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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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CONTENTS

Effect of high intensity interval training under hypoxic conditions in a normobaric environment on moderately trained university students' antioxidant status

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

Abstract

Purpose: The effects of high intensity interval exercises on antioxidant defence system are not clear. Since there is an evident lack of studies focused on oxidative stress in moderately trained males following high intensity interval training, we investigated oxidative stress markers (malondialdehyde [MDA], catalase [CAT], glutathione peroxidase [GPX], superoxide dismutase [SOD]) by completing a high intensity interval training program (HIITP) under hypoxic and normoxic conditions in a normobaric environment.

Material: The study was carried out on moderately trained university students who had regular exercising habits. The participants completed 8-week wingate based high intensity interval training under normoxic and hypoxic conditions (2500 m.) in the normobaric environment. They were instructed to maintain their normal dietary practices during the study not to take any antioxidant containing vitamin tablets.

Results: The interaction effect (time×group) for SOD ($p=0.230$), CAT ($p=0.736$), GPX ($p=0.517$), and MDA ($p=0.596$), revealed no significant change in repeated response.

Conclusions: Although 8 weeks of high-intensity interval training significantly affected only SOD and GPX ($p<0.05$), the normoxic and hypoxic conditions did not present any significant change between treatments.

Keywords: interval training, superoxide dismutase, catalase, glutathione peroxidase, malondialdehyde.

Introduction

In recent decades, intensive research in the field of oxidative damage indicates that exercise exacerbates the generation of reactive oxygen species (ROS) and reactive nitrogen species (RNS), some of which are free radicals [1, 2]. A free-radical is any specie capable of existence with one or more unpaired electron [3]. ROS/RNS refer to oxygen or nitrogen containing free-radicals and their non-free-radical derivatives [4]. ROS are generated by regular metabolic process in vivo and can initiate a cascade of free-radical formation and damage to macromolecules [5], Oxidative stress is an inevitable consequence of aerobic life, and there is growing evidence that the endogenous generation of ROS plays a major role in aging and many pathological conditions [6]. In resting state the body is equipped with both non-enzymatic and enzymatic antioxidant defence system to scavenge the potentially harmful effects of ROS [7, 8]. This system includes antioxidant enzymes such as glutathione peroxidase (GPX), catalase (CAT), and superoxide dismutase (SOD), and non-enzymatic molecