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In general, the editors express hope that the journal "Physical Education of Students" contributes to information exchange to combine efforts of the researchers from the East-European region to solve common problems in health promotion of students, development of physical culture and sports in higher educational institutions.

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PHYSICAL EDUCATION OF STUDENTS

Sex-and sport related differences in the personality traits students in volleyball, basketball and judo athletes

Zbigniew Obmiński[1ACD], Helena Mroczkowska[1ABD], Marina Jagiełło[2ADE], Artur Litwiniuk[3ADE]

[1] *Warsaw Institute of Sport-National Research Institute, Poland*
[2] *Gdansk University of Physical Education and Sport, Poland*
[3] *Warsaw J. Pilsudski University of Physical Education, Biala Podlaska Faculty of Physical Education and Sport, Poland*

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Abstract

Purpose: Psychology is a very important field of knowledge in every area of human life, and personality and temperament have a large impact on the quality of human life, including mental and physical health, and indirectly on the results achieved in elite sport. The purpose of the study was to verify the assumption that there are differences in the psychological profile of professional sportsman students depending on the gender and type of sports discipline.

Material: The research covered athletes of both sexes belonging to academic sports clubs practicing volleyball, basketball and judo. The size of each of the six groups was 24 people. Standardized psychological tests were used to determine the levels of selected personality and temperamental traits; trait anxiety, neuroticism, extraversion, briskness, perseveration, sensory sensitivity, emotional reactivity, endurance, activity, and six components of aggressiveness: physical aggressiveness, verbal aggressiveness, indirect aggressiveness, negativism, suspiciousness, resentment, irritability, overall and guilty sense. Two-way analysis of variance (sex * sport) was used to assess the differences between the groups.

Results: Women showed higher trait anxiety, extraversion, perseveration, emotional reactivity results and lower physical aggressiveness levels compared to men. Basketball practitioners had the lowest levels of aggressiveness components, and the highest levels of briskness.

Conclusions: The results suggest that the psychological profile of women participating in competitive sports may account for a higher emotional cost than men in terms of competition and failure. This fact should be taken into account by the coaches of female sports teams. The differences between sports may be due to the different structure of the task.

Keywords: volleyball, basketball, judo, gender, personality

Introduction

Personality and temperament greatly affect the quality of human life, including mental and physical health and interpersonal relationships. To assess the psychological profile, questionnaires examining the intensity of individual features are used, which allows to some extent to predict the behavior of the respondent in various circumstances. In the case of athletes, getting to know the personality may be important, in the case of problems in the player-coach relationship, excessive arousal before the competition, i.e. poor coping with pre-competition stress, reduced motivation for performance or excessive perfectionism. Many observations were made in team sports, because in this case the type of player's personality determines the quality of team cooperation. Research conducted in volleyball players of various teams showed differences in the levels of neuroticism, extraversion and conscientiousness depending on the sports class [1], while in basketball, "The Big Five" differed slightly between players in different positions [2].

The level of state anxiety accompanying the competition correlates with the trait anxiety trait, therefore this parameter, determined in neutral conditions, can be used as a predictor of situational anxiety during the competition. The study of anxiety during volleyball and basketball competitions showed a statistically non-existent lower level of the variable (by 9%) in basketball players [3]. Comparisons between the group of martial arts (wrestling, karate, judo, kick boxing, taekwondo and MMA) and the group of team games (football, basketball, volleyball and handball) showed significantly higher levels of self-esteem and neuroticism of game players [4].

Comparing the personalities of adult athletes of various sports raises doubts as to the extent to which the observed differences are the result of many years of experience in a sports career, and what is the share of psycho-physical predispositions in adolescents in the choice of a given sport. Partial explanation of this problem can be obtained by selecting for research such sports in which the requirements for somatic structure are the same. This criterion is met by basketball and volleyball. In both sports, high growth determines the selection at the beginning of the sports career, while the specific psycho-motor performance is formed by appropriate training measures. The physical performance parameters in both sports must correspond to the structure of the task. Basketball players cover a distance several times longer during a match than in a similar time volleyball players

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[5-7], as a result, blood lactate concentration, which is a marker of exercise intensity, is almost twice as high [8, 9].

The players of both sports games are exposed to injuries both during competitions and training. The most common among volleyball players are ankle joint and knee joint injuries as a result of repeated maximum jumps during attack and defence [10-12]. Basketball is a contact sport, hence one of the causes of injuries are collisions with an opponent [13, 14]. As a result, in basketball players the incidence of injuries is many times higher during matches than during training, while for volleyball players the relationship is opposite [15].

Interestingly, women who practice basketball are more likely than men to be at risk of lower limb injuries [16]. It should be emphasized that in basketball players injuries caused by the opponent are not intentional, as fouls are punished. On the other hand, the offensive style of play, which is one of the causes of injury, is also one of the conditions for gaining an advantage over the opponent. In the case of judo, the sport of combat, the energy expenditure during a single fight lasting a few minutes is small, while the intensity of this effort estimated on the basis of blood lactate concentration is very high [17]. However, during one-day competition, athletes perform a lot of maximum effort, which leads to an accumulation of fatigue at the end of the tournament and a partial loss of the ability to maximum muscle contraction [18].

The risk of injury to judo athletes a during the official fight results, among others from the very idea of competition, which assumes gaining a physical advantage over the opponent in direct confrontation as a result of immobilization by placing a lever on the elbow joint (arm lock) or using throwing techniques. The o-soto-gari and o-uchi-gari techniques may athletes (uke) cause serious head injuries [19, 20].

The analysis of the frequency of injuries during the high morning of the competition showed a greater risk in the group of men in heavy weight categories, and in women in lighter weight categories, while the overall frequency of injuries was lower in female athletes [21]. The above characteristics of the mentioned sports with a different task structure in the mentioned ones, and the risk of injury depending on the sex, prompts us to formulate a hypothesis about the causal relationship between the athlete's psychological profile and the sports discipline practiced by him. The premise for this assumption is the results of personality studies conducted on men in four Far Eastern martial arts, differing in the degree of risk of serious head injury [22, 23].

Data analysis showed that the greatest tendency to aggressive behavior was shown by participants in shotokan karate, where no body protection, including head protection, is used against kicks. The results could suggest that the level of aggressiveness was proportional to the number of physical contacts resulting in injury. The aim of the presented study was to compare an extended personality analysis of men and women practicing volleyball, basketball and judo.

Material and Methods

Participants. Psychological research covered athletes of both sexes, aged 22-26, who trained volleyball, basketball and judo on a daily basis in various academic clubs. Some of them were the backbone of the national team and took part in central training camps, and then participated in international competitions of the highest rank. These people used a wide range of diagnostic biomedical tests, including psychological tests carried out at the Institute of Sport in Warsaw. The size of each of the six groups was the same (n = 24).

Research design. Psychological studies were conducted to determine the psychological profile, which consisted of relatively constant personality traits: Level of anxiety (TA), neuroticism (Ne), extroversion (Ex), general aggressiveness (OA) and its components, physical aggressiveness (PA), verbal aggressiveness (VA), indirect aggressiveness (IA), negativity (Ng), suspicion (Su), aversion (Re), irritability (Ir) and guilt (GS). In addition, selected characteristics of temperament were determined: briskness (Br) perseverance (Pe) sensory sensitivity (SS) emotional reactivity (ER), endurance (En) and activity (Ac). For these studies, standardized psychological tests were used: State / Trait Anxiety Spielberger (Polish version), Buss AH Durkee A Inventory (Polish version), MPI test by Eysenk: neuroticism and extroversion (Polish version) and the FCZ-KT by Strelau and Zawadzki inventory of temperamental traits. The research was carried out in the morning (9:00-11:00) in conditions ensuring concentration, without time pressure. The respondents agreed to participate and the research protocol was approved by the Ethics Committee at the Institute of Sport.

Statistical analysis. Two-way ANOVA (gender x sport) was used to compare the differences in the results of these variables. The assumptions of this test, the normality of the distribution for variables were checked with the Shapiro-Wilk test and the homogeneity of variance with the Leven test. Calculations were made on logarithm data, and then Bonferroni's post-hock test was applied to determine the significance of differences ($p < 0.05$) between groups for each variable.

Results

Table 1 shows the means and standard deviations for each of the six groups separately; i.e. men training basketball (MB), volleyball (MV), judo (MJ) and women from the same disciplines, FB (Females, Basketball), FV (Females, Volleyball) and FJ (Females, Judo), respectively. The mean values of psychological variables in sports in terms of gender were compared. The variables differentiating the statistically studied sports groups and gender are marked in bold with an index indicating the differences between the groups.

Table 2 shows the means, standard deviations, and mean differences between the sexes for the combined sports and between sports for the combined genders. Variables statistically differentiating genders and sports are marked in bold.

Table 1. Data of personality traits scores in six groups *n=24, two sexes *n=72 and three sports*n=48. Between-groups comparisons of the variables by sexes and sports.

Personality Traits (Abbreviations)	**Sport*Sex Groups**					
	Basketball (B)		**Volleyball (V)**		**Judo (J)**	
	Males (MB)	**Females (FB)**	**Males (MV)**	**Females (FV)**	**Males (MJ)**	**Females (FJ)**
Trait anxiety (TA)	36.7±6.4	39.1±4.5	37.4±4.5	37.0±4.9	35.2±4.4	40.2±5.9
Neuroticism (Nu)	**19.9±9.2**	25.7±8.7	26.4±10.0	19.3±6.5	22.5±8.4	**28.6^{MB}±7.9**
Extraversion (Ex)	29.9±10.0	32.4±7.9	**26.4±10.4**	**36.6^{MV}±9.0**	31.7±9.8	30.3±10.7
Briskness (Br)	16.5±2.3	**17.5^{FV}±2.0**	15.3±2.5	**15.1±1.9**	15.5±2.5	15.8±3.9
Perseveration (Pe)	12.0^{FB}±3.9	15.5±3.1	14.3±2.9	14.3±2.6	12.7±3.4	**13.2^{FB}±2.9**
Sensory sensitivity (SS)	14.5±3.7	15.9±1.6	16.0±1.8	15.8±1.9	14.9±3.4	15.0±4.0
Emotional reactivity (ER)	7.1±3.9	9.8±4.1	9.0±4.0	8.5±4.2	**6.8±3.0**	**11.8^{MJ}±3.5**
Endurance (En)	11.3±5.6	12.5±5.2	6.4±5.1	7.0±1.8	11.1±3.9	11,0±4.8
Activity (Ac)	**11.1±4.8**	**13.9^{MB}±3.6**	13.0±3.2	14.0±2.8	**14.1^{MB}±4.8**	12.5±4.4
Overall aggressiveness (OA)	61.4±22.6	69.4±24.7	79.5±14.1	77.2±25.1	76.5±26.4	79.1±20.1
Physical aggressiveness (PA)	**7.7 ^{MJ}±4.0**	7.3±3.4	10.2±3.1	7.8±5.1	**13.8±5.1**	**9.8 ^{MJ}±3.9**
verbal aggressiveness (VA)	10.7±5.6	13.0±6.1	13.2±4.9	13.8±5.3	12.6±5.7	12.7±5.1
Indirect aggressiveness (IA)	7.1±4.2	7.5±4.2	9.3±3.2	8.8±4.2	7.4±3.8	10.3±3.4
Negativism (Ne)	9.9±5.5	10.9±5.2	13.6±3.0	14.6±4.6	13.8±5.0	14.7±4.9
Suspiciousness (Su)	6.5±3.1	9.8±4.8	9.5±3.8	8.6±4.8	9.0±5.8	9.6±4.3
Resentment (Re)	5.4±3.2	7.1±5.2	8.1±2.3	6.9±4.2	6.6±3.9	6.9±3.2
Irritability (Ir)	12.8±6.0	14.3±6.3	15.7±5.0	16.8±5.6	13.3±6.6	15.2±6.4
Guilty sense (GS)	13.5±4.6	13.4±3.3	13.8±4.7	12.3±2.5	11.7±4.1	13.3±5.7

Note: Statistical difference between variables was set at p<0.05 and was marked in bold.

Table 3 and 4 present in detail results of analysis of variance.

The results of the variables and comparisons between the genders within each sport and between sports revealed significant differences for the Br Ex and Ac indices. The data in Table 2 shows that a group of women (n = 72) practicing three sports had statistically higher scores for the following features: TA by 13.4%, Ex by 13.0%, Pe by 10%, ER by 31.6% and lower PA level by 21.7%. The remaining components of aggressiveness in women (VA,

Table 2. Data of personality traits scores and their overall comparisons by sex and sport

Personality Traits	Sex		Sport		
	Males	Females	Basketball	Volleyball	Judo
Trait anxiety (TA)	**36.1±5.2**	**38.8 M±5.2**	37.4±5.5	37.2±4.6	37.7±5.7
Neuroticism (Nu)	23.0±9.6	24.5±8.5	23.8±9.3	22.8±9.2	25.6±8.6
Extraversion (Ex)	29.3±10.2	33.1M±9.2	31.2±9.0	31.6±10.8	31.0±9.9
Briskness (Br)	16.1±2.6	16.2±2.7	**17.0±2.2**	**15.2 B±2.1**	16.2±3.2
Perseveration (Pe)	**13.0±3.4**	**14.3 M±3.0**	13.7±3.2	14.3±2.7	13.0±3.2
Sensory sensitivity (SS)	15.1±3.1	15.6±2.7	15.2±2.8	15.9±1.9	15.0±3.7
Emotional reactivity (ER)	**7.6±3.7**	**10.0 M±4.1**	8.5±4.2	8.8±4.0	9.3±4.1
Endurance (En)	9.6±5.4	10.2±4.8	**11.9 V±5.4**	**6.7±3.8**	**11.1V±4.3**
Activity (Ac)	12.7±4.4	13.5±3.7	12.5±4.4	13.5±2.9	13.3±4.6
Overall aggressiveness (OA)	72.4±22.9	75.2±23.7	79.5±14.1	77.2±25.1	77.2±25.1
Physical aggressiveness (PA)	10.6±4.8	8.3 M±4.3	7.5±3.7	9.0±4.3	11.8V,B±5.0
Verbal aggressiveness (VA)	12.2±5.5	13.2±5.5	11.8±5.2	13.5±5.2	12.7±5.3
Indirect aggressiveness (IA)	7.9±3.8	8.9±4.1	7.3±4.2	9.0±3.7	8.9±3.9
Negativism (Ne)	12.4±5.1	13.4±5.2	**10.4±5.0**	**14.1V±3.9**	**14.3V±5.1**
Suspiciousness (Su)	8.3±4.5	9.3±4.6	8.1±4.4	9.1±4.3	9.3±4.9
Resentment (Re)	6.7±3.3	6.9±4.2	6.3±4.3	7.53.4	6.7±3.5
Irritability (Ir)	13.9±5.9	15.4±6.1	13.5±6.2	16.2±5.2	14.3±6.4
Guilty sense (GS)	13.5±4.6	13.3±4.0	13.4±3.7	13.5±3.8	12.5±5.0

Note: Statistical difference between variables was set at $p<0.05$ and was marked in bold.

IA, Ne, Su, Re and Ir were insignificantly higher than in men, therefore the general aggressiveness (OA), which is an algebraic sum of all components, is slightly higher in the group of women. Temperament parameters: average Br results, En is differentiated by three sports. Similarly the components of aggressiveness, PA and Ne are also different in three sports disciplines. The lowest values of these indicators were noticed in basketball.

Table 3. Detailed results of variance analysis for selected personality traits

Personality traits	Source of the variance	F-value	P-value	η square	observed test power (α)
trait anxiety	Sport	0.107	0.888	0.002	0.066
	Sex	**9.99**	**0.002**	**0.068**	**0.881**
	interaction	**3.62**	**0.029**	**0.050**	**0.661**
neuroticism	Sport	1.65	0.196	0.023	0.343
	Sex	1.16	0.282	0.008	0.188
	interaction	**9.30**	**0.000**	**0.119**	**0.976**
extraversion	Sport	0.026	0.974	0.000	0.054
	Sex	**5.57**	**0.020**	**0.039**	**0.549**
	interaction	**4.44**	**0.014**	**0.060**	**0.755**
briskness	Sport	**5.89**	**0.004**	**0.079**	**0.869**
	Sex	0.052	0.820	0.000	0.056
	interaction	1.18	0.310	0.017	0.256
perseveration	Sport	1.94	0.148	0.027	0.396
	Sex	**6.50**	**0.011**	**0.045**	**0.716**
	interaction	**3.98**	**0.021**	**0.055**	**0.705**
sensory sensitivity	Sport	1.32	0.272	0.019	0.281
	Sex	0.952	0.330	0.007	0.163
	interaction	0.992	0.374	0.014	0.220
emotional reactivity	Sport	0.538	0.585	0.008	0.137
	Sex	**15.0**	**0.000**	**0.098**	**0.971**
	interaction	**6.22**	**0.003**	**0.083**	**0.888**
endurance	**Sport**	**18.1**	**0.000**	**0.208**	**0.999**
	Sex	0.555	0.458	0.004	0.115
	interaction	0.270	0.764	0.003	0.092
activity	Sport	0.862	0.425	0.012	0.196
	Sex	1.48	0.226	0.011	0.027
	interaction	**3.43**	**0.035**	**0.047**	**0.636**

Note: Statistical difference between variables was set at p<0.05 and was marked in bold.

Table 4. Detailed results of variance analysis for components of aggressiveness

Personality traits	Source of the variance	F-value	P-value	η square	observed test power (α)
overall aggressiveness	**Sport**	**5.13**	**0.007**	**0.069**	**0.817**
	Sex	0.546	0.461	0.004	0.114
	interaction	0.665	0.516	0.009	0.160
physical aggressiveness	**Sport**	**12.9**	**0.000**	**0.158**	**0.997**
	Sex	**10.3**	**0.002**	**0.069**	**0.889**
	interaction	2.47	0.088	0.035	0.490
Verbal aggressiveness	Sport	1.13	0.326	0.016	0.246
	Sex	1.16	0.284	0.008	0.188
	interaction	0.532	0.588	0.008	0.136
Indirect aggressiveness	Sport	3.01	0.052	0.042	0.576
	Sex	2.22	0.138	0.016	0.316
	interaction	2.56	0.081	0.036	0.505
Negativism	Sport	9.53	**0.000**	**0.122**	**0.979**
	Sex	1.39	0.240	0.009	0.216
	interaction	0.000	0.999	0.000	0.050
Suspiciousness	Sport	0.938	0.394	0.013	0.210
	Sex	1.72	0.191	0.012	0.256
	interaction	2.75	0.067	0.038	0.536
Resentment	Sport	1.36	0.260	0.019	0.289
	Sex	0.094	0.757	0.001	0.061
	interaction	1.81	1.68	0.026	0.373
Irritability	Sport	2.60	0.078	0.036	0.511
	Sex	2.14	0.145	0.015	0.307
	interaction	0.047	0.954	0.001	0.057
Guilty sense	Sport	0.941	0.393	0.013	0.210
	Sex	0,278	0,599	0,002	0,0082
	interaction	0,744	0,476	0,011	0,174

Note: Statistical difference between variables was set at p<0.05 and was marked in bold.

Discussion

The reasons for the differences in some of the examined features between sports are the different structure of the sports task, the starting and training load and the different risk of injury, as mentioned in the introduction. In men, similar rates of anxiety were reported across all three sports. It should be noted that due to the too small size of the studied groups, the analysis of the influence of the players' position on the personality was omitted. In both sexes, the categories of average weight were most numerous in women from 57 to 70, and in men from 73 to 90 kg. Such an uneven distribution makes it impossible to assess the influence of body weight on personality. An additional factor that hinders the interpretation of the results obtained is the lack of information on injuries, especially those that excluded players from sport for a longer period and / or required medical intervention. Research on the impact of an injury and the level of anxiety provides ambiguous conclusions. Athletes with an injury experience, concussion, or orthopedic trauma exhibited a similar state and trait anxiety. Both groups declared the importance of psychological support from the family, doctor or trainer as a factor alleviating anxiety during rehabilitation [24, 25].

Serious injuries cause psychological anxiety/tension, as well as anger and hostility, the greater and the more serious the injury. Also in this case, mental support reduces the intensity of negative emotions [26]. After the rehabilitation period, the fear of renewing a past injury delays return to sport, and also has a negative impact on the level of performance of sports tasks [27, 28].

The results of studies by other authors are surprising, who noted slightly lower anxiety in athletes with an injury history related to practicing sports and sports competitions [29].

In this case, it can be assumed that players with an increased level of anxiety engage in sports tasks with greater caution (precautionary measures) so as not to risk injury. In our research, the anxiety trait level is generally higher in women in contact sports. Taking into account the indicator of this dimorphism, which is the anxiety of women: fear of men, this parameter is the highest in judo (1.142), slightly lower in basketball (1.065) and in volleyball it reaches the value of 1. These results are consistent with the observations of anxiety as a state among the elite of Polish players and judo players in the 4-day period immediately preceding the start in high-level competitions. Pre-contest anxiety increased in both genders, but the differences between the sexes deepened, reaching the highest level on the day of the start [30].

Parallel changes have been noted in blood cortisol levels, which is considered a manifestation of somatic anxiety. Observations carried out on a large NY population in 2002 [30], or one year after the terrorist attack and then 15 years after this event [31], revealed a greater severity of post-traumatic stress disorder (PTSD) in women. The same pattern was found in children in Japan after a strong earthquake [32].

This suggests a stronger perception of the state of emergency in them. Gender differences were also noted in the levels of emotional reactivity (RE). The parameter reflects, similarly to TA, the tendency to strong emotional reactions in response to external stimuli. The level of both indicators has a biological basis and the role here is played by the level of testosterone in the circulation, which is much lower in women. This may result in a lower propensity to be physically aggressive and a higher level of extroversion (Ex). It should be noted that the lower level of aggressiveness in women is compensated for by a slightly higher level of verbal and indirect aggressiveness, so with these indicators which, although destroying interpersonal relations, theoretically do not pose such a high risk of physical confrontation in the event of a conflict with the environment. The explanation is the high level of aggressiveness in volleyball players, lower level of physical aggressiveness (PA) in basketball players than in volleyball players, although the former often have to physically fight their opponent for the ball. It can be assumed that the rules of sports competition in this contact game do not allow fouls, and moreover, the very high intensity of the match dissipates negative emotions, while volleyball players do not have such opportunities.

Genetic and environmental factors are responsible for the level of temperamental traits [33]. It can be concluded that in our research the environmental factor was specific and different in the sports studied, training measures used for over a dozen years, which resulted in lower levels of Br and En in volleyball players compared to these variables noted in basketball and judo. Significant correlations between temperament and the strength and time of reaction confirm the role of temperament variables in shaping psycho-motor features [34]. The reason for these differences is the relatively low intensity of the starting effort in the retina, as shown in the introduction. They can also affect the quality of life sportsman [35].

Conclusions

1. The research revealed sport-related differences in selected personality and temperamental traits.
2. Women showed a greater intensity of those negative personalities that indicate a higher emotional cost in stressful situations. Trainers of female sports teams should be informed about this psychological sexual dimorphism.

Conflict of interests

The authors declare that there is no conflict of interests.

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Information about the authors:

Zbigniew Obminski; http://orcid.org/0000-0002-3754-9748; zbigniew.obminski@insp.waw.pl; Institute of Sport-National Research Institute, Warsaw, Institute of Sport-National Research Institute in Warsaw, Trylogii 2 street, 01-982, Warsaw Poland.

Helena Mroczkowska; http://orcid.org/0000-0003-3469-8745; helena.mroczkowska@insp.waw.pl; Institute of Sport-National Research Institute, Warsaw, Institute of Sport-National Research Institute in Warsaw, Trylogii 2 street, 01-982, Warsaw, Poland.

Marina Jagiello; (Corresponding Author); http://orcid.org/0000-0001-5591-4537; wjagiello1@wp.pl; University of Physical Education and Sport in Gdansk, Kazimierza Gorskiego 1 street , 80-336 Gdansk, Poland.

Artur Litwiniuk; http://orcid.org/0000-0002-1351-740X; artur.litwiniuk@awf-bp.edu.pl; J. Pilsudski University of Physical Education, Warsaw, Faculty of Physical Education and Sport, Akademicka 2 street 21-500 Biala Podlaska, Poland.

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PHYSICAL EDUCATION OF STUDENTS

Effect of training on the development of exercise-induced arterial hypoxemia in volleyball players

Selcen Korkmaz Eryılmaz[1ABCD], Kerimhan Kaynak[2BE]

[1] *Cukurova University, Turkey*
[2] *Erciyes University, Turkey*

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

Abstract

Purpose: The purpose of this study was to examine the effect of volleyball training on the development of exercise-induced arterial hypoxemia during incremental exercise in male competitive volleyball players.

Material: Eight male amateur volleyball players (age 21±1.3 years) participated in a 6-week volleyball training program three times a week in the pre-season preparatory period. All participants were students of the Faculty of Sport Sciences. Before and after the training period, all players performed an incremental treadmill test to determine maximal oxygen uptake (VO_{2max}), and oxyhemoglobin saturation (SaO_2) was continuously measured using a pulse oximeter during the test. Maximal values of minute ventilation (VE_{max}), respiratory exchange ratio (RER_{max}), ventilatory equivalent for oxygen (VE/VO_2) and carbon dioxide (VE/VCO_2) were determined. Exercise-induced arterial hypoxemia (EIAH) was defined as a SaO_2 decreased by at least 4% ($\Delta SaO_2 \leq -4\%$) from resting level.

Results: All the players exhibited exercise-induced arterial hypoxemia before ($\Delta SaO_2 = -8.8 \pm 3.3\%$) and after ($\Delta SaO_2 = -8.31.5\%$) the training period. SaO_2 was significantly decreased from 97.6±1% at rest to 88.7±2.7% at exhaustion before the training period, and from 97.2±1.1% at rest to 88.8±2.1% at exhaustion after training period ($p < 0.001$). There was no significant difference in resting and lowest SaO_2 values by comparison between the before and after training ($p > 0.05$). There were no significant changes in VO_{2max}, VE_{max}, RER_{max}, VE/VO_2 and VE/VCO_2 after training period ($p > 0.05$).

Conclusions: The results of this study showed that volleyball players with a history of anaerobic training may exhibit EIAH, but that 6-week volleyball training has no effect on the degree of exercise-induced arterial hypoxemia.

Keywords: desaturation, pulse oximetry, oxyhemoglobin saturation, team sports athletes

Introduction

Maximal oxygen uptake (VO_{2max}) is one of the most important factors determining aerobic endurance performance [1]. It has been shown that the respiratory system may be a factor limiting VO_{2max} in healthy athletes [2]. Many athletes have been shown to experience exercise induced arterial hypoxemia in a normoxic environment [3, 4]. This negative finding accompanied by decreased partial pressure of oxygen in arterial blood may contribute to local muscle fatigue [5]. It has been shown that when the fraction of inspired oxygen increased during exercise, the decrease in oxyhemoglobin saturation (SaO_2) prevented, the endurance time to exhaustion and VO_{2max} increased [6, 7].

Exercise-induced arterial hypoxemia (EIAH) manifests as decreased partial pressure of oxygen in arterial blood (PaO_2) or decreased SaO_2 below the pre-exercise level [2]. EIAH is classified as mild (93–95% SaO_2), moderate (88–93% SaO_2), and severe (< 88% SaO_2) [2]. The mechanism underlying of EIAH is still not clearly understood. Several potential causes of EIAH including inadequate alveolar hyperventilation, oxygen diffusion limitations, ventilation-perfusion inequality, intra- and extra-pulmonary shunts, low pulmonary capillary blood transit time and interstitial edema or an interaction among these factors have been proposed [2, 8, 9, 10].

Studies investigating EIAH mostly focused on endurance athletes and reported that EIAH is more common in athletes with high aerobic capacity [2, 3, 10, 11]. The finding of negative correlation between SaO_2 and VO_{2max} supported the suggestion that improving aerobic capacity by physical training may be associated with the occurrence of EIAH during strenuous exercise [12]. On the other hand, we and others have recently demonstrated that EIAH can occur in anaerobic trained athletes and non-endurance sportsmen (relatively low VO_{2max}) [13, 14].

A few researchers investigated effects of physical training on EIAH, however, showed different results [12, 14, 15]. Low ventilator chemoresponsiveness may be induced by physical training and it has been suggested that it may contribute to less hyperventilation and therefore EIAH during strenuous exercise in trained subjects [10, 12, 14]. It has been shown that physical training-induced increases in VO_{2max} were accompanied by more severe EIAH [12, 14]. On the contrary, Dominelli et al. showed that VO_{2max} increased after physical training, but the degree of EIAH was at the same level as before the training program [15]. To our knowledge, there is no previous study examining the effects of volleyball training on EIAH during incremental exercise.

The purpose of this study was to examine the effect of volleyball training on the development of exercise-induced arterial hypoxemia during incremental treadmill exercise in male competitive volleyball players.

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Material and Methods

Participants

Eight male volleyball players (mean ± SD; age 21 ± 1.3 years, height 181.4 ± 3 cm, body mass 71 ± 4.7 kg) who played in Erciyes University volleyball team volunteered to participate in the present study. All participants were students of the Faculty of Sport Sciences. All players had trained and competed regularly in volleyball for at least 4 years. Measurements were performed following the approval of the Ethics Committee and carried out in accordance with the Declaration of Helsinki. All testing and training procedures were fully explained, and written informed consent was obtained for each participant.

Experimental Design

The experimental protocol consisted of baseline testing, a 6-week training intervention, and post-testing. Players performed a volleyball training program three times per week for 6 weeks at the beginning of the pre-season preparatory period. All training sessions were conducted at the same time of day on Monday, Wednesday and Friday of each consecutive week. One week before the start of the 6-week training period and two days after its completion all players performed an incremental treadmill test. During the study, the players were not allowed to perform any additional strength and conditioning training that would affect the results of the study.

Data Collection

Incremental running test was performed on a motorized treadmill (h/p/Cosmos Quasar med, Nussdorf-Traunstein, Germany). Throughout all tests, expired air was measured online using a breath-by-breath cardiopulmonary exercise testing system (Quark PFT Ergo, Cosmed Srl, Rome, Italy). During the incremental testing period, heart rate (HR) was monitored continuously using a wireless HR monitor (S610i, Polar, Finland) and was synchronized to ventilatory signals. Before each test, ambient conditions were measured, and the gas analysers and turbine flowmeter were calibrated with known certified gas concentrations (16 %O_2, 5 %CO_2, and balanced N_2) and a 3 L calibration syringe, respectively, following the manufacturer's instructions.

Breath-by-breath data was smoothed using a five-step average filter and then reduced to 15 s stationary averages. Maximal oxygen uptake (VO_{2max}), maximal values of minute ventilation (VE_{max}) and respiratory exchange ratio (RER_{max}), ventilatory equivalent for oxygen (VE/VO_2) and carbon dioxide (VE/VCO_2) were determined during the incremental treadmill test.

SaO_2 was measured continuously and recorded every 15 s during the incremental treadmill test, using a finger pulse oximeter (Spiropalm 6MWT; COSMED, Rome, Italy). For most accurate readings, the sites were vigorously cleaned with alcohol and gauze pads. EIAH was assumed to have developed when SaO_2 decreased by at least 4 % ($\Delta SaO_2 \leq -4$ %) from the baseline values [2]. Delta SaO_2 (ΔSaO_2) was calculated as the difference between rest and maximal exercise values.

Incremental Treadmill Test

Before test, the players performed a standardized warm-up consisting of a 5 minutes run at their own pace followed by about 3 minutes of stretching. Players started running at 7 km/h with speed increments of 1 km/h every minute until they could no longer keep pace. All players were given strong verbal encouragement throughout the test to elicit their best performance.

Achievement of VO_{2max} was considered as the attainment of at least two of the following criteria: 1) a plateau in VO_2 despite increasing speed, 2) a respiratory exchange ratio (VCO_2/VO_2) above 1.10, and 3) a HR within 10 beats per minute of age-predicted maximum HR (220 –age). The VO_{2max} was defined as the highest 15 s VO_2 value reached during the incremental test and expressed as a relative value (milliliters per minute per body mass; ml/kg/min). VE/VO_2, VE/VCO_2, VE_{max} and RER_{max} were expressed as the highest 15 s average value obtained during the last stage of the incremental exercise test.

Training Program

A single training session lasted approximately 120 minutes (comprising warm-up, main and cool-down periods). The warm-up period consisted of jogging, different types of running and accelerations, submaximal jumps, mobility exercises, full body stretching and specific volleyball warm-up drills with the ball, and lasted 20-25 minutes. Each training session ended with a 10-15 minutes cool-down consisting of walking and stretching. The main part of the volleyball session consisted of on-court skills training and the game-based drills including small-sided games and real-game volleyball drills. On-court skills training included serving, passing, and setting in small groups, spiking, blocking and digging drills, as well as skills-based conditioning drills such as lateral movement and blocking, lateral movement and dig drill, moving off of the net and retrieving a ball. Training sessions concluded with high-intensity game-based drills to work on offensive and defensive strategies and individual tactics. The game-based drills included small-sided games such as 3 vs. 3 and 4 vs. 4, where the volleyball court was divided into two smaller courts, and 6 vs. 6 real-game volleyball drills.

Statistical Analysis:

Data are reported as mean ± standard deviation (SD). Statistical significance was accepted at $p < 0.05$. The normality distribution of the data was checked with the Shapiro-Wilk test. Within-group changes before and after the 6-week training period was compared using paired t-test for normally distributed data, and Wilcoxon matched-pair signed-rank test for non-normally distributed data. To allow a better interpretation of the results, effect sizes were also calculated using Cohen's d [16]. Effect sizes were interpreted as negligible ($d \geq 0.2$), small ($0.2 \leq d \leq 0.5$), medium ($0.5 \leq d \leq 0.8$) or large ($0.8 \geq d$). SPSS version 21 was used for all analyses (SPSS Inc., Chicago, IL).

Results

Table 1 shows the players' responses to incremental treadmill test. All the players exhibited EIAH (as defined by $\Delta SaO_2 \leq -4$ %) before and after the training program (Figure 1). SaO_2 was significantly decreased from 97.6±1 % at rest to 88.7±2.7 % at exhaustion before the training program ($p < 0.001$, d= 5.5), and from 97.2 ± 1.1 % at rest to 88.8 ± 2.1 % at exhaustion after training program ($p < 0.001$, d= 5.3). There was no significant difference in resting SaO_2 % and ΔSaO_2 values by comparison between the before and after training program ($p > 0.05$, d= 0.4). The lowest SaO_2 % values occurred at or near VO_{2max} in both exercise tests with no significant difference the before and after training program ($p > 0.05$, d= 0.04) (Figure 1).

Figure 2 shows the changes in SaO_2 plotted as a percent of the relative work rate (i.e. VO_{2max} %). EIAH was begun at 70.4 ± 21.1 % of maximum work rate (i.e. VO_{2max} %) before the training program and at 70.9 ± 18.1 % of maximum work rate after the training program. There were no significant differences in the exercise intensity of began to experience EIAH after training program compared to before ($p > 0.05$, d= 0.03). There were no significant changes in VO_{2max}, VE_{max}, RER_{max}, VE/VO_2 and VE/VCO_2 after training program compared to before ($p > 0.05$) (see Table 1).

Discussion

In the present study, the incremental treadmill test caused EIAH in all volleyball players, and this response was found to be similar after the 6-week volleyball training program. In addition, volleyball training had no statistically effect on VO_{2max}, VE_{max}, RER_{max}, VE/VO_2 and

Table 1. Results of the incremental treadmill test of the volleyball players before (pre) and after (post) the 6-week training period

Variables	Pre- training	Post- training	p	d
ΔSaO_2 (%)	8.8 ± 3.3	8.3 ± 1.5	0.7	0.2
VO_{2max} (ml/kg/min)	50.3 ± 3.1	51.3 ± 3.3	0.9	0.3
VE_{max} (L/dak)	155.4 ± 7.7	160.6 ± 10.8	0.07	0.5
RER_{max}	1.16 ± 0.05	1.2 ± 0.06	0.2	0.7
VE/VO_2	41.3 ± 4.2	42.4 ± 4.6	0.4	0.2
VE/VCO_2	37.7 ± 2.9	36.6 ± 3.6	0.2	0.3

Note: Values are means ± SD; VO_{2max} = maximal oxygen uptake, RER_{max} = maximal respiratory exchange ratio, VE_{max} = maximal minute ventilation, VE/VO_2 = ventilatory equivalent for O_2 at maximal exercise intensity, VE/VCO_2 = ventilatory equivalent for CO_2 at maximal exercise intensity, ΔSaO_2 = difference between rest and maximal exercise values of oxyhemoglobin saturation.

