leading factor in vascular tone regulation [28].

To study myogenic mechanisms in cerebral blood flow regulation against a decrease in perfusion pressure, we used carotid artery compression. As a rule, carotid artery compression provokes the autoregulatory reaction compensating cerebral blood flow deficiency. This results in the dilation of the pial arteries and activation of anastomoses of a convex cerebral surface. The linear blood flow velocity in the middle cerebral artery decreases to not less than 50-70%. Carotid artery deocclusion results in the increase of the linear blood flow velocity above the initial level proportionally to the time of compression (reactive hyperemia).

The analysis of the remaining linear blood flow velocity (% to initial LBFV) in the basin of the main carotid revealed standard values for a myogenic reserve in the control group – 74.00%±1.50%. These values were 15% less in athletes with muscular imbalance – 65.11±19.03 %.

Peripheral blood flow is regulated by the balance between the mechanisms responsible for vasodilation and vasoconstriction. Free radicals, by-products considered as toxic in vivo, are recognized as important signal molecules which provide vasoactive responses [22].

It is also necessary to take into account the mechanism of the development of cerebrovascular dysfunction as a result of traumatic brain injury provoked by kicking technique during sparring activities and competitions [11, 29].

Studies of the relationship between peripheral blood biomarkers and the results of cerebral hemodynamics are of practical significance [30, 31]. Changes in cerebral blood flow are associated with the concentration of PRDX-6 and T-Tau proteins in the blood (MAPT). Increased MAPT concentrations in the CNS and blood are associated with axonal damage. In particular, an increase in MAPT was observed in the blood of Olympic boxers even after a slight head injury suggesting minor CNS damage [32].

According to E.D. Bell et al. [33], traumatic brain injuries usually result in autoregulatory dysfunction associated with the inability of cerebral vessels to maintain homeostasis. The authors argue that cerebrovascular autoregulatory dysfunction does not depend on the chemical environment in the brain tissues against or after traumatic brain injury.

Thus, reduced cerebral blood flow may be associated with oxidative stress being the result of cranial and cerebral injuries caused by shock and other factors. It should be noticed that physiological disorders caused by reduced cerebral blood flow can often be latent in their clinical course [30].

The results obtained during the study can be used in sports physiology and sports medicine, as well as in rehabilitation and health facilities for the prevention and treatment of myofascial dysfunctions and vertebral disorders in martial arts athletes.

Conclusions.

1. Kickboxers are characterized by the disturbance in a functionally significant muscle group manifested in increasing or decreasing tone and muscle imbalance. Differentiated disorders of sensory and motor conductivity lead to impaired afferentation and pronounced muscle imbalance.
2. Kickboxers with muscular imbalance provoked by the intensive physical load are characterized by the disturbances in pre-cerebral and cerebral hemodynamics. Angiospasm and vascular ischemia determine the increase in the linear blood flow velocity in the carotid system and the decrease in the vessels of the vertebrobasilar system against the increase in resistivity indicators in the carotid basins and vertebrobasilar system in kickboxers.
3. Correlation analysis revealed visceromotor connections proving the influence of the functional status of the regional muscular system on the cerebral hemodynamics.
4. Analysis of the muscle tone and strength characteristics, cerebral blood flow, and the speed of excitation propagation in kickboxers indicates the need for correcting the muscle and tone asymmetry of the paravertebral zone.

Conflict of interests

The authors declare that there is no conflict of interests.

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Monitoring training loads: from training to competition

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: Monitoring is a new method that allows coaches and physical trainers to manage training in order to meet the needs of athletes. This study aims to evaluate through a scientific approach the homogeneity between the training program established by the coach in the pre-competition period, and the characteristics of the competition.

Material: The study was conducted at the FAR (Royal Armed Forces) Sports Association in Salé from February 10, 2019 to March 16, 2019, on a sample of 12 taekwondo athletes (5 girls and 7 boys), category "senior" with a middle age of 26.28 ± 1.97 for boys and 24.4 ± 3.32 for girls. The data collection concerns two different periods, the training and the competition period, in order to make a comparison between the different phases of the combat situations (preparation phase, exchange phase and recovery phase) during these two periods.