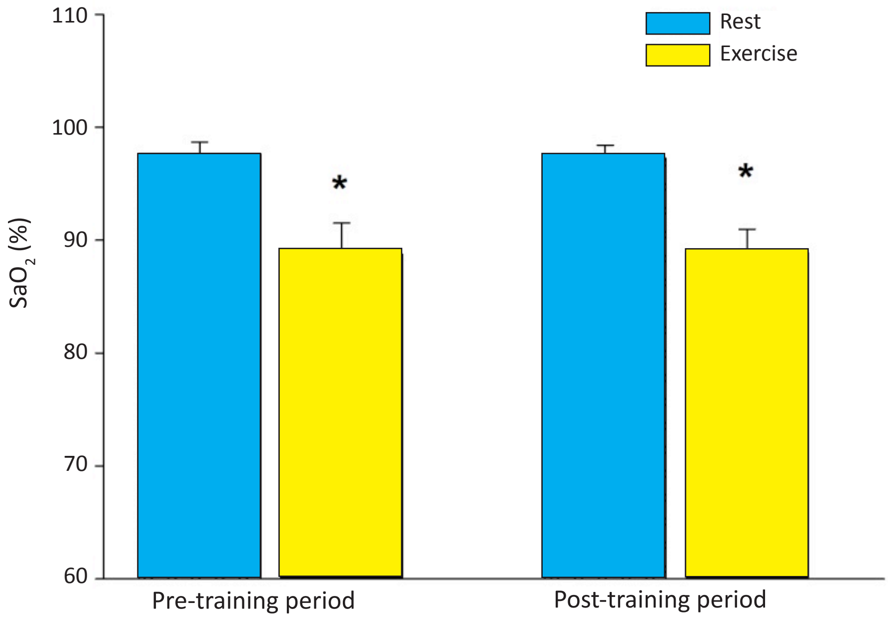

Figure 1.* Significantly different from pre-training (baseline) values. SaO_2 values at rest and maximum work rate during incremental treadmill test before (pre) and after (post) the 6-week training period.

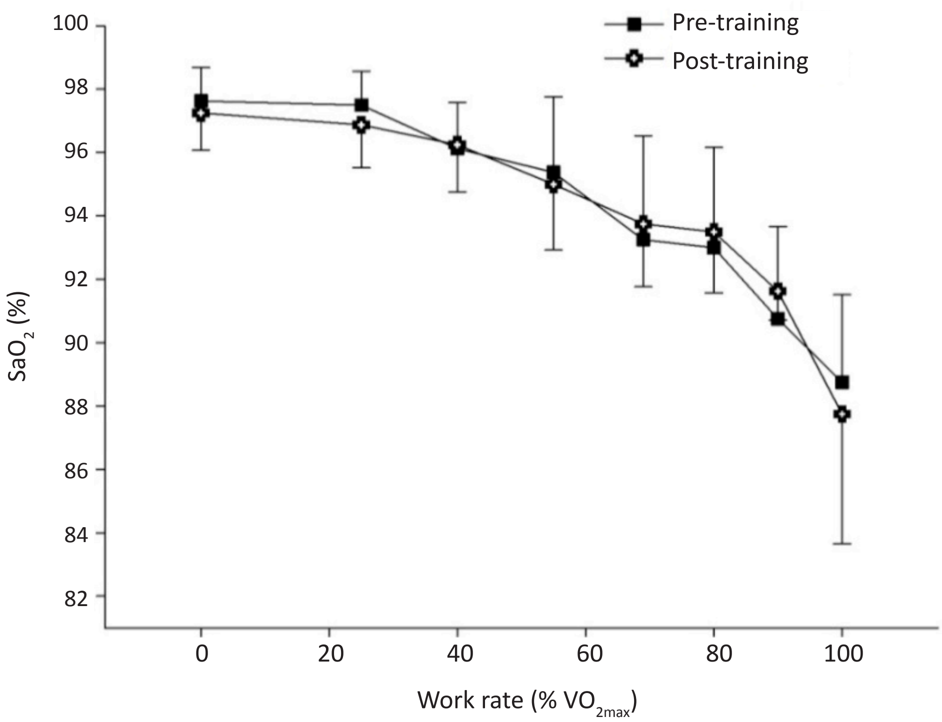

Figure 2. Mean values for the changes in the percent of oxyhemoglobin saturation (SaO_2) at different percentages of relative work rate during incremental treadmill test before (pre) and after (post) the 6-week training period.

VE/VCO_2. These findings suggest that anaerobic trained athletes may exhibit exercise-induced arterial hypoxemia, but volleyball training has no effect on the degree of exercise-induced arterial hypoxemia.

We found that EIAH occurred in all subjects before and after the training period. On the other hand, previous studies have observed that EIAH did not occur in all trained athletes [4, 17]. In particular, EIAH has been reported to occur mostly in endurance athletes with a VO_{2max} greater than 60 ml/kg/min [3, 10, 11, 17]. Powers et al. found that 52% of the highly trained athletes occurred EIAH during incremental cycle exercise test, whereas none of the untrained or moderately trained subjects developed EIAH [17]. A more recent study has shown that EIAH during incremental treadmill exercise occurs in 70% of well-trained endurance athletes [4]. Differences in measured SaO_2 may be explained by differences in exercise modality and types of protocols used [18, 19]. It has been shown that a greater drop in the SaO_2 during treadmill running compared with cycle ergometry exercise in the same subjects [20]. Mucci et al. showed that non-endurance sportsmen developed EIAH after an eight-week supra-maximal interval-training program [14]. In our recent study, we showed that EIAH during incremental treadmill exercise occurred at similar level in both aerobic and anaerobic trained athletes with different aerobic fitness levels [13]. It appears that studies examining EIAH have primarily focused on endurance athletes [11, 17, 21]. The more severe occurrence of EIAH in elite athletes may be due to the trained athletes being able to push their physical capacity to the limit during maximal exercise rather than aerobic capacity level.

Pulse oximetry has been widely used in the literature to determine EIAH and has been recognized as a valid and reliable tool for continuously monitoring SaO_2 % during exercise [22, 23]. Similar to previous studies using pulse oximetry, in our study, the SaO_2 % values decreased in the range between 85% and 92% during incremental exercise [3, 24, 25]. SaO_2 decreased 8.8% and 8.3% from rest before and after training period, respectively, similar to previous studies performed during incremental treadmill exercise [13, 26]. In our study, volleyball players were considered to have developed EIAH when SaO_2 fell at least 4 % ($\Delta SaO_2 \leq -4$ %) from the baseline values [2]. During the incremental treadmill exercise, we followed the time course of SaO_2 from rest state to exhaustion. EIAH developed at the about 70.4 and 70.9 % of maximum work rate (i.e. VO_{2max} %) before and after the training program, respectively, and peaks at or near maximal exercise intensity. There was no difference in the work rate of began to experience EIAH after training program compared to before. Our findings are consistent with studies in the literature showing that EIAH begins to occur at submaximal exercise in some subjects and usually peaks at or near maximal exercise intensity during the incremental exercise [13, 21, 27]. Inadequate hyperventilation and widened alveolar-to-arterial oxygen difference are the most likely mechanisms for EIAH occurs at moderate intensity workloads [2, 9, 21, 27].

There are limited studies in the literature investigating the effect of training on EIAH [12, 13, 15]. Interval training has been shown to increase VO_{2max}, while decreasing

SaO_2 more during heavy exercise [12, 14]. It is suggested that the more severe occurrence of EIAH after training is caused by less alveolar hyperventilation response [12, 14]. In these studies, the decrease in VE/VO_2 after the training period compared to before was interpreted as less hyperventilation response developed with training [12, 14]. Mucci et al. associated the development of EIAH after 8 weeks of interval training with a decrease in VE/VO_2 despite an increase in maximal ventilation during exercise [14]. The decreased hyperventilatory response during strenuous exercise may be related to the lower adaptation of the ventilator system to physical training [12]. It has been suggested that less hyperventilation during strenuous exercise after training period may be related to adaptations in ventilator chemo-responses [12]. Endurance athletes endowed with low ventilator chemo-responses have been reported to breathe less than non-athletes at similar exercise intensities [28]. The low chemoresponsiveness of the respiratory system has been shown to contribute to less hyperventilation and arterial hypoxemia during strenuous exercise [10, 29]. Granger et al. suggested that chemoreceptor sensitivity to carbon dioxide may play a role in the development of EIAH in aerobically trained athletes, partially explaining the variability in EIAH occurrence and severity [10]. VO_{2max} did not change after 6 weeks of volleyball training in our study. In addition, it may be suggested that less hyperventilation response did not develop with volleyball training, as there were no significant changes in VE/VO_2 and VE/VCO_2. As a matter of fact, no difference was found in the degree of EIAH in volleyball players after the training program compared to before. The ability of the neuromuscular system to produce power during intense exercises such as various sprints, jumps and high-intensity court movement is the most important factor determining athletic performance in volleyball [30]. Volleyball training may not include physiological adaptations to improve the aerobic capacity of athletes.

On the other hand, exercise-induced arterial hypoxemia has been suggested to not necessarily worsen with aerobic training [15]. There are some researchers showing that aerobic training did not increase the severity of EIAH [15]. Dominelli et al. showed that female runners' VO_{2max} increased after five months of endurance training, but the degree of EIAH remained similar during the maximal exercise test [15]. Some researchers reported that arterial hypoxemia during strenuous exercise was accompanied by less hyperventilation response and lower alveolar oxygen partial pressure [21, 31]. On the contrary, others concluded that the increase in alveolo-arterial oxygen pressure difference ($A\text{-}aDO_2$) plays a major role in the occurrence of arterial hypoxemia during strenuous exercise and ventilation contributes less [32]. It has been reported that the increase in $A\text{-}aDO_2$ during strenuous exercise is mainly due to oxygen diffusion limitation caused by the shortening of the pulmonary capillary blood transit time when cardiac output reaches its maximum in trained athletes [21, 11]. One of the possible causes of the increase in $A\text{-}aDO_2$ is the increase in ventilation-perfusion mismatch as a result of the greater increase in minute ventilation volume compared to perfusion during exercise [9]. In addition, the development of interstitial pulmonary edema due to a high cardiac output during exercise contributes to the enlargement of $A\text{-}aDO_2$ by decreasing PaO_2 [2]. However, there are very few longitudinal studies examining the specific effect of aerobic or anaerobic training on EIAH. Our data represent a rather novel finding that could be of considerable importance for showing occurrence of EIAH in volleyball players, but that volleyball training has no effect on the severity of EIAH.

Conclusions

The results of this study showed that volleyball players with a history of anaerobic training may exhibit exercise-induced arterial hypoxemia, but that 6-week volleyball training has no effect on the degree of exercise-induced arterial hypoxemia. Further research is needed to investigate the effects of training on exercise-induced arterial hypoxemia in in different team sport branches.

Conflict of interest

Authors declare no conflict of interest.

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Information about the authors:

Selcen Korkmaz Eryılmaz; (Corresponding Author); http://orcid.org/0000-0002-3680-3580; selcen_korkmaz@yahoo.com; Department of Coaching Education, Faculty of Sport Science, Cukurova University; 01330 Balcalı, Sarıçam. Adana. Turkey.

Kerimhan Kaynak; http://orcid.org/0000-0002-5608-2661; kerimhankaynak07@hotmail.com; Department of Coaching Education, Faculty of Sport Science, Erciyes University; Kayseri, Turkey.

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ORIGINAL ARTICLE

Effect of positive and negative dimensions of mental imagery and self-talk on learning of soccer kicking skill

Gholamreza Lotfi[1ABCDE], Farshid Tahmasbi[1ABCE], Mohammad Hossein Forghani[1ABCDE], Andrzej Szwarc[2DE]

[1]*Shahid Rajaee Teacher Training University, Tehran, Iran*
[2]*Gdansk University of Physical Education and Sport, Poland*

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

Abstract

Purpose: Mental imagery and self-talk are two important mental skills that are used for improvement of performance and learning of motor and sport skills. This study aimed to investigate the effect of positive/negative mental imagery and positive/negative self-talk on learning of soccer kicking skill.

Material: Participants included 48 young soccer player students. Participants were soccer player students with mean age 18.44 and SD=.88 years. After selecting the sample and filling out the personal detail form, the imagery and self-talk instructions, the method of completing mental imagery questionnaire, Moore-Christine kick-skill test instructions, and principles of free kick at soccer were explained to participants. Then, the mental imagery test and kick-skill test were run in 4 blocks of 4 attempts and the results were recorded. Based on their pre-test scores, the participants were divided into 4 groups. The acquisition sessions were held for 3 weeks and 2 sessions per week, with 8 blocks of 4 trials (32 trials) per session. The data was analyzed using one-way ANOVA, mixed ANOVA, and two-way ANOVA tests at different learning stages (significance level= 0.05).

Results: The results of data analysis showed that positive imagery and positive self-talk groups performed significantly better than negative imagery and negative self-talk groups. Also, due to the significance of interactive effect of imagery × training sessions, it was found that the positive imagery groups performed significantly better than negative imagery groups from the third session onwards.

Conclusions: According to the results, it was recommended that trainers use this aspect of self-talk at early stages of training. Also, the positive imagery can be emphasized by increasing the training sessions in more skilled individual.

Keywords: mental imagery, self-talk, acquisition, retention, transfer, soccer.

Introduction

Athletes spend a lot of time training skills in different situations to promote their performance. Meanwhile, stress is a factor that always affects performance; athletes should do mental and cognitive trainings to coping with anxiety and control their arousal to promote their performance, especially at those skills that need focus and attention. There are many factors such as personal problems, exercise needs, fear of failure, and emotional issues that cause anxiety and prevent the athlete from achieving his/her performance goals. Thus, various mental and physical interventions are run on athletes. The psychological methods and control of athlete's mind are interventions that the psychologists run to help the athlete overcome his/her fear of failure, cope with his/her worries and obstacles, and improve his/her performance [1].
The mental trainings include self-talk, mental imagery, relaxation techniques, and goal setting. In recent decades, the psychologists have developed various definitions for mental imagery; one of them defined it as "using senses to create or recreate an experience in mind" [2].

Self-talk is one of the most important cognitive strategies used by athletes. Self-talk includes statements that a person says to him/herself, whether loudly or repeatedly in his/her mind [3]. Using appropriate keywords, the self-talk helps athletes' control and organize their thoughts, focus on key areas of skill, and motivate themselves to work harder during training [4]. The researchers recently combined self-talk with psychological skills and found that it impacts positively on student performance [5].

The sport psychologists have found that the cognitive skills may improve performance; control anxiety, fear of failure, worry, and arousal; and impact positively on self-confidence and success of athletes. Meanwhile, self-talk and mental imagery are mental skills that athletes apply before, during, and after performance or training of skill. Therefore, it is possible that the combination of main cognitive strategies such as mental imagery and self-talk have an effect on learning free kicks at soccer [6].

Cognitive strategies such as mental imagery and self-talk are the best interventions to improve the performance of athletes. Mental imagery is an intervention that leads to desirable results such as increased focus and attention, improved self-confidence, and improved performance. The mental imagery is applied to improve focus, promote self-confidence, fix performance weakness, control emotional responses, training and learning sports skills and strategies, and cope with pain and injury [7]. The sports psychology researchers have highlighted weaknesses in mental training methods, including mental fatigue [8].

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Balance at performance is not effective in relaxing the body and it even seems to be completely inconsistent with physical condition of athletes during the performance. They believe that the mental imagery is more effective when all senses are involved and kinesthetic senses are experienced during actual skill performances [9]. According to researchers, the mental imagery is used to simulate movements by exercising areas of brain that are common between physical performance and mental imagery; this can facilitate performance and speed up learning [10]. The mental imagery also helps prepare mentally to perform skills and creates focus for performing skills.

The theory of arousal regulation is one of the mental imagery effectiveness theories. Based on this theory, the imagery improves performance in two ways: First it adjusts the level of arousal to have optimal performance; and second it conducts the attention to current tasks. If athlete focuses on task-related images in mental imagery, it is less likely that unrelated stimuli distract him/her, However, if the imagery is used for negative communication, it would lead to undesirable results [6].

Self-talk is a constant conversation between individuals and themselves that affects their feelings and behavior. There are different types of self-talk including positive self-talk (in the form of instructional or motivational self-talk), negative self-talk, and neutral self-talk. Positive self-talk encompasses a wide range of inner thoughts; it helps a person focus on positive phrases of a desired outcome or goal. In particular, positive educational self-talk focuses on providing technical training to athlete [11].

A good addition to improving the efficiency of technical training to athletes is: monitoring of athletes' motor actions [12]; psychological climate in the team [13-15]. In this context, soccer should attach great importance to the development of rational self-talk [16] and the search for effective methods to activate it [17]. It may be considered that sufficient performance of the soccer players results from self-completion, motivation, belief in themselves and desire to act for success by using their skills [18].

There are some applied theories which are used to understand the structure of self-talk such as Nideffer's theory of attentional underpinning [19] and Bandura's self-efficacy theory [20]. Nideffer [21] details how initial stressors such as real/imagined dangers, competitive environments, or unknown situations cause both a physical response (increased heart rate, changes in respiration, muscle tension, increased perspiration) and a psychological response (feeling confused, loss of focus, mental rigidity, inner directed attention and tunnel vision). Bandura [22, 23] situates self-efficacy within a theory of personal and collective agency that operates in concert with other sociocognitive factors in regulating human well-being and attainment.

Due to lack of appropriate theories, researchers have suggested to examine effects of self-talk by conducting individuals' attention [24]. Like mental imagery, self-talk is used often to improve focus, have continued learning, increase motivation, and reduce anxiety. Self-talk, like mental imagery, can be both positive and negative [6].

From theoretical perspective, the interaction between mental imagery and self-talk is explained by dual coding theory and action - language - imagery model. Both theories assume that information is acquired through two independent channels; one system is allocated to non-verbal information (such as mental imagery and observing what is displayed) and the other is for verbal information [25, 26].

Since performance and learning sports skills require high focus and reflect thoughts and feelings, research is needed to find out which strategies athletes should use to cope with challenges.

The present research is necessary, because most of research on effect of mental imagery and self-talk on performance of various skills is qualitative and individuals have expressed the extent of using these strategies. Also, the research has mostly considered the positive aspect of these psychological interventions and have ignored their negative effects on acquisition of skills.

There is also little research on applying combination of these skills as intervention to improve attention and focus. So, it is important to examine the compensatory, weakening, and reinforcing effects of such cognitive strategies on acquiring and memorizing attention and focus skills.

It is necessary to use scientific methods other than traditional trainings in order to create better conditions for performance of these skills. Since trainers and athletes try to improve attention skills performance by using a variety of methods, the self-efficacy and mental imagery may have a positive effect on learning it. This method can be used to prevent stress and anxiety during competition and improve the performance of athletes while performing attention and focus skills.

However, the research questions are as following: if learning of skills that require attention and focus, such as free kicks, is weakened by negative mental experiences, can positive self-talk help to improve it? Whether improved learning by positive mental experiences can be weakened by negative self-talk experiences? Whether the improved learning by positive mental experiences can be improved more by positive self-talk experiences? And, Whether the weakened learning by negative mental experiences can be impaired more by negative self-talk experiences?

Material and Methods

Participants. The participants included 48 volunteered experienced soccer player students that were tested for imagery ability and footedness. Participants were soccer player students with mean age 18.44 and SD=.88 years. Then, they were tested by Moore-Christine kick-skill test. Based on acquired scores, the participants were divided into 4 homogenized groups of 12.

Research design. This was an applied research and was semi-experimental research based on executive method. Data were gathered at field study and because of two independent variables, a factorial design were used.

Task: To run Moore-Christine kick-skill test, the goal was divided into two parts, 120 cm in diameter. In total, 4 identical circles were located on either side of goal. The participants would have the opportunity to kick in four stages and each stage with 4 kicks, each kick toward one of circles alternatively (16 kicks) from a distance of 16 meters. The score 10 was awarded to kicks which enter the ball to the goal circle and the score 4 was awarded to kicks which enter the ball to the other circles. The balls that were rolled on the ground were not awarded points. So far, no specific norm has been proposed for it [27].

Procedure: In research process, the subjects were first trained on correct way to kick the goal. Then, the soccer kick performance pre-test was run and the imagery ability questionnaire was completed by participants. At this stage, the average score (total score divided by number of kicks) was used. The study was conducted at two stages; it lasted 2 weeks and 3 sessions per week. The stages included general training and special training. After training sessions, the soccer kick performance was tested by 32 kicks, 16 shots from the right and 16 shots from the left. At this stage, also, the average score (total score divided by number of kicks) was used.

Movement Imagery Questionnaire (MIQ-R) was used to assess movement imagery ability; it includes eight self-report items: visual imagery (four items) and kinetic imagery (four items). Individuals evaluated the resolution of their mental representation using seven-point Likert scale. The participants were classified into two scales: (a) ability of visual imagery (1= very difficult to see, 7= very easy to see) and ability of kinetic imagery (1= too hard to feel, 7= too easy to feel). Hall and Martin found a significant correlation between MIQ and MIQ-R in both visual and kinetic imagery subscales. They concluded that MIQ-R was an acceptable modification of MIQ [28].

Statistical Analysis. One-way ANOVA were used for comparing groups in pre-test, the mixed ANOVA with repeated measures on training sessions were used for analysis of acquisition phase, and two-way ANOVA were used for analysis of retention and transfer stages. The data was analyzed at significance level, $p < 0.05$, using SPSS software, version 22.

Results

The mean of performance scores of all 4 groups at pre-test, acquisition (6 sessions), retention, and transfer stages are summarized in figure 1.

Based on results of Levene's test, the homogeneity of variances was confirmed. The results of Shapiro-Wilk test showed that the data had a natural distribution at all research stages. One-way ANOVA test was used to compare the mean scores of kicks at pre-test stage and it was found that there was no significant difference between groups, also the one-way ANOVA was used to compare the mean scores of mental imagery ability at pre-test stage; the homogeneity of groups was confirmed.

In order to evaluate the acquisition phase, a 2 (imagery) × 2 (self-talk) × 6 (training sessions) mixed ANOVA with repeated measures was used. The results are summarized in table 1.

Considering the table results, the main effect of imagery, the main effect of self-talk and interactive effect of imagery × sessions were reported to be significant; other main effects and interactive effects were not significant.

Considering the significance of main effect of imagery

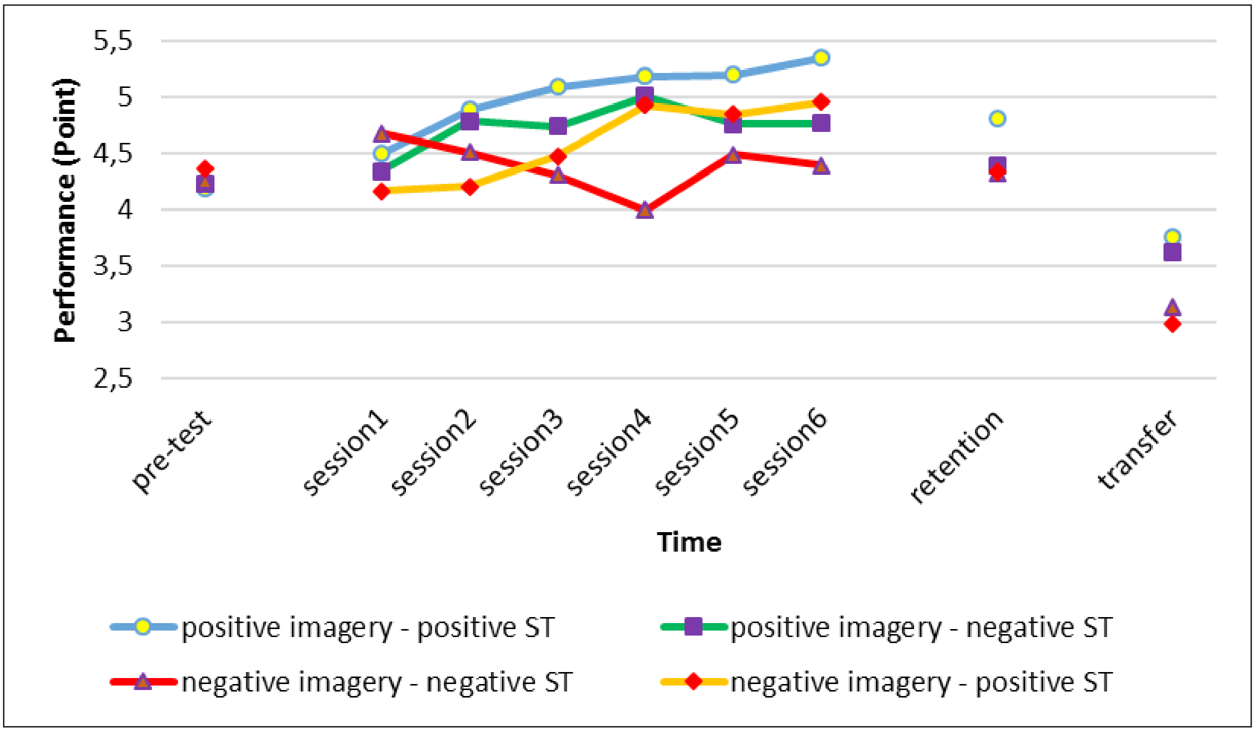

Figure 1. Mean of performance in different stages

Table 1. Results of mixed ANOVA with repeated measures in acquisition phase

Source	SS	df	MS	F	Sig.
Imagery	24.89	1	24.89	18.21**	0.001
Self-talk	8.87	1	8.87	6.49*	0.014
Sessions	2.04	3.51	0.58	1.50	0.21
Imagery * Self-talk	0.16	1	0.16	0.12	0.734
Imagery * Sessions	6.80	3.51	1.93	5.01**	0.001
Self-talk * Sessions	1.89	3.51	0.54	1.39	0.243
Imagery * Self-talk * Sessions	1.99	3.51	0.57	1.47	0.221

Note: *significant at 0.05 level; **significant at 0.001 level

and main effect of self-talk, referring to mean values, it was found that at acquisition stage, the positive imagery and positive self-talk groups performed significantly better than negative imagery and negative self-talk groups. Also, considering the significance of interactive effect of imagery × sessions, independent t-tests (alpha adjustment to 0.008) and repeated measures tests were used for follow up. The independent t-tests were run to compare the performance of both positive and negative imagery groups at each training session and the results showed that from the third session onwards, positive imagery groups performed significantly better than negative imagery groups.

The results of Bonferroni post-hoc test showed that at positive imagery groups, there was a significant difference between mean scores of first session and other sessions; however, there was no significant difference between mean scores of second, third, fourth, fifth, and sixth sessions. The results of mixed ANOVA with repeated measures showed that the effect of training sessions on negative imagery group was not significant.

Discussion

The findings showed that at self-talk acquisition stage, the effect of imagery and sessions was significant; positive self-talk and positive imagery groups performed better. Also, the difference between positive and negative imagery groups was significant from the third session onwards. At positive imagery groups, there was significant difference between first session and other sessions in terms pf performance; this difference was not significant at negative imagery groups. The results of imagery acquisition stage are consistent with results of Lotfi et al. [27], Tolul et al. [29], and Ghorbani et al. [30]. Also, the results of studying imagery are consistent with results of Parvizi [6], Nicholas et al. [31], and Taylor and Shaw [32]; they showed that learning according to type of task or skill may weaken acquiring imagery skills. This approach in teaching motor activities in soccer must be perceived as Practice in Mind (PIM) Training. It is a combination of imagery and physical training program which consists of sevens PETTLEP components (i.e. Physical, Environment, Timing, Task, Learning, Emotion, Perspective) [17]. This fact proves that soccer players adapt their movements to opportunities within the surrounding environment by engaging in visual exploratory activity (VEA) to pick up information [33].

Mamassis and Doganis showed that mental training skills such as imagery reduce cognitive and physical anxiety and increase self-confidence in adolescent athletes [34]. However, the results were inconsistent with results of Fathi et al. [35]; they found that negative mental imagery in individual with social anxiety disorder could be associated with their better performance. So, it can be said that depending on psychological conditions of individuals, the negative imagery may improve performance. It seems that this type of imagery does not affect athletes [35].

The results of studying self-talk were consistent with results of Chang et al. [36], Lotfi et al. [37], Van Raalte et al. [38], Klovelonis et al. [39], Kruni et al. [40], and Ghorbanzadeh [41]. Lotfi et al. [42] showed that at positive motivational self-talk group, the anxiety was significantly lower than pre-test and negative group post-test performance. There was no difference between groups at retention and transfer tests [42].

These results can be explained by Action - Language - Imagination (ALI) model of movement imagery; this model suggests that there is a relationship between imagery and verbal system for movement processing and information. According to Annette, movement imagery forms a bridge between independent information and coding system. Thus, the movement system is responsible for coding human actions through observation, while the verbal system is responsible for obtaining information through talking or writing. The language-action bridge operates through movement imagery and allows actions to be seized and taken, and it also allows individuals to be able to respond to verbal instructions [6].

Conclusions

Considering the findings, it was suggested that the soccer coaches use positive imagery to teach free kick skills to more skilled individual. Also, considering the effect of self-talk on motivation of individuals, it was recommended that trainers use this aspect of self-talk at early stages of training. Also, the positive imagery can be emphasized by increasing the training sessions; it has a significant effect on learning of free kick skill in more skilled individual.

Conflict of interest

The authors declare no conflict of interest.

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Information about the authors:

Gholamreza Lotfi; (Corresponding author); Associate professor in motor behavior; http://orcid.org/0000-0002-4506-5313; gholamrezalotfi@sru.ac.ir; Shahid Rajaee Teacher Training University, Lavizan, Tehran, Iran.

Farshid Tahmasbi; Assistant professor in motor behavior, http://orcid.org/0000-0001-8946-5856; farshidtahmasbi@yahoo.com; Shahid Rajaee Teacher Training University, Lavizan, Tehran, Iran.

Mohammad Hossein Forghani; Master of motor behavior; http://orcid.org/0000-0003-1881-5059; forghanihossein9@gmail.com; Shahid Rajaee Teacher Training University, Lavizan, Tehran, Iran.

Andrzej Szwarc; https://orcid.org/0000-0003-1959-3902; Associate professor; andrzej.szwarc@awf.gda.pl; Department of Sport, Gdansk University of Physical Education and Sport Gdansk, Poland.

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ORIGINAL ARTICLE

The effect of acute exercise on cognition

Blanka Dwojaczny[1BCD], Sergii Iermakov[2ADE], Tetiana Yermakova[3ADE], Mirosława Cieślicka[1ADE]

[1]*Collegium Medicum im. L.Rydygiera in Bydgoszcz, Nicolaus Copernicus University in Toruń, Poland*
[2]*Gdansk University of Physical Education and Sport, Poland*
[3]*Kharkiv State Academy of Design and Arts, Ukraine*

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

Abstract

Purpose: Several lines of evidence indicate that physical activity has a positive impact on central nervous system. The positive impact is observed in areas of brain related to cognitive processes such as memory, learning and attention. The majority of studies focused on the chronic effects of exercise. Relatively limited number of reports addresses the problem of influence of acute exercise (single bouts of exercise) on cognitive functions.

Material: We examined the influence of a single bout of exercise on cognitive performance of young volunteers (23 males; aged 20,91 ± 1,01). To evaluate the cognitive performance in our subjects we used Face/Name Association Test, Stroop Test and Trail Making Test. Volunteers run for 30 minute at moderate –intensity.

Results: The mean results in the Face/Name Association Test before acute exercise were 63,52 ± 5,65% and after acute exercise 67,34 ± 5,82% ($p<0,005$). Statistically differences results were also observed in duration of the retrieval phase of this test ($p<0,005$). In the Trial Making Test, in part A mean results before acute exercise were 66,26 ±11,24 seconds and after physical training 52,39 ± 11,10 seconds ($p<0,005$). In part B mean results were 80,60 ± 22,52 and 70,47 ± 14,54 seconds before and after acute exercise, respectively ($p<0,05$). We have not observed statistical difference in results of the Stroop Test.

Conclusions: Our data suggest that a single bout of exercise can influence the level of cognitive performance. We demonstrate improvement in cognitive function depending on hippocampus (short-term memory) and prefrontal cortex (attention, cognitive flexibility). We have not observed influence of acute exercise on Stroop test (executive function) results.

Keywords: short-term memory, cognitive flexibility, hippocampus, prefrontal cortex, cognitive tests

Introduction

Regular physical activity exerts beneficial influences on several aspect of the central nervous system. In particular, the positive effects are observed in the areas of brain which are related to cognitive processes such as memory, learning and attention [1-4]. Currently it is accepted that regular physical activity leads to improvement of cognitive function via stimulation of neural stem cells proliferation, increases the survival of newly formed nerve cells [2, 3, 5]. Physical exercise enhances cognitive function in both young and older adults but in elderly humans' regular physical exercise additionally helps reduce the risk of neurodegenerative diseases [6-9].

Majority of research focused on the chronic effects of exercise [10-12]. Relatively limited number of research addresses the problem influence of acute exercise (single bouts of exercise) on cognition [13-16]. Previous research indicates that acute bout moderate aerobic exercise improves choice reaction task [17, 18], simple reaction task [19, 20] and confliction task [21].

Other studies reported the following:

- acute exercise improves only prefrontal cortex function such as attention, concentration, reasoning and planning but not hippocampal function [22-24];
- acute high-intensity exercise may enhance true episodic memories, and possibly, also increase the rate of false episodic memories [25];
- acute moderate-intensity aerobic exercise is not associated with prospective memory performance but provides some suggestive evidence that acute exercise may reduce the rate of false memories [26];
- 20 minutes of moderate-intensity exercise benefits EF (executive function) performance in high school students [27];
- acute exercise demonstrates different time-dependent effects of acute exercise on cognition in TEMP and COLD. Study reveals facilitating effects of exercise on university students' processing speed and working memory in both environments. However, in contrast to TEMP, effects on working memory in COLD are transient [28].

There is still very limited research which showed that acute exercise improves long-term memory, associative memory and learning [15, 29-31].

The potential mechanism through a single bout of exercise can influence on cognitive function is unclear. The effect of acute exercise on cognition seems to be depend on many factors: type of exercise, intensity, duration, time course post-exercise cessation.

Therefore, it seems necessary to carry out further research which clearly indicate that impact of single bout of exercise on cognitive process. In the current study we determine the impact of 30 minutes of running on the

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cognitive function such as: declarative memory, selective attention, ability to inhibit habitual responses, attention and cognitive flexibility before and after acute physical activity.

Material and Methods

Participants.

The study was conducted in accordance with the Declaration of Helsinki for Human Studies. The study protocol was approved by a local Ethics Committee.

Volunteers (23 males; aged 20, 91±1, 01) were recruited from the Kazimierz Wielki University in Bydgoszcz (Poland). The volunteers were students from the Faculty of Physical Education. In order to limit the influence of hormonal factors on the obtained results only boys were qualified in this study. In order to limit the differences in their level of education, physical activity and socioeconomic background, all volunteers were students of the same faculty. All students were regularly engaged in weakly schedule at least 9 hours of supervised intense physical activity (including soccer, competitive swimming, volleyball, track athletics).

Research Design.

Evaluation of cognitive abilities was based on scores obtained by participants in Face/Name Association Test, Stroop Test and Trial Making Test. All cognitive tasks were conducted both before and after acute exercise session. The detailed experimental protocols for these tests were described previously [32]. Shortly, in the acquisition phase of the face/name association test, subjects were exposed to 100 faces associated with a single name on a computer screen. Each face/name pair was presented for 2 seconds. After 10 min from the end of acquisition phase the retrieval phase began. During this phase test subjects were presented with the same faces as in acquisition phase but each face was associated with two names, one of which was the same name as in acquisition phase. The task of the subject was to indicate the name associated with the face during acquisition phase. No time limitations for retrieval phase were imposed by the protocol. The percent of correctly answered names, and the duration of the retrieval phase were monitored for each subject. Face/name test evaluating short-term declarative memory associated with hippocampal activity [33].

The Stroop test consisted of four pages. The first test page contained the names of colours written in two columns in black ink (20 words in each column). The task was to read the names of colours. The second page contained the rows of cross marks in two columns (20 rows in each column). The rows of cross marks were displayed in different colours. A colour of each row was recognized and pronounced by each participant. The third and fourth pages contained the names of colours written in two 20-word columns. An ink colour was different than the name of a colour. The written name of colour (third page) or the colour of the ink (fourth page) were recognized and pronounced by each subject. For each page the time of reading duration was recorded. In the statistical analysis we used the reading time of the last page expressed as a percentage of the first page reading time. The Stroop test measure multiple cognitive processes such as executive control, selective attention and ability to inhibit habitual responses [34, 35]. These abilities are strongly associated with the activity of prefrontal and anterior cingulate cortical areas [36].

The Trail Making Test consisted of two pages. The first page contained numbers from 1 to 25 which are randomly arranged on a piece of paper. The task of the subject is to connect numbers of a continuous line (without revealing a paper and pencil). The second page contained numbers (from 1 to 13) and letter (from A to L) which are randomly arranged on a paper. The task of the subject is to connect alternately numbers and letters (without revealing paper and pencil). The result of the test is the time it took to complete part A and part B, respectively. TMT test measures prefrontal cortex-dependent attention and cognitive flexibility [37].

Volunteers were engaged in 30 minutes running at moderate-intensity (16 km/h). Physical activity session with 5-min.warn up and 5-min. cool down period for a total of 40 min. of exercise. Cognitive tests took place 20-30 minutes after physical training.

All tests were performed between 9:00 am and 14 pm.

Statistical Analysis.

Statistical significance of the differences between before-exercise tests and after-exercise tests was assessed using two-tailed paired T-Test. The results are presented as means with standard deviation. $p<0.05$ was considered statistically significant.