Results: For the combat in the training period we saw that the percentage of the preparation phase was 80.11%, the exchange phase was 19.69%, and the recovery phase was 0.18%, however, in the competition period, the percentage of the preparation phase is 21.60%, the exchange phase is 39.84%, and the recovery phase is 38.54%. The study of the correlation between the three phases of combat in the training period and the competition shows that there is no link between the different phases except between the exchange phase and the recovery phase (sig = 0.021 < 0.05).

Conclusions: Our study was able to reveal that the requirements of the competition were not taken into consideration by the coach, which influenced the performance of the athletes during the competition. Therefore, a monitoring program is necessary in order to better plan the training and even predict the results of the competition.

Keywords: monitoring, taekwondo, training load, performance, competition, combat, Morocco.

Introduction

In preparing an athlete for a competition, we must consider two important criteria: the training load and the fatigue. Generally, any coach seeks to push the fatigue limits without exceeding the threshold at which the athlete risks overtraining [1, 2]. This strategy is complicated to apply since a taekwondo coach addresses his/her athletes as a group and not as individuals, thus a standard workout can suit some athletes, while causing others to either under or over train, eventually impacting their competitiveness [3, 4].

Observing, monitoring and verifying the progress and quality of training over a set period of time are very important steps in determining if the training program is well suited for an athlete, and can help prevent injuries. This is defined as Monitoring. A new method that allows coaches and physical trainers to manage training to meet the needs of athletes [5]. The monitoring of athletes is becoming a necessity, and this to better understand the athlete and to know if the training carried out is coherent or not with the competition [6, 7]. Despite the lack of data on high level athlete's publications, athlete tracking can provide an explanation of performance changes. This can help reduce the degree of uncertainty related to the results during the competition. More importantly, load monitoring is also put in place to reduce the risk of injury, especially in combat sports as taekwondo [8].

Hypothesis: the surveillance of athletes training may help the coach to determine the problems related to the training program, in order to prevent any kind of overtraining or athletes exhaustion, and also for a better training planning which will be in correlation with the competition requirement.

Purpose: The objective of our study is to evaluate by a scientific approach the conformity between the training established by coaches in the phase of preparation, and the characteristics of the competition.

Material and methods:

Participants:

The studied population consisted of 12 "senior" taekwondo athletes (5 girls and 7 boys), with a mean age of 26.28 ± 1.97 for boys and 24.4 ± 3.32 years for girls. They practice at the Royal Armed Forces Sports Club of Salé "FAR" league center. These athletes were qualified for the finale of Morocco's championship.

Research design:

The study focuses on the collection of several variables described in Table 1 and 2, in two different periods, training and competition, in order to make a comparison between combat situations during training and competition, the number of athletes participating for the training phase was 12, of which only four will be followed in the competition phase due to the lack of materials and human resources to carry out the follow-up for the whole sample (12 athletes).

Statistical analysis

For the analysis of the link between the two groups we chose the study of correlation between the different phases

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Table 1. The different variables studied in the training phase

Training Phase: Variables	Objective
Warm up	-time ; -nature : - General warm up ; - Specific warm up ;
Recovery time	The time taken for recovery
Cognitive engagement	The time taken to explain the exercises by the coach.
Motor Engagement	the application time of the exercises explained by the coach
Combat situation	- Number of fights; - The duration of each phase of the fight - The techniques performed in each fight;
Return to the initial state	Method with which the athletes return to the initial state (stretching ....)