Results

The mean score of Face/Name Association Test before acute exercise was 63, 52 ± 5, 65%, after the exercise the scores were 67, 34 ± 5, 82 %. 19 volunteers improved their score. The score decreased in 4 volunteers (Fig.1). In the same test before acute exercise the mean retrieval duration equalled 301, 21 ± 78, 97 seconds, after acute exercise mean retrieval duration equalled 259, 26 ± 55, 83 seconds. 19 volunteers improved their score. The score decreased in 4 volunteers (Fig. 2). Statistically significant differences were observed between percentage of correctly recognized pair face/name and the duration of the retrieval phase of this test.

We also observed statistically differences in a Trail Making Test ($p<0.005$). The mean results in TMT A before acute exercise were 66, 26 ± 11, 24 seconds, after acute exercise the mean results were 52, 39 ± 11, 10 seconds. 20 volunteers improved their score. The score decreased in 3 volunteers (Fig.3). The mean results in TMT B before acute exercise were 80, 60 ± 22, 52 seconds. After the acute exercise the mean results were 70, 47 ± 14, 54 seconds. 18 volunteers improved their score. The score remained unchanged in 1 and decreased in 4 volunteers (Fig.4). Statistically differences were observed between results before and after for TMT A (p<0, 005) and for TMT B (p<0, 05).

Statistically differences were not observed in Stroop test conducted before and after acute exercise. The mean

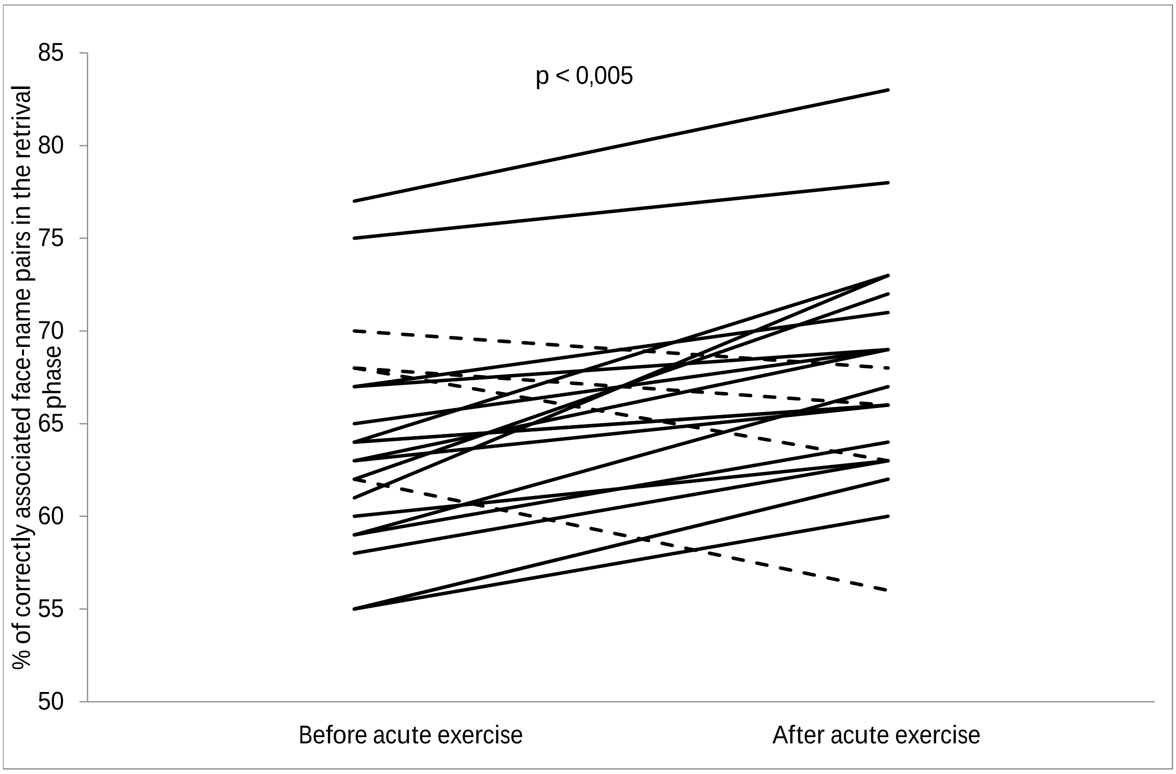

Fig.1. Individual scores in the face/name association test - % correctly associated face-name pairs. Each subject's results from before and after acute exercise are connected by a line. Solid line depicts subjects who fared better on the post-exercise test, dashed lines those who fared worse after acute physical exercise.

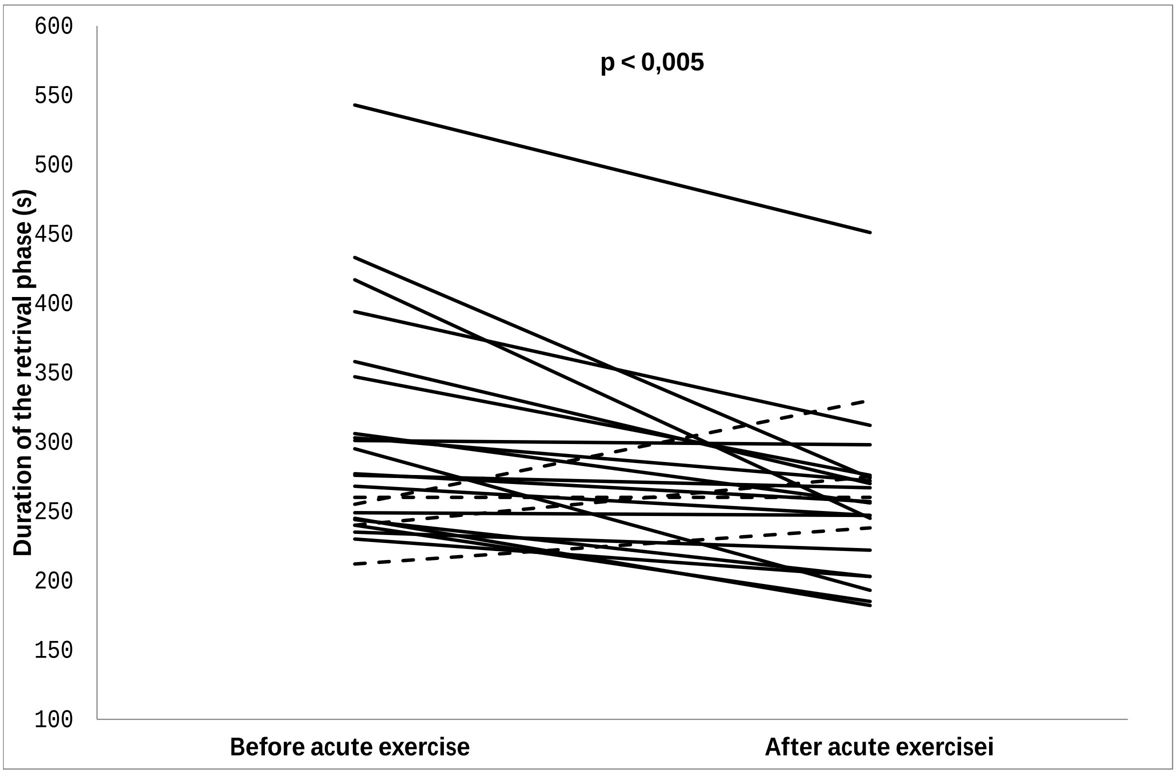

Fig.2. Individual scores in the face/name association test – duration of the retrieval phase. Each subject's results from before and after acute exercise are connected by a line. Solid line depicts subjects who fared better on the post-exercise test, dashed lines those who fared worse after acute physical exercise.

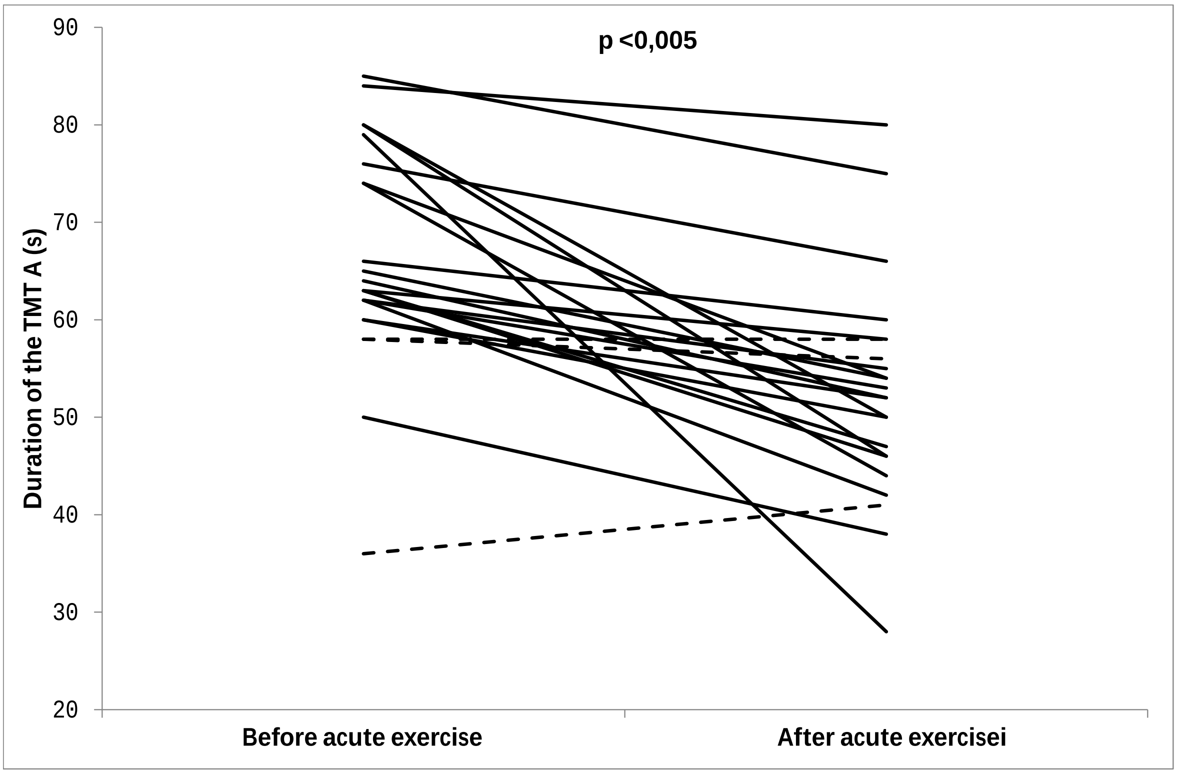

Fig.3. Individual scores in the Trial Making Test – duration of the TMT A phase. Each subject's results from before and after acute exercise are connected by a line. Solid line depicts subjects who fared better on the post-exercise test, dashed lines those who fared worse after physical exercise.

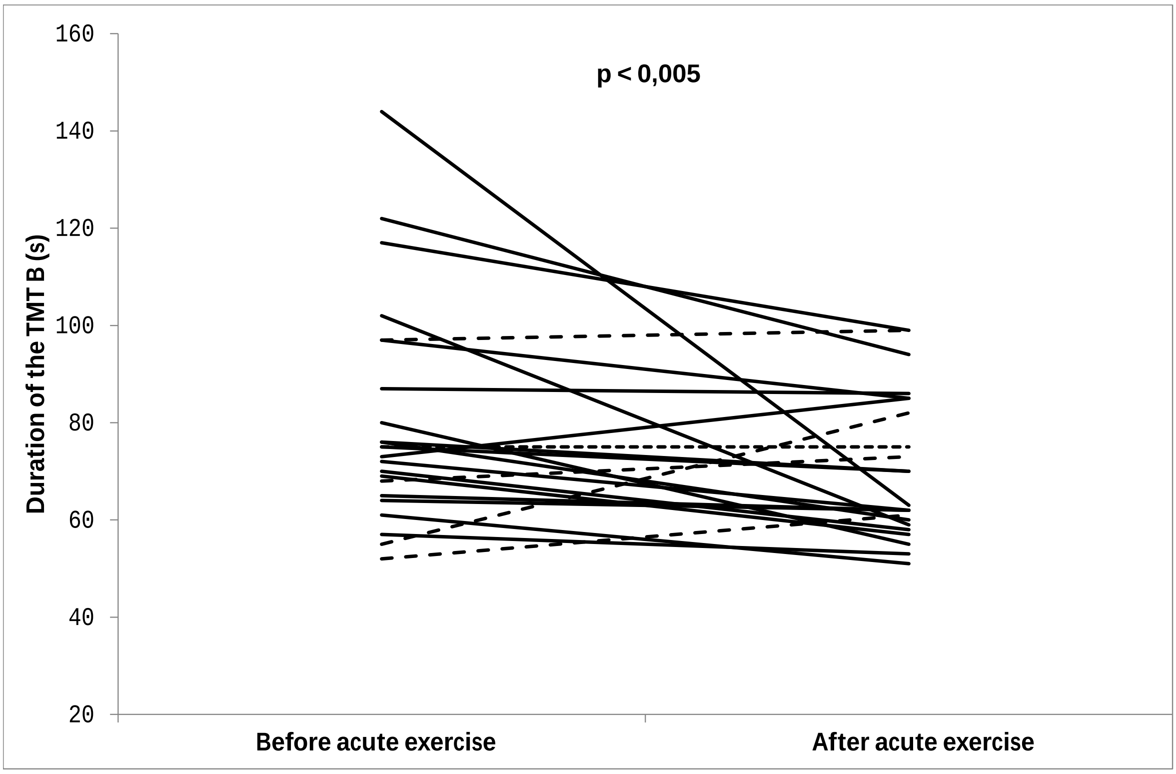

Fig.4. Individual scores in the Trial Making Test – duration of the TMT B phase. Each subject's results from before and after acute exercise are connected by a line. Solid line depicts subjects who fared better on the post-exercise test, dashed lines those who fared worse, dotted lines represents individuals with score unchanged after acute physical activity.

result in the Stroop test was 199, 0 ± 29, 56 % and 200 ± 27, 02% in the before and after acute exercise results, respectively.

Discussion

The data presented in this report indicate that a single bout exercise can have significant influence on some cognitive function. 20-minutes of running improved short–term declarative memory expressed by Face/ Name Association Test and attention determined by Trial Making Test. There were no significant differences in the Stroop Test before and after a single bout exercise. Short-term declarative memory is closely associated with hippocampal activity while attention and cognitive flexibility depend on prefrontal cortex. Cognitive processes assessment by the Stroop test remain under control several discrete areas of cerebral cortex and are strongly associated with the activity of prefrontal and anterior cingulate cortical areas.

In contrast to studies of the impact of regular physical exercise on central nervous system, relatively limited number of publications describe influence of single bout exercise on cognitive function. Our findings are consistent with the results from other studies which demonstrated influence of acute exercise on cognitive function [17-21, 38]. However, the results obtained so far are difficult to interpret due to differences in duration, intensity, modality of exercise and the population assessed. Currently, the potential mechanism for the effect of single bout of physical activity on the cognitive function is unclear. Previous research suggests that acute exercise can impact cognitive processing by induced increase brain derived neurotrophic factor (BDNF), insulin-like growth factor (IGF-1) and increase peripheral levels of monoamines such as: dopamine, epinephrine and norepinephrine [39-42]. 30 minutes running at moderate intensity can result in the increase of level BDNF, IGF-1, dopamine and maintain their elevated level up to 90 minutes after the end of exercise. BDNF stimulate growth of new neurons, neuronal differentiation and survival also enhances synaptic plasticity and may promote learning and memory. Studies have shown a positive association between acute exercise- induced peripheral BDNF levels and short-term memory and motor skill memory [43-45]. Studies conducted by Winter et al. showed a significant increase in serum BDNF after anaerobic training. IGF-1 similar like BDNF regulate neurogenesis, neuronal survival and differentiation [39]. Single bout of exercise increase levels of dopamine and serotonin in hippocampus, prefrontal cortex and striatum [46-49]. This neurotransmitters may be a part of positive effect acute exercise has on cognitive functioning [39, 49, 50].

The improvement of result in the Face/Name Association Test and Trail Making Test described in this paper may be a result of influence of 30 minutes running on neurotrophic factors and levels of monoamines. Although research conducted by our team doesn't indicate the mechanism of the observed change of cognitive abilities but they confirm earlier reports about the impact of acute exercise on cognitive function.

Conclusion

The data suggest that a single bout of exercise can influence on level some cognitive performance in young individuals. In our studied acute exercise improves cognitive function depending on hippocampus and prefrontal cortex However, more research is needed to understand the mechanisms of observed changes.

Conflict of interests

The authors have no conflict of interests to declare.

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Information about the authors:

Blanka Dwojaczny; (Corresponding author); https://orcid.org/0000-0002-2253-1502; blanka.dwojaczny@cm.umk.pl; Department of Human Physiology, Collegium Medicum im. L.Rydygiera Bydgoszcz, Nicolaus Copernicus University in Toruń; Toruń, Poland.;

Sergii Iermakov; Doctor of Sciences in Pedagogy, Professor; http://orcid.org/0000-0002-5039-4517; sportart@gmail.com; Department of Sport, Gdansk University of Physical Education and Sport; Gdansk, Poland.

Tatiana Yermakova; Doctor of Sciences in Pedagogy, Professor; https://orcid.org/0000-0002-3081-0229; yermakova2015@gmail.com; Department of Pedagogy, Kharkov State Academy of Design and Arts; Kharkov, Ukraine.

Mirosława Cieślicka; http://orcid.org/0000-0002-0407-2592; m.cieslicka@cm.umk.pl; Department of Human Physiology, Collegium Medicum im. L.Rydygiera Bydgoszcz, Nicolaus Copernicus University in Toruń; Toruń, Poland.

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ORIGINAL ARTICLE

Influence of static balances level on competitive performance indicators of athletes 17-21 years old in beach volleyball

Oleksandr Solovey[1ABCDE], Valeriy Hunchenko[1ABCDE], Dmytro Solovey[1BCDE], Krzysztof Wnorowski[2DE]

[1]*Prydniprovska State Academy of Physical Culture and Sports, Ukraine*
[2]*Gdansk University of Physical Education and Sport, Poland*

Contribution of authors:
A - Research design; B - Data collection; C - Statistical analysis; D - Preparation of the manuscript; E-Funds Collection

Abstract

Purpose: To determine the influence of the level of static balance on the competitive activity of athletes aged 17-21 in beach volleyball.

Material: The study involved athletes aged 17-21 years, who play beach volleyball in the Kherson region. The research was focused on the main indicators: the total number of serves, passes, tactical strikes, blocks, and how the development of static balance affects the level of their performance.

Results: Acrobatic exercises in training activities for special physical training positively contributed to the increase in the samples of Bondarevsky ($p < 0.05$), Romberg ($p < 0.05$) and Yarotsky ($p < 0.05$). Samples with different nature of the work performed reflect different aspects of static equilibrium: samples of Bondarevsky and Yarotsky most reflect the nature of the work performed during the competitive activities of athletes; Romberg's test only partially corresponds to these indicators.

Conclusions: The proposed methodological approach significantly affects the performance of competitive activities and is directly related to the quality of tactical strikes, high-level performance in defense and the number of serves. The results of the study indicate the difference in samples with different nature of the work. Overstrain of the vestibular centers can negatively affect the quality of tactical strikes in the attack and blocking.

Keywords: beach volleyball, competitive activity, efficiency, vestibular stability, correlation coefficient, static balance.

Introduction

The stage of preparation for the highest sports skills is one of the key steps in the preparation process of athletes to the main competitions in the chosen kind of sport. The task of the stage is reaching the maximum results in all kinds of sports. The main purpose of the stage is to ensure the rapid flow of adaptation processes through the use of tools that can cause them [1]. The conditions of training should correspond to the following: the period of the most intensive training loads should coincide with the period of maximum propensity of the athlete to achieve the highest results [1]. Physical training of athletes is the basis of the process of sports improvement [1-3].

The leading physical qualities of beach volleyball athletes are: strength, and on its basis – speed-power and speed qualities and agility [4-8]. Agility is based on coordination abilities, which largely depend on the stability of vestibular reactions. The feeling of the position of the body and individual biolinks in space, including movement, refers to the properties of the central nervous system. This ability is divided into: static balance (the ability to maintain the stability of the pose); dynamic balance (the ability to maintain balance during the movements of the whole body) and the most important and significant quality – vestibular (statokinetic) stability (the ability to accurately perform individual or global movements during vestibular stimuli) [9, 10].

Statokinetic stability depends on static and dynamic balance and stability of vestibular reactions [11, 12]. Game sports are accompanied by constant changes in body position, jumping, falling, accelerating and rapid transitions from one stage to another [13-15].

In various sports, statokinetic stability plays a significant role in the manifestation of coordination skills and agility. According to Platonov [3] coordination abilities are manifested in predetermined conditions of complex movements. Agility is based on coordination abilities and is manifested in unpredictable conditions, namely the influence of external or internal factors on the movements of the athlete. External factors may include weather conditions (sun, wind, loose soil), variable trajectory of the ball, opposition of the opponent, to internal – deviations in the initial positions of the body due to changes in external factors and correction of body movement taking into account afferent innervation body. All these factors are integral and pronounced components of competitive activity in beach volleyball. In view of this, in relation to beach volleyball, it is advisable to use the term – agility. Therefore, the study of one of the components of vestibular stability, as a component of agility, should be of interest to scientists involved in the problem of successful human motor activity. One of the areas of this issue is training in sports, and in particular in beach volleyball, where it is extremely important. However, the analysis of scientific and methodological literature shows that at present there are only a few pieces of information on improving the process of physical training of beach volleyball athletes by improving psychomotor qualities.

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In volleyball, this problem was solved by Kozina et al. [16] and Zamporri et al. [17], using exercises to develop static balance. Horchanyuk [18, 19] emphasizes the need to use models of jumps and movements to improve the process of sports training in sports training. Lysyansky et al. [20] pay attention to the control over the process of sports training in beach volleyball and its adjustment on this basis. Kostyukov [21, 22], Hemberg and Papaheorhiou [23], consider didactic and methodological approaches to the training process, improving the technical and tactical component of training of athletes, give examples of physical, technical and tactical training of leading athletes in beach volleyball and provide scientific advice on improvement of the specified work due to optimization of process of trainings and use of the advanced practical experience.

Lin [24] and Gunchenko [25] state that high-quality performance of various, in particular power serve, is a significant reserve for improving the effectiveness of competitive activities, emphasize that in the competitive activities of volleyball players there is both static and dynamic balance, which actualizes the adoption of appropriate tactics in practice.

Giatcis [26] came to the conclusion that the latest changes in the rules of the beach volleyball game (the size of the court) have led to an increase in the spectacle of matches, an increase in the number of games, where the result is determined in 3 sets. This determines their uncompromisingness and unpredictability of the result. It also increases the total number of draws held in the game, which puts forward increased requirements for the physical fitness of athletes.

Drikos et al. [27] derive the coefficients of efficiency of the serve (the ratio of lost serves to the won) and the coefficient of the efficiency of the attack (the ratio of the won blows to the lost and blocked).

Portuguese scientists Araújo et al. [28] note that competitive activities in men's volleyball are characterized by constant adaptation to the tactics of the players as attack and defense. The relationship between blocking and strikes in an attack in elite men's beach volleyball is given. The coefficients of effectiveness of a particular type of blocking depending on the attack zone were calculated, these trends must be taken into account in the training process.

Platonov [3] argues that the physical training is a key component for achieving results in competitive activities. Tymoschenko [5] emphasizes the development of maximum force accuracy. Solovey and Hunchenko [4] found that increasing the number and quality of stable power supplies in the jump in beach volleyball and offensive strikes makes it impossible to predict the development of offensive actions. This precludes the construction of appropriate defensive actions, which significantly increases the effectiveness of tactical offensive strikes of a bypass nature and the effectiveness of competitive activities in general. The increase in quantitative indicators in actions that require maximum explosive force directly depends on the physical fitness of athletes. Further sports improvement involves increasing the efficiency of the training process through new areas and strategies to improve the process.

Most scientists suggest increasing the intensity and volume of load in the process of sports improvement. However, this direction has its limits, which are determined by the objective regularity of development and formation of sportsmanship. In this regard, it is essential to find alternative sources to improve the process of sports training.

Platonov [1, 3], Kozina [16] emphasize the need for individualization and differentiation of means and methods of sports training, as well as the development of new approaches to building a training process in preparation for higher achievements.

Competitive activity determines the features of the sport. Beach volleyball, like other sports, is a complex coordination sport [3, 13, 29].

The effectiveness of certain elements of the technique of the game during the competition indicates the level of game readiness of athletes. This determines their competitiveness and achievements during the competition. Analysis of the strengths and weaknesses of the training of athletes allows us to conclude which technical components and physical shortcomings require increased impact and determine the leading physical qualities in beach volleyball.

Thus, Doroshenko [30] focuses on the processes of management of technical and tactical activities and sports training on the basis of control data; Balasas et al. [31] prove that 12 weeks of fitness training in beach volleyball increase the level of development of strength and endurance of leg muscles, increase the effectiveness of the jump by 11.6%, including on hard surfaces; Kostiukevich [29] suggests using exercises of increased coordination difficulty during the training process in sports games. This will provide a significant level of variability in technology. Shankulov et al. [32] show that the greatest number of loads on the development of coordination, agility and vestibular stability should be planned in the preparatory period. This will help to achieve the best state of sports readiness of the team before the start of the competitive season. At the end of the preparatory period, the amount of load is purposefully reduced in order to maintain optimal functional and physical fitness of athletes.

The analysis of the strengths and weaknesses of the training of athletes allows us to draw conclusions about which technical components and physical shortcomings need increased impact and determine the leading physical qualities in volleyball.

Tili and Giatcis [33] analyzed the growth rates of the winners of women's games under the aegis of the FIVB depending on the specialization and size of the court. Silva et al. [34] carried out research on analytical materials used in classical volleyball. These materials were comparative and prognostic in nature. The influence of the conducted methods on the performance and efficiency of games, as well as computer programs used were investigated. Medeiros et al. [35] state a gradual transition from descriptive to comparative and prognostic analysis of beach volleyball matches. Also they state the lack of analytical studies of the impact of physical components of sports fitness on technical and tactical level and the level of resistance to the performance of competitive activities in general. Coliago [36] in his study developed the structure and content of sports training in the annual cycle of beach volleyball athletes. He offered an effective ratio of training loads, versatility and efficiency of performance of technical receptions that promoted increase of efficiency of performance of separate game elements. Castro et al. [37] investigated the dependence of the effectiveness of a counterattack in classical volleyball depending on its speed, power, and the number of blocking opposing players. Papadimitriu et al. [38] analyzed the effectiveness of attacking actions of world-class volleyball teams depending on the quality of actions of the player performing the passing.

The social status of beach volleyball is constantly growing. The problems of improving the training process of beach volleyball athletes in scientific publications at the expense of alternative directions and strategies for the development of the sport are insufficiently covered. This determined the relevance of our study.

Hypothesis. It is assumed that the static balance and stability of vestibular reactions have a significant impact on the efficiency and effectiveness of certain technical elements during the competition, and on the outcome of competitive activities in beach volleyball.

The purpose of the study is to determine the influence of the level of static balance on the indicators of competitive activity of athletes aged 17-21 in beach volleyball.

Material and Methods

Participants. This study involved beach volleyball athletes aged 17-21 who play beach volleyball in the Kherson region (Ukraine). During the experiment, an experimental group of 20 young men was created. All study participants gave written consent to participate in the experiment.

Research Design.

The basis for the study were: Kherson State University (Kherson, Ukraine), Children's and Youth Sports School № 6 (Kherson, Ukraine). Training participants were trained 6 times a week. The training process lasted from December 2018 to April 2019 and was allocated 704 hours (32 hours per week) during the training period.

The main task of microcycles was to ensure the adaptation in the body of athletes, solving the main tasks of physical and technical and tactical training. During the work, special attention was paid to special physical training with an emphasis on acrobatic training. Two blocks of acrobatic exercises were developed, which were used in the preparatory and main part of each of the training sessions of complex orientation and totaled 20 minutes of training work. In the exercise blocks, rollovers, a "wheel" and handstands were used. Both blocks of exercises were used in each of the classes. The total amount of work for all types of training was characterized as significant, and the load was 70-80% of the maximum possible.

At the end of the preparatory period, the level of ability to static balance was tested using a number of tests, such as the Romberg test, the Yarotsky's test and the Bondarevsky test. Romberg's test [39] was as follows – the time during which the subject maintained balance was measured; Modified Yarotsky's test (MYT) [12] – balance retention time was measured; Bondarevsky's test [11]– the number of attempts for which the subject could stand in balance for 1 minute was counted.

Subsequently, a video of games in which athletes participated in the experiment (one game of each participant) at the Games of the Championship of Ukraine (U21) and the open championship of Kherson State University in beach volleyball (Kherson, Ukraine) was recorded. The method of expert evaluation of athletes' actions based on videos was used. Five experts (coaches with more than 20 years of experience) were involved. The number and level of performance of certain elements of beach volleyball technique in competitive conditions were analyzed. The level of performance provided for the division of elements of technology into three stages: high level, medium and low. The high level of performance of the element of technology provided: the ability to perform the following technical actions of his team, winning a point, or extremely difficult further technical actions of the opposing team. Medium level – made it difficult for the players of his team to carry out further technical actions or significantly complicated the actions for the opposing team. Performing a technical technique at a low level resulted in a point loss, did not complicate the further actions of the players of the opposing team, or significantly complicated the performance of further technical actions of his team.

Statistical analysis. In the process of analysis average, average error, correlation and variation coefficients were calculated. To determine the consistency of experts' opinions on each of the technical actions, a coefficient of variation was calculated, and a correlation analysis was calculated to establish the relationship between the indicators. Microsoft Excel 2007 was used to calculate the correlation coefficient of tests for static balance with quantitative and qualitative indicators of performance of elements of game technique in competitive conditions. The result was significant at $p < 0.05$.

Results

The application of a methodical approach to the planning of training sessions on special physical training based on the use of acrobatic training, as well as ensuring the adaptation of athletes in beach volleyball, positively contributed to the increase in the samples of Bondarevsky ($p < 0.05$), Romberg ($p < 0, 05$) and Yarotsky ($p < 0.05$) (Table 1).

Purposeful influence on the main parameters of the arsenal of technical and tactical actions allowed increasing the effectiveness of attacking actions of athletes in beach volleyball. There is a noticeable tendency to increase the number of: medium and low levels ($p < 0.05$) and medium levels of reception (p <0.05), high and medium levels (p <0.05); high-level tactical strikes (p <0.05); high-level power strikes (p <0.05) and high level of defense (p <0.05); high-level blockages (p <0.05).

The consistency of experts' opinions on each of the technical actions was quite high. Coefficients of variation range from 8.15% to 12.47%. Since V ≤ 15%, the opinions are consistent, the set is homogeneous and the results can be trusted.

The obtained correlation coefficients indicate the presence of an inverse relationship at the average level of the quantitative indicator of the performed feeds with the Bondarevsky's test (Table 2).

That is, with increasing test rate (deterioration) the number of serves decreases. No significant dependencies were detected with the performance of the serve at a high level. With the performance of the mid-level serve, there is an inverse relationship between the middle level and the low-level feed. As the test rate increases (deterioration), the number of serves in general and performed at medium and low levels decreases.

With the technical action of the serve in the test there is a complex relationship. With the implementation of the reception of the serve at a high level there is a weak inverse relationship, with the implementation of the medium level, the average direct dependence. As the test deteriorates, the number of medium-level serves increases and the high level decreases slightly.

Bondarevsky's test with the pass for the attack has an inverse relationship with the quantitative indicator and its performance at a high level. With its implementation at medium and low levels revealed a direct relationship. As the test rate deteriorates, the number of quality passes decreases and the average and low quality performance increases.

With a hit in a tactical attack there is an inverse correlation with the quantitative indicator and qualitative actions and actions at the average level. With the performance of a low-level strike, a direct dependence of the low level is revealed. This indicates an increase in quantitative and qualitative indicators in the performance of tactical strikes with the improvement of test performance data and an increase in low-quality strikes with its deterioration.

With a strike in a strength attack, the Bondarevsky's test has a slight inverse correlation with all indicators.

Table 1. Indicators of static balance of athletes in beach volleyball before and after the experiment (n = 20)

N	Test	To the experiment		After the experiment		Δx	t	p
		$\overline{X}$	S	$\overline{X}$	S			
1.	Bondarevsky	8.89	1.22	7.72	1.23	2.02	3.08	p<0.05
2.	Romberg	16.68	10.29	29.92	26.07	2.02	2.11	p<0.05
3.	Yarotsky	21.30	6.97	36.32	19.11	2.02	3.30	p<0.05

Table 2. Influence of the level of static balance on the indicators of competitive activity of athletes aged 17-21 (n = 20)

Tests / indicators of game technique	The number of serves	Medium level of seer	Low level of serves	Medium level of serve reception	The number of passes	High level of pass	The number of tactical strikes	High level of tactical strikes	The number of strength strikes	High level of defense	The number of blocks	High level of blocking
Tests	Correlation coefficients between indicators											
	To the experiment											
Bondarevsky	**-0.55**	-0.28	0.19	**0.49**	-0.24	**-0.45**	-0.23	**-0.39**	-0.26	0.17	**-0.36**	-0.21
Romberg	-0.27	0.09	-0.25	0.22	-0.24	**-0.36**	-0.02	-0.20	**-0.31**	0.12	-0.17	-0.14
Yarotsky	**-0.35**	-0.11	**-0.75**	**-0.37**	**-0.44**	**-0.54**	-0.21	**-0.52**	-0.19	-0.10	-0.28	**-0.30**
	After the experiment											
Bondarevsky	**-0.57**	**-0.55**	**-0.35**	**0.66**	-0.19	**-0.39**	**-0.36**	**-0.45**	-0.1	**-0.35**	-0.01	-0.05
Romberg	**-0.34**	0.01	**-0.47**	0.28	-0.26	**-0.35**	-0.02	-0.23	**-0.33**	0.03	-0.2	-0.19
Yarotsky	**-0.39**	-0.2	**-0.35**	**0.49**	**-0.38**	**-0.54**	-0.2	**-0.42**	-0.02	-0.07	-0.29	**-0.36**

Note: reliability at α = 0,444

The inverse correlation of increased significance with the majority of indicators is observed with the game in defense in Bondarevsky's tests. With a low level of performance, the coefficient is negligible. As the test rate improves, the quality of the defense improves. With blocking indicators, the Bondarevsky's test does not show significant correlations with any of the indicators.

The Romberg test with the most-serve technique shows a negative correlation coefficient. With the indicator of the average level of performance of the supply of significant dependencies are not detected. As the Romberg test rate increases, the number of serves performed and their performance at a low level decreases.

With the reception of the serve there is a direct correlation between the test at the average level with the average level of performance. As the test rate improves, the number of technical actions performed at the average level increases.

With the pass for the strike, we observe the inverse dependence of the average level with the quantitative indicator of its performance and the indicator of its performance at a high level. The indicator of low quality of performance has a direct correlation dependence of the average level. As the test rate improves, the transmission rate decreases in both cases.

No significant correlations were found with other technical actions. Yarotsky's test with technical action of giving with the majority of indicators reveals inverse correlation dependence. As the test rate improves, the level of serve performance increases and the rate of serve performance deteriorates.

With the rate of serve reception, the test shows a direct correlation between the average level and its performance at the average level. The improvement of the test rate is accompanied by the performance of technical action at a level not lower than average.

There is a complex relationship with the serve to strike in the attack. With a quantitative indicator and its performance indicator at a high level, there is an inverse dependence of the average level. As the sample rate improves, the quantity and quality of the serve deteriorates.

The following correlation dependence is revealed with hits in an attack: with a tactical hit, a high level of its execution it is reversed, and with a force hit with a low level of its execution it is straight and of medium level. That is, with the improvement of the sample rate, the quality of execution of both tactical and force strikes decreases. This may be explained by the presence of a directly opposite dependence of the stability of vestibular reactions with the quality of the hits in the attack, which is the exact opposite of our previous hypothesis.

Yarotsky's test does not reveal significant dependencies with the game in defense. With the technique of blocking there is an inverse correlation with all indicators, quantitative, high, medium and low levels of its performance. Taking into account the specifics of the test (constant rotation of the head), it can be noted that in the game there is no need for constant long-term (for more than 20 s) irritation of the vestibular centers. This leads to overstrain of the vestibular static balance system and does not meet the needs of the game. To a greater extent, short-term stimuli (up to 2-3 s) of the system are required in the episodes of the game, which is reflected in the presence of positive dependences in samples with a less pronounced effect of irritation of the vestibular centers.

The obtained results of the study indicate the difference in samples with different nature of the work. In particular, Yarotsky's test characterizes somewhat other qualities of vestibular stability, which are not used during competitive activities in beach volleyball, and the test significantly outweighs the game factors of irritation of athletes' vestibular centers. However, the planned exercise in these conditions (significant excess of the allowable time) during sports training can have a positive effect as an increase in statokinetic (vestibular) balance and improve the agility of beach volleyball athletes in the future.