Table 2. The different variables studied in the competition phase

Competition Phase Variables	Objective
Preparation Phase	This is the exploration phase, looking for rifts in the opponent's game, feints, false attacks, displacements, footwork.
Exchange Phase	As soon as one of the two fighters triggers an action, we enter a so-called exchange phase that ends with the last action of one of the two protagonists. An exchange is constituted at least by an action (kick or punch) or more. - The techniques performed in each fight
Referee phase	Corresponds to the time of passivity where the referee stops the game to intervene and where the fighters do nothing.
Recovery	-Nature: -The number and duration of preparation of attack and displacement (active recovery). -The duration of passive recovery.

Table 3. Table representing the analysis of the warm-up part

Times	Duration (%)
T.T	26min (100%)
S.T	3min22s (11.53%)
E.T = T.T-ST	23min22s (88,47%)

Warming up:

This table presents the analysis of the warm-up part which lasts in total (TT) 26minutes, the stopping time (ST) is 3m22s and that of effort (ET) is 23min22s and represents a percentage of 88 , 47% of the total time.

Note: T.T: total time, S.T: stopping time, E.T: effort time, R: recovery.

Table 4. Table showing the analysis of the motor Engagement (effort time) part.

Times	Duration (%)
E.T	32,84min (80,87%)
S.T	5min (9,85%)
R	3,98ms (9,80%)

Motor Engagement:

The table shows that the motor engagement time or the effort time represents 80.87% of the total time, the sopping time represents 9.85%, and the recovery time represents 9.80%.

Note: T.T: total time, S.T: stopping time, E.T: effort time, R: recovery.

of the combat in the training and in the competition, with the software SPSS version 25.

And for the monitoring and data collection we used:
-An observation sheet;
-A stopwatch;
-A camera;
-Software SPSS;
-DARTFISH software.

Results

Training phase:

The average duration of sessions of the program 1h48min (tabl. 3, 4).

Recovery time analysis:

According to the analysis of this phase we note that the recovery was active with a percentage of 13.01% of the total time of the session which corresponds to 12min12s.

Analysis of combat situations:

According to the results obtained throughout the program, the time devoted to combat situations represents 8 minutes (11.13%) of the total time.

Analysis of the combat phases in the training: From the table below, we note that the percentage of the preparation phase is 80.11%, the exchange phase is 19.69%, and finally the recovery phase with a percentage of 0.18%.

Table 5. Evaluation of the combat phases in training

training Combat Phases	Duration	Percentage
Preparation phase	01min 07s 00ms	80,11%
exchange phase	0min 31s 22ms	19,69%
recovery phase	0min00s30ms	0,18%

Competition phase:

This table represents the characteristics of each subject, as well as the results of the competition.

Table 6. Characteristics of the subjects studied

subjects	height (m)	weight (kg)	gender	competition result
1	1,93	87	male	wins
2	1,71	58	female	wins
3	1,60	46	male	lose
4	1,90	68	female	lose

Analysis of the combat phases for the 4 subjects From the table below, we note that the average percentage of the preparation phase is 21.60%, the exchange phase is 39.84%, and finally the recovery phase with a percentage of 38.54%.

Table 7. Evaluation of the combat phases in the competition.

Competition combat phases	Durée	Percentage
preparation phase	01min 22s 00ms	21,60%
exchange phase	2min 31s 22ms	39,84%
recovery phase	2min26s30ms	38,54%

-The correlation between combat in training and competition:

According to the table below, there is a difference between the techniques used, the number of shots and the points scored by each technique between the fight in the training phase and the fight in the competition phase.

From Table 9 we find that there is a significant correlation between the exchange phase and the recovery phase (sig = 0.021 <0.05). While there is no correlation between the other phases of training and competition.

Discussion

At the international level, many coaches and physical trainers are taking an increasingly scientific approach to design and monitor their training programs, whereas in Morocco these approaches are rarely used. This demonstrate itself by the huge lack of bibliography in this sense, despite the fact that the training supervision allows to reach a sufficiently large load to improve the targeted qualities, with managing the magnitude of the fatigue that can lead to the fateful threshold leading to the injury [9, 10]. With this in mind, we sought to identify the gaps that may exist between training and competition in the precompetitive period among qualified taekwondo athletes practicing within the FAR Sports Association in Salé, Morocco.