Bondarevsky's test is directly related to the quality of tactical strikes, high-level performance in defense and the number of the serves not below the average. Romberg's test leads to the improvement of the quality of serves by reducing the number of serves at a low level. However, it has a negative relationship with the quantitative and qualitative indicators of hits in a forceful attack.

Overstrain of the vestibular centers can negatively affect the quality of the hits in the attack and blocking. Therefore, the process of sports training should include restorative microcycles, during which the process of adaptation to previous vestibular loads is fully completed.

Discussion

During our study, the average value of the Yarotsky sample was determined to be 35.8 s. According to Serhienko in co-authorship [8] the scale of assessment of static balance in the sample is 35 s - excellent, 20 s - good, 16 s - satisfactory. We found: the assessment well is registered in 35% of respondents. 65% of respondents are rated well.

We determined the relationship between the levels of static balance in different tests and the performance of individual elements of the technique of playing beach volleyball in a competitive environment. Bondarevsky's test most predictably corresponds to indicators of efficiency of technical actions. With the improvement of the sample (decrease of the indicator) the quantitative and qualitative indicators of technical actions increase, in particular the serve, the serve reception, the passing, the tactical strike in the attack, the game in the defense. With the elements of the game of speed and force character (the hit in the attack of force and blocking character, the leading physical quality is jumping ability), the dependence of the stability of vestibular reactions is not observed. Romberg's test with not all elements of technology is predictable. In particular, there is a mismatch in the serve and the pass due to the overvoltage of the vestibular centers. The discrepancy between the expected and existing dependence of Yarotsky's test with the quality of technical actions was revealed. This indicates the presence of overstrain of the vestibular centers, which has no immediate effect, but may have a delayed effect. The time of Yarotsky's test significantly exceeds the vestibular loads that an athlete experiences during competitive beach volleyball activities. This issue requires additional research. All these factors make it possible to determine the areas of coordination skills and dexterity on the basis of which it is necessary to build the process of further sports improvement of beach volleyball athletes.

The study confirmed the data of Tymoshchenko [5], Pelzer et al. [6], Wergin et al. [7], Kostiukevich [29] on the management of technical and tactical activities and sports training, strength and endurance of leg muscles. The data of Balasas et al. [31] on the use of loads for the development of coordination, agility, vestibular stability, strength and endurance of the leg muscles are also confirmed. The opinions of Shankulov et al. [32] agree on the relationship between efficiency and quality of performance of certain technical actions with special physical qualities, including strength and agility (accuracy and timeliness) in volleyball. Solovey and Hunchenko [8] share the same opinion regarding beach volleyball. In the study the data of Platonov [3], Kostiukevych [29], Doroshenko [30] as for the basis for competitive activities in complex coordination sports, in particular - the physical fitness of athletes; and also the data of Kostyukov [22], Hemberg et al. [23] and Koliago [36] on the dependence of the effectiveness of competitive beach volleyball activities on the rational construction of the process of sports training, were developed.

The data of Horchaniuk [18, 19] concerning the uneven distribution of efforts of unskilled beach volleyball athletes during movements and jumps have been supplemented. When performing jumps, the horizontal position of the foot is not provided, which does not correspond to the model characteristics of jumps and movements of highly qualified athletes? All this leads to the athlete being delayed in the place of repulsion during the jump when changing the direction of the ball. This is due to insufficient special physical training of athletes, in particular insufficient development of agility and vestibular stability.

The data of Castro et al. [37], Papadimitriu et al. [38], Jaworska et al. [40], Wnorowski et al. [41] on the dependence of the effectiveness of offensive actions on the speed of attack, the quality of transmission that precedes them, and the level of development of special physical qualities of athletes received further development.

Highlights

The study was performed in accordance with the thematic research plan of the Dnipro State Academy of Physical Culture and Sports (Ukraine) for 2016-2020 on the topic "Theoretical and methodological foundations of planning and control in sports games in the process of long-term improvement", state registration number 0116U003012.

Conclusions

The proposed methodological approach significantly affects the performance of competitive activities and is directly related to the quality of tactical strikes, high-level performance in defense and the number of serves. The process of sports training should include restorative microcycles, during which the process of adaptation to previous vestibular loads is fully completed.

Conflict of interests

The authors state that there is no conflict of interests.

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Information about the authors:

Oleksandr Solovey; (Corresponding author); https://orcid.org/0000-0001-8480-2323; 1Soloveyaleksandr@gmail.com; Department of Sports Games; Prydniprovsk State Academy of Physical Culture and Sports; Naberezhna Pobedy str., 10, Dnieper, 49010, Kiev, Ukraine.

Valeriy Hunchenko; https://orcid.org/0000-0002-1986-1068; altair66v@gmail.com; Department of Sports Games; Prydniprovsk State Academy of Physical Culture and Sports; Naberezhna Pobedy str., 10, Dnieper, 49010, Kiev, Ukraine.

Dmytro Solovey; https://orcid.org/0000-0001-8105-2061; 1Soloveydmitriy@gmail.com; Department of Sports Games; Prydniprovsk State Academy of Physical Culture and Sports; Naberezhna Pobedy str., 10, Dnieper, 49010, Kiev, Ukraine.

Krzysztof Wnorowski; https://orcid.org/0000-0001-5505-7985; krzysztof.wnorowski@awf.gda.pl; Department of Sports, Gdansk University of Physical Education and Sport,; Gdansk, Poland.

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ORIGINAL ARTICLE

Examination of lower-upper limb of power and force parameters of elite athletes

Samet Aktaş[1ACDE], Oktay Çakmakçı[2ABDE]

[1]*University of Batman, Batman, Turkey*
[2]*University of Selcuk, Konya, Turkey*

Authors' Contribution: A – Study Design, B – Data Collection, C – Statistical Analysis, D – Manuscript Preparation, E – Funds Collection

Abstract

Purpose: In this study, it is aimed to evaluate the power and force parameters of lower and upper extremities of the individual and team athletes who practice different branches.

Material: 32 elite athletes, most of whom are university students, with an average age of 21.16 ± 2.08, who are active in sports, participated in the study. The groups were formed from Boxing and Handball (BG and HG) branches in which the upper extremities are used predominantly and from Taekwondo and Football (TG and FG) branches in which the lower extremities are used predominantly. The anaerobic power values of each individual's upper and lower extremities were measured by a Monark 894E. The isokinetic force values of dominant arms and legs were measured by a Cybex humac norm device.

Results: After examination of the data it was found that the upper extremity power values of BG and HG were significantly higher than TG when the top values of peak powers (PP) were evaluated. In the evaluations with respect to leg 60°/s and 180°/s extension and flexion; HG and FG was significantly higher than TG in 60°/s extension at PP; HG and FG were significantly indifferent but they were significantly higher than BG and TG in 60°/s flexion at PP. In the comparisons of the groups' 60°/s and 180°/s extension and flexion values of lower extremities anaerobic power and isokinetic force and lower extremities' wingate values, a number of positive relations were found between all of the groups. All of the groups were positively related to each other in terms of upper extremities wingate and 60°/s, 180°/s internal and external isokinetic forces.

Conclusions: Both the isokinetic arm force values and arm wingate levels were higher in the branches in which the upper extremities are used predominantly than the branches in which the lower extremities are used predominantly. On the other hand, the difference seen in the upper extremities was not seen in the lower extremities.

Keywords: anaerobic power, extremity, isokinetic force, peak powers

Introduction

Athletics not only have many physical effects on human body but also increase the prestige of nations and have positive effects on morale structure of societies [1]. The high-level performance of athletes is characterized as a whole in the concept of being the proof of physiological and psychological factors. Because of this, the scientists in athletics area conclude that the scientific researches and trial-and-error method are more useful than the observational results throughout the period in which athletes prepare for their athletics competition [2].

Isokinetic means constant speed. Isokinetic power means the maximum power generated by some muscle or muscle groups against a stable object. The tension arisen from the isokinetic contractions of a muscle has a constant speed (iso-kinetic) throughout the joint's range of motion and is at the maximum level [3].

Regularly assessing anaerobic power is important for athletes from sports with an explosive strength component [4]. Anaerobic power is the one of the two components of anaerobic performance. The power is the highest power amount gained in one unit of time at the explosive type loads. Anaerobic power depends on the ATP-PC system in terms of regeneration of ATP at intense loads [4]. Alactic anaerobic power is very important when the explosive moves lasting up to 8 seconds are needed in such conditions as 100 m sprint, weight lifting, boxing, wrestling and fencing [5].

This study was conducted to determine the anaerobic power and isokinetic force levels of upper and lower extremities of the individuals who are actively engaged in athletics in elite level.

Material and Methods

Participants

32 male elite athletes whose (most of whom are university students) with an average age of 21.16 ± 2.08 (average height is 177.59±7.49 cm and average body weight is 79.66±2.68 kg), participated in the study. The boxing and taekwondo athletes were chosen among the professional athletes who were at the national team level, the handball athletes were at the super league level of Turkey and the football athletes were at the third league level of Turkey at least. 8 athletes were participated in each branch for this research.

The participants were tested 2 hours after their breakfast. The measurements of upper and lower extremities' anaerobic power and isokinetic force were taken between 9:00-11:00 a.m. in different days. The measurements were taken as wingate upper and lower

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tests on Tuesday and Wednesday, and as isokinetic arm and leg tests on Thursday and Friday.

This study was conducted in accordance with the 19.12.2017 dated and 2017/5 numbered decree of noninvasive clinical research ethics committee of Sport Sciences Faculty of Selçuk University.

Wingate Anaerobic Test

For the wingate test, a Monark 894E arm and leg cycle ergometer with weight basket (Made in Sweden) that was connected to computer modified for the test and that had the compatible software for the computer was used. The machine was adjusted according to each one of the athletes' height before the test. The load used as the external resistance on the ergometer was determined as 50 gr/kg for the arm and 75 gr/kg for the leg. The participants were asked to pedal at their highest speed for 30 seconds against the resistance and they were supported verbally to be able to show a high performance [6].

Isokinetic Strenght Test

The participants' internal and external rotation concentric force of the dominant arm's shoulder was measured from 5 submaximal repetition at 60˚/s and 180˚/s angular velocity. These 5 repetitions were measured after 3 submaximal preliminary repetition of exercises at the same angular velocities and a relaxation period. The isokinetic force of the dominant leg was measured at 60°/s velocity with 5 repetition and 180°/s with 15 repetition. 30 seconds breaks were given between the 60°/s and 180°/s angular velocities. The measurements were taken by Humac NORM isokinetic dynamometer (Lumex Inc, Ronkonkoma, New York, USA) which's reliability and validity have been proven through different studies [7].

Statistical Analyses

SPSS 22 package program was used for the statistical analyses of the data. The parameters and standard deviations of all subjects are given. To look at the normality of the data belongs to the study, Shapiro-Wilk test was used. Among the normally distributed data, independent sample t test was used for the binary variables, one way analysis of variance (Anova) was used for the comparisons of branches and to be able to determine that which group is the source of difference LSD and Tukey tests which belong to post hoc tests family were conducted. The correlation matrix was used for the relational approach. The level of statistical significance was taken as 0.05.

Results

As shown in Table 1, the average age of boxers among the participants was 21.38±2.39, their average height was 172.50±8.43, the average body weight was 69.00±10,58. The average age of handball athletes was 20.75±2.43, their average height was 182.25±6,36 and the average body weight was 89.50 ± 23.24. The average age of footballers was 22.13±1.25, the average height was 179.38±4.03 and the average body weight was 72.87±7.27. The average age of taekwondo athletes was 21.16±2.08, the average height was 177.59±7.49 and their average body weight was 79.66±21.68. The participants' age and height values were all statistically similar. The body weights of HG were significantly different from the other three groups ($p<0.05$). The rest results are in tables 2-7.

Table 1. Descriptive information of the participants.

Parameters	Branches				
	BG	HG	FG	TG	Total
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Age(year)	21.38±2.39[a]	20.75±2.43[a]	22.13±1.25[a]	20.38±2.00[a]	21.16±2.08
Height (cm)	172.50±8.43[a]	182.25±6.36[a]	179.38±4.03[a]	176.25±7.78[a]	177.59±7.49
Body weight (kg)	69.00±10.58[b]	89.50±23.04[a]	72.87±7.27[b]	74.75±9.18[b]	79.66±21.68

Note. BG - Boxing Group, HG - Hendball Group, FG - Football Group,TG - Taekwondo Group. a, b - The difference between the averages with different letters in the same row are statistically significant (P <0.05).

Table 2. Wingate results of participants' upper and lower extremities categorized in branches

Wingate	Group	Lower Limb Mean±SD	Letter	Group	Upper Limp Mean±S	Letter
PP (W)	BG	725.54±157.83	b	BG	894.96±146.32	a
	HG	934.94±165.62	a	HG	802.69±263.09	a
	FG	844.85±133.37	ab	FG	682.82±64.83	ab
	TG	712.39±122.34	b	TG	539.98±129.57	b
RPP (W/kg)	BG	10.58±1.27	ab	BG	13.19±2.70	a
	HG	10.34±2.36	ab	HG	9.64±3.93	ab
	FG	11.75±1.98	a	FG	9.30±1.00	b
	TG	9.34±1.36	b	TG	7.11±2.09	b
AP (W)	BG	520.82±91.87	b	BG	454.83±53.29	a
	HG	634.60±96.79	a	HG	447.13±65.29	a
	FG	604.94±69.89	ab	FG	387.15±34.30	ab
	TG	542.73±83.57	b	TG	346.86±54.53	b
RAP (W/kg)	BG	7.56±1.03	-	BG	6.78±0.89	a
	HG	7.26±1.09	-	HG	5.29±1.11	b
	FG	7.91±0.25	-	FG	5.11±0.56	b
	TG	7.13±0.80	-	TG	4.43±0.92	b

Note. a, b - The difference between the averages in the same column is significant (P <0.05). BG - Boxing Group, HG - Hendball Group, FG - Football Group,TG - Taekwondo Group. PP - Peak Power, RPP - Relative Peak Power, AP - Avarage Power, RAP - Relative Avarage Power

Table 3. Dominant arm and leg isokinetic test results of the participants at 60°/s and 180°/s rotation

Parameters			Group	Lower Limb Mean±SD	Lower Limb Letter	Parameters	Group	Upper Limp Mean±SD	Upper Limp Letter
60°/s	PP(Nm)	Extension	BG	220.25±44.00	ab	İnternal	BG	66.75±12.28	-
			HG	245.75±31.25	a		HG	62.88±10.33	-
			FG	255.25±43.88	a		FG	56.75±10.54	-
			TG	191.63±41.09	b		TG	53.25±6.73	-
		Flexion	BG	113.75±18.27	b	External	BG	41.50±8.70	-
			HG	135.63±17.98	a		HG	42.00±8.62	-
			FG	138.25±28.08	a		FG	33.13±3.52	-
			TG	108.75±16.92	b		TG	36.13±6.96	-
	AP (W)	Extension	BG	144.50±29.90	ab	İnternal	BG	52.00±10.23	a
			HG	169.75±22.99	a		HG	49.13±8.11	a
			FG	167.50±29.24	a		FG	40.88±5.72	b
			TG	129.38±27.87	b		TG	40.00±4.63	b
		Flexion	BG	84.50±15.32	ab	External	BG	33.13±6.24	-
			HG	101.50±15.68	a		HG	33.63±7.37	-
			FG	99.50±19.56	a		FG	26.63±2.20	-
			TG	80.13±15.90	b		TG	29.13±5.64	-
180°/s	PP (Nm)	Extension	BG	130.50±26.16	bc	İnternal	BG	59.88±15.73	a
			HG	168.63±31.24	a		HG	55.88±8.39	a
			FG	157.63±26.55	ab		FG	49.00±9.17	ab
			TG	118.63±30.79	c		TG	41.25±12.21	b
		Flexion	BG	73.38±20.38	-	External	BG	33.75±7.25	-
			HG	85.38±9.80	-		HG	32.25±8.21	-
			FG	90.25±24.62	-		FG	30.25±4.74	-
			TG	68.00±21.14	-		TG	28.13±6.03	-
	AP (W)	Extension	BG	218.88±45.50	bc	İnternal	BG	88.00±23.40	-
			HG	277.63±53.07	a		HG	78.75±14.44	-
			FG	253.75±49.69	ab		FG	65.88±9.67	-
			TG	194.75±47.02	c		TG	58.63±14.65	-
		Flexion	BG	119.38±35.48	-	External	BG	50.13±13.87	-
			HG	136.25±19.93	-		HG	44.75±12.91	-
			FG	139.50±34.01	-		FG	41.88±7.77	-
			TG	109.25±35.41	-		TG	37.75±5.82	-

Note. a, b, c - The difference between the averages in the same column is significant (P <0.05). BG - Boxing Group, HG - Hendball Group, FG - Football Group,TG - Taekwondo Group. PP - Peak Power, RPP - Relative Peak Power, AP - Avarage Power, RAP - Relative Avarage Power.

Table 4. The correlation analysis of the participants' wingate data and dominant arm and leg 60°/s and 180°/s rotation isokinetic data categorized in branches.

Parameters			Group	Wingate Lower Limb AP (W) r	Wingate Lower Limb AP (W) p	Parameters	Group	Wingate Upper Limp AP (W) r	Wingate Upper Limp AP (W) p
AP (W)	60°/s	Extension	BG	0.58	0.12	İnternal	BG	0.75*	0.03
			HG	0.76*	0.02		HG	0.56	0.15
			FG	0.44	0.27		FG	0.03	0.95
			TG	0.41	0.30		TG	0.62	0.10
		Flexion	BG	0.31	0.46	External	BG	0.61	0.10
			HG	0.47	0.24		HG	0.64	0.08
			FG	0.32	0.44		FG	0.19	0.65
			TG	0.26	0.53		TG	0.39	0.33
	180°/s	Extension	BG	0.46	0.25	İnternal	BG	0.81*	0.01
			HG	0.91**	0.00		HG	0.56	0.15
			FG	0.59	0.12		FG	0.08	0.85
			TG	0.78*	0.02		TG	0.51	0.19
		Flexion	BG	0.35	0.39	External	BG	0.58	0.13
			HG	0.88**	0.00		HG	0.73*	0.03
			FG	0.53	0.17		FG	0.31	0.45
			TG	0.14	0.74		TG	0.63	0.09

Note. **Correlation is significant at 0.01 level. *Correlation is significant at 0.05 level. **AP:** Avarage Power. BG - Boxing Group, HG - Hendball Group, FG - Football Group,TG - Taekwondo Group.

Table 5. Wingate test results of the participants in terms of extremity dominancy

Parameters	Group	Lower Limb Mean±SD	p	Group	Upper Limp Mean±SD	p
PP (W)	ÜEASB	830.24±190.05	0.47	ÜEASB	848.82±211.10	0.00*
	AEASB	778.62±141.29		AEASB	611.40±123.44	
RPP (W/kg)	ÜEASB	10.46±1.84	0.89	ÜEASB	11.41±3.74	0.00*
	AEASB	10.54±2.06		AEASB	8.21±1.95	
AP (W)	ÜEASB	577.71±108.46	0.91	ÜEASB	463.67±121.51	0.00*
	AEASB	573.84±81.06		AEASB	367.00±48.68	
RAP (W/kg)	ÜEASB	7.41±1.04	0.94	ÜEASB	6.03±1.24	0.00*
	AEASB	7.52±0.70		AEASB	4.76±0.81	

Note. *p<0.05 ÜEASB=Boxing + Handball. AEASB= Football+Taekwondo. PP - Peak Power. RPP - Relative Peak Power. AP - Avarage Power. RAP - Relative Avarage Power

Table 6. Dominant arm and leg isokinetic force results of the participants at 60°/s and 180°/s rotation in terms of extremity dominancy.

Parameters		Dominant Leg	Lower Limb Group	Mean±SD	p	Dominant Arm	Upper Limp Group	Mean±SD	p
60°/s	PP (Nm)	Extension	ÜEASB	233.00±39.15	0.56	İnternal	ÜEASB	64.81±11.14	0.00*
			AEASB	223.44±52.59			AEASB	55.00±8.73	
		Flexion	ÜEASB	124.69±20.83	0.89	External	ÜEASB	41.75±8.37	0.00*
			AEASB	123.50±27.08			AEASB	34.63±5.55	
	AP (W)	Extension	ÜEASB	157.13±28.88	0.44	İnternal	ÜEASB	50.56±9.04	0.00*
			AEASB	148.44±33.90			AEASB	40.44±5.05	
		Flexion	ÜEASB	93.00±17.36	0.63	External	ÜEASB	33.38±6.60	0.00*
			AEASB	89.81±19.91			AEASB	27.88±4.33	
180°/s	PP (Nm)	Extension	ÜEASB	149.56±34.09	0.35	İnternal	ÜEASB	57.88±12.36	0.00*
			AEASB	138.13±34.31			AEASB	45.13±11.17	
		Flexion	ÜEASB	79.38±16.64	0.97	External	ÜEASB	33.00±7.52	0.10
			AEASB	79.13±24.97			AEASB	29.19±5.36	
	AP (W)	Extension	ÜEASB	248.25±56.58	0.23	İnternal	ÜEASB	83.38±19.38	0.00*
			AEASB	224.25±55.79			AEASB	62.25±12.56	
		Flexion	ÜEASB	127.81±29.13	0.77	External	ÜEASB	47.44±13.24	0.05*
			AEASB	124.38±37.00			AEASB	39.81±6.97	

Note. *p<0.05. PP - Peak Power. AP - Avarage Power.

Table 7. Correlation analysis between the wingate data of the participants and their dominant leg and arm isokinetic force data at 60°/s and 180 °/s rotation in terms of extremity dominancy.

Parameters		Group	Wingate Lower Limb AP (W) r	p	Parameters	Group	Wingate Upper Limp AP (W) r	p
AP (W)	Extension 60°/s	ÜEASB	0.74**	0.00	İnternal 60°/s	ÜEASB	0.49	0.05
		AEASB	0.55*	0.02		AEASB	0.35	0.19
	Flexion 60°/s	ÜEASB	0.56*	0.02	External 60°/s	ÜEASB	0.58*	0.01
		AEASB	0.42	0.10		AEASB	0.17	0.52
	Extension 180°/s	ÜEASB	0.79**	0.00	İnternal 180°/s	ÜEASB	0.45	0.08
		AEASB	0.74**	0.00		AEASB	0.46	0.07
	Flexion 180°/s	ÜEASB	0.58*	0.01	External 180°/s	ÜEASB	0.57*	0.02
		AEASB	0.43	0.09		AEASB	0.52*	0.03

Note. AP - Avarage Power; **Correlation is significant at 0.01 level. *Correlation is significant at 0.05 level.

Discussion

There were not any significant differences between the 4 groups' average ages and average heights. The HG's average body weight was significantly higher than the other three groups but there was not any significant body weight difference between the BG, TG and FG.

When the lower extremity wingate results were analysed, it was seen that the PP level of the GH was significantly higher than the BG and TG (p<0.05), but the other three groups were similar to each other. The AP parameter was significantly higher in the HG than the BG and TG (p<0.05) but again there was not any significant difference between the other three groups about the AP parameter (Table 2).

Bilge and Tuncel have informed that the RPP group average of elite handball athletes was 8.77±1.15 W/kg [8]. Üstündağ et al. have informed that the elite boxers average RPP was 8.32±1.21 and the elite taekwondo athletes' value was 8.53±0.7, [9]. Finally, Arslan stated that the elite football athletes' average RPP level was 11,20 W/

kg. Hereby with this study the RPP levels were found as 10.5±1.27 for the BG, 9.14±3.89 for the HG, 11.75±1.98 for the FG and 9.34±1.36 for the TG, so these results are similar to the statements above [10]. Micklewright et al. presented the maximum power level of the regularly exercising 15 healthy males whose average age is 24 and average body weight is 75.4 kg as 633 W after doing the leg wingate test in a study conducted to put the difference between athletes and non-athletes [11].

When the upper extremity wingate anaerobic power was examined intergroups, the BG and HG's PP levels were found significantly higher than the TG ($p<0.05$), and the other averages were similar among the groups. The BG's RPP level was significantly higher than FG and TG, the average values of other groups were significantly similar to each other. The BG and HG were significantly higher than TG in the AP parameter ($p<0.05$) and the other AP parameters were similar to each other. For the RAP, the BG's value was significantly higher than the HG, FG and TG's ($p<0.05$, Table 2).

The literature has valuable researches done for the average RPP values of some athletes [12], Kounalakis et al. has found the elite handball athletes' average RPP as 7.58 W/kg [13], Ozan has found the football athletes' value as 6.30±3.93 W/kg and the taekwondo athletes' RPP level as 7.32±1.19 W/kg. The results came from these various studies differ from the findings of the study hereby. These differences can be explained by the different performance levels of the groups and by some individual differences such as the body weights of participants [14].

Determining the optimal load is very critical for the aforementioned-type studies and this value is one of the essential sources of differences. Thereby the differences between the power outcomes are related to the ages, body weights and lean body weights. On the other hand, the determination of the optimal load for the wingate anaerobic power test has not reached a final and certain solution yet [6].

In terms of the groups' dominant leg extension and flexion isokinetic outputs at 60°/s and 180°/s rotation, the HG and FG's values were significantly higher than TG at 60°/s PP extension, the BG and TG's values were significantly higher at 60°/s PP flexion but the HG and FG were similar to each other at 60°/s PP flexion ($p<0.05$), (Table 3).

The HG's 180°/s extension PP level were significantly higher than the BG and TG's values and similar to FG's; the FG's value was significantly higher than the TG's. There was no significant difference between the 180°/s flexion PP levels of the groups (Table 3).

In a similar study Hammami et al. has found the dominant leg extension level at 60°/s rotation for the elite taekwondo athletes as 231.26±16.54, the flexion value at 60°/s rotation as 129.83±25.54, the dominant le extension at 180°/s as 132.37±18.23, the flexion value as 95.77±17.65 [15]. Kocahan et al. has stated the dominant leg extension PP level of elite boxers at 60°/s rotation is 212 N/m, and the flexion PP level at 240°/s rotation is 85 N/m and the extension value is 123 N/m [16]. Kafkas and Çoksevim has stated the dominant leg extension level at 60°/s rotation of handball athletes actively playing as 149.02±9.1, the 60°/s flexion as 93.14±22.03, 90°/s extension as 214.86±31.00 90°/s flexion as 110.10±28.0 [17]. Özkan has found the dominant leg extension level of elite football athletes at 60°/s rotation as 133.1±17.3, the flexion level at 60°/s rotation as 92.6±60.3 [18].

There are different results in the studies present in the literature. The reasons for the higher dominant leg isokinetic values at 60°/s and 180°/s obtained in our study and the absence of similarity between the other existing studies are thought to source from the differences between the study groups' level of leagues and their performances.

When the internal and external isokinetic outputs of the dominant arms at 60°/s and 180°/s rotation are analysed in detail, it can be seen that there is not any significant difference between the groups' 60°/s internal and external PP levels. However, if the 60°/s internal and external averages are taken into consideration, it is obvious that the average values of BG and HG in which the upper extremities are used more intensively are higher than the FG and TG's. As in 60°/s PP, the average 180°/s internal and external PP levels are higher in the BG and HG in which the upper extremities are used predominantly than the FG and TG. Having said that, the average internal 180°/s levels of the BG, HG and FG were found significantly higher than the TG's ($p<0.05$). Although there was no significant difference between the external 180°/s PP levels of the groups, again the group averages of the BG and HG in which the upper extremities are used more intensively were higher than the FG and TG's. These results make us think that the arm force of the athletes who participate in upper-extremity dominant sport branches is higher than the other branches (Table 3).

The outputs of the literature survey indicate some similarities to our study. Kocahan et al. stated the 60°/s internal rotation PP level of elite boxers as 67 N/M, the eternal value as 33 N/m, the 240 °/s internal PP as 65 N/m and the external value as 27 N/m [16]. Franceshini et al. stated the 60°/s internal PP level as 57.05±17.73, the external value as 35.48±9.63 and 180 °/s internal rotation PP level as 51.45±10.09, the external level as 36.17±9.44 among the male volleyball athletes who were below the age of 17 [19]. The study's slightly lower average values than our data draw the attention. This difference is thought to be originated from especially the age average. Similarly, Aguada-Hanche et al. has found the 60°/s internal rotation AP level as 20.28±4.02, the external 60°/s as 14.57±3.27, the 180°/s internal as 19.96±4.08 and the external level as 15.38±2.96 among the elite swimmers whose average age was 13.2±1.1 years [20]. Not only the PP values but also AP values were also different in this case due to the lower age average. Indeed, as also evidenced within the study hereby, the important effect of the age on the force is expressed in the literature.

When the relationship between the wingate results and isokinetic forces of the groups are looked at, it can be seen that all groups' 60°/s extension and flexion, 180°/s extension and flexion values are positively correlated with the lower extremity wingate results. This correlation is at the significant level among the HG's 60°/s extension, 180°/s extension and 180°/s flexion values (Table 4).

A positive correlation was confirmed between all groups' upper extremity wingate results and their isokinetic forces. This positive correlation was at a statistically significant level for the BG's internal 60°/s-180°/s AP levels and wingate AP level, so a strong relationship was determined according to the correlation level. Similarly, there were a significantly strong correlation between the HG's external 180°/s value and the wingate upper extremity level. Hence, a general positive correlation between the isokinetic and wingate upper and lower extremity values was established in this study. This correlation was found stronger for the specific groups (Table 4). Similarly, Başpınar [21] has determined an important correlation between the lower extremity isokinetic force and 30 and 10 m speed 60°/s flexion in a study in which the relationship between isokinetic muscle force and anaerobic force of the young football athletes aged 5-16 was examined. However, no difference was stated between the 30 and 10 m 60°/s extension and 180 °/s extension and flexion in the same study [21].

Bozoğlu informed that the upper extremity isokinetic and wingate levels were positively correlated and this correlation was significant for the 60°/s and 180°/s external rotation and arm wingate values in a study conducted with 17 tennis athletes whose average age was 24.15±2.7 years [22].

When the groups' lower extremity power wingate power averages are examined according to the extremity dominancy, the results showed that there was no significant difference between UEASB (HG and BG) and AEASB (TG and FG) in terms of the PP, RPP, AP and RAP levels. However, the expectation was that the values of the branches in which the lower extremities are dominantly used (AEASB) would be higher. The similarity can be explained by the performance of the groups (Table 5). Similarly, Ozan et al. have found that there was not any significant difference between the boxing, football, taekwondo and bicycling groups' lower extremity PP, RPP and AP wingate averages whose age average was 21-22 years [23]. The conjunct evaluation of the data resulted from the study hereby with the Ozan's study in which some similar parameters such as 75 gr/kg load and similar age and body weight averages shows that the lower extremity anaerobic power parameters do not differ significantly within the branch.

When the groups' upper extremity wingate power averages are examined according to the extremity dominancy, the results showed that the UEASB groups' PP, RP, AP and RAP levels were significantly higher than the AEASB groups' ($p<0.05$), (Table 5). Similarly again, Ozan et al. have found that the lower extremity PP and RPP averages of the boxers and Greco-roman wrestlers who use their upper extremities dominantly are significantly similar to the bicycling and football groups', but the arm wingate PP and RPP levels of the boxers and Greco-roman wrestlers were significantly higher than the taekwondo and football athletes ($p<0.05$) [23]. The difference confirmed on the upper extremities is not detected, at least in a statistical manner, on the lower extremities between the UEASB and AEASB groups. This situation can be originated not only from many individual specialties but also from the performance levels and conditions at the time of measurement. On the other hand, the evaluations of some other studies like Ozan et al. strengthen the conclusions. Indeed, the lower extremities take an important role in the branches that use upper extremities dominantly. On the contrary, the activeness level of the upper extremities in the lower extremity dominant branches reviewed in this study (football, taekwondo) may not be in the foreground as much as the lower extremities' in the upper extremity dominant branches [23]. Both the results we get and the similar research support our standpoint.

When the groups' dominant leg isokinetic force results at 60°/s and 180°/s rotation in terms of the extremity dominancy, the results showed that there was no significant difference between the UEASB and AEASB groups in both the 60°/s extension and flexion PP and AP averages and the 180°/s extension and flexion PP and AP averages (Table 6). Similarly Teixeira et al. stated that the dominant leg extension and flexion PP averages at 60°/s and 180°/s rotation were significantly similar between the elite football players whose age averages were 23,29±2,55 years and 23,32±2,12 years [24] . Bamaç et al. (2008) stated that the dominant leg power PP levels of the 20 volleyball athletes whose age average was 19,55±5 years and the 20 elite basketball athletes whose age average was 23,06±7 at 60°/s and 180°/s extension and flexion were similar in a study which included a control group, but the values were significantly higher ($p<0,05$) than the control group for both of the athlete groups [25]. No significant difference was detected between the branches in which a dominant extremity is used in terms of dominant leg isokinetic levels in the study. The similar results were supported by the studies states above. The parallelism between the results and lower extremity wingate outputs draws attention

When the groups' dominant arm isokinetic force results at 60°/s and 180°/s rotation in terms of the extremity dominancy, the results showed that the internal and external PP levels at 60°/s rotation, the internal and external AP levels at 60°/s, the internal and external AP levels at 180°/s, and the internal PP level at 180°/s rotation of the UEASB groups were significantly higher ($p<0,05$), but the external PP level at 180°/s rotation was statistically similar. The dominant arm parameters of the UEASB group were significantly higher ($p<0,05$) in general. Thus, the results gained from the upper extremity dominant branches (the HG and BG) supported the deduction (Table 6).

Similarly, Boyios et al. stated that the 60°/s internal level of 15 handball athletes who are at 1. league and whose age average is 24.9±2.09 is 60.78±10.79, their 60°/s external level is 36.44±7.23, 180°/s internal level is 52.56±9.23, 180°/s external level is 28.57±5.19 [26].

Tasiopoulos et al. (2018) have found the 60°/s internal rotation concentric PP level of 22 elite level boxers whose age average is 25.7±2,9 as 56.7±4.8, the eccentric power level as 62.6, the 60°/s external rotation concentric PP level as 32.1±2.9, the eccentric as 42.0±4.2, and the average 60°/s external power level as 37.05. Again thanks to this study they stated the boxers' 180°/s internal rotation concentric PP level was 46.6±5.0, the eccentric power level was 62.0±5.0, the 180°/s internal PP level was 54.3, the eccentric PP level at 180°/s external rotation was 28.2±2.8, the eccentric level was 39.5±2.8 and the average 180°/s external PP level was 33.85. Both of the studies aforementioned are highly similar to the study in terms of the isokinetic PP levels of both elite handball athletes and elite boxers [27]. However, the literature research don does not give a sufficient number of comparative researches for the lower and upper extremities dominancy. The related studies generally concentrated on the comparison of some certain branches and groups. So, it is expected that this study can be a norm for the potential research of the literature.

Positive correlations were found between the UEASB and AEASB in the lower extremity dominancy at 60°/s and 180°/s rotation and the lower extremity wingate AP levels. This correlation was strong for the UEASB at 60°/s and 180°/s extension and was at a moderate level at 60°/s and 180°/s flexion for the same group. The correlation was at a moderate level for the AEASB group at 60°/s extension, was weak at 60°/s flexion, was strong at 180°/s extension and finally was weak at 180°/s flexion. When the relationship between the upper extremity dominancy at 60°/s ve 180°/s rotation of the UEASD and AEASB groups and their wingate upper extremity AP levels, positive correlations were detected in general. However, this correlation was weak or at a moderate level according to the outputs of the correlation matrixes (Table 7).

In a study conducted for evaluating the correlation between the speed and force levels of young football athletes, Peñailillo et al. stated a negative correlation at 5m speed (r = -0.40), a strong negative correlation in 15 m speed (r = -0.72), a moderate level negative correlation in 20 m (r = 0.067) [28]. Bozoğlu stated a moderate level correlation between the upper extremity and leg wingate power levels in the 60°/s internal PP levels and a weak correlation in the AP levels in a study conducted with 17 tennis athletes whose age average was 24.15±2.7 [22].

As a result, it was found that there is a correlation between the isokinetic force parameters and wingate levels and this correlation is stronger in lower extremities when compared to upper extremities. Not only the isokinetic arm force bot also the arm wingate levels were found significantly higher in the branches in which the upper extremities are used dominantly than the branches in which the lower extremities are used dominantly ($p<0.05$). However, this difference found in upper extremities was not detected in the lower extremities. Apparently, this situation arises from the fact that the existence of high level physical dynamism of the lower extremity in the branches in which the upper extremities are used dominantly (the BG and HG) is not valid for the upper extremities in the branches in which the lower extremities are used dominantly (the FG and TG).

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Conflict of interests

The authors have no conflict of interests to declare.

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Information about the authors:

Samet Aktaş; (Corresponding Author); https://orcid.org/0000-0001-6857-2599; sametaktas85@hotmail.com; School of Physical Education and Sport, University of Batman; Batman, Turkey.

Oktay Çakmakçı; https://orcid.org/0000-0002-8612-1334; ocakmakci@gmail.com; Faculty of Sport Sciences, University of Selcuk; Konya, Turkey.

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CONTACT INFORMATION
box 11135, Kharkov-68, 61068, Ukraine
phone. +38 099 430 69 22
http://www.sportpedu.org.ua
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