The descriptive analysis of the training phase allows us to see that the average duration of the sessions of the program that was 1h48min, the warm-up time lasts in total before each session 26 minutes which is a good result, due to the role warm-up in the prevention of injuries during intense training sessions [11].

The analysis of the training program allows us to say that the athletes work the same training program, which is explained by the fact that the coach does not follow the most important training principle, which is individualization. It is a fundamental factor for the progression of athletes, and allows to establish a training program according to the athlete's abilities, characteristics and needs [12-15].

Calculating the average part of the combat situation throughout the entire program, we found out its percentage to be around (11.13%). It is a very small and negligible result given that the athletes were in a pre-competition period. This negligible percentage does not benefit athletes since it doesn't give them the opportunity to experience combat situations as part of their training in order to ready themselves for real matches [12].

From these results, we found that there is no correlation between the different phases of the combat during training and during the competition, which proves that the training plan does not support the characteristics of the competition, except between exchange and recovery (sig = 0.021 <0.05), which can be explained by the fact that the more the exchange time (effort time) increases the more the athlete needs time to recover [16-19].

Several techniques used by the athletes in the competition have not been established in the training program namely; DWITT TCHAGUI for athlete number 2 and subject 4 on the table 8, who used this technique in

Table 8. Analysis of techniques used during training combat and those used in competitive combat:

Subjects	Techniques	Training Shots number	points scored	competition Shots number	Points scored
1	YOP TCHAGUI	10	4	3	0
	DOLYEU TCHAGUI	18	9	39	7
	MON DOLYEU TCHAGUI	0	0	0	0
	DWITT TCHAGUI	*9*	*2*	4	1
	NELYEU TCHAGUI	*5*	*0*	2	3
	PUNCHE	12	8	8	3
2	YOP TCHAGUI	12	3	1	1
	DOLYEU TCHAGUI	24	8	20	1
	MON DOLYEU TCHAGUI	0	0	0	0
	DWITT TCHAGUI	*0*	*0*	13	2
	NELYEU TCHAGUI	*8*	*2*	0	0
	PUNCHE	12	4	17	3
3	YOP TCHAGUI	12	6	10	0
	DOLYEU TCHAGUI	21	3	76	4
	MON DOLYEU TCHAGUI	0	0	0	0
	DWITT TCHAGUI	5	0	1	0
	NELYEU TCHAGUI	4	3	0	0
	PUNCHE	6	4	10	5
	HITCHEU	2	0	0	0
4	YOP TCHAGUI	17	5	6	0
	DOLYEU TCHAGUI	12	3	31	4
	MON DOLYEU TCHAGUI	0	0	0	0
	DWITT TCHAGUI	*0*	*0*	9	0
	NELYEU TCHAGUI	*2*	*0*	2	0
	PUNCHE	6	1	12	0

Table 9. Correlation between the preparation phase, exchange and recovery in training and competition.

Indicators			Training phase Preparation	Exchange	Recovery
Competition Phase	Preparation	- C. c -Sig.(bilateral)	1,000	0,095	0,279
				0,823	0,503
	Exchange	-C. c	0,095	1,000	0,786
		-Sig.(bilateral)	0,823		**0,021***
	Recovery	- C. c	0,279	0,786	1,0000
		-Sig.(bilateral)	0,503	**0,021***	

*. The correlation is significant at the **0.05 (bilateral). C.C: coefficient of correlation**

the competition without being able to try it in the training period.

Conclusion

The monitoring or the surveillance of athletes using technological tools, can help the coach to fairly judge their athletes, and to better program trainings that are based on tangible data. This study revealed that the requirements of the competition were not taken in consideration by the coach, which influenced the performance of the athletes during the competition. However, this method can also be used to analyze the game of potential opponents during the preparation stage of competitions.

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Contributions of the authors

All the authors contributed to the conduct of this work.

Conflicts of interest

There is no conflict of interest.

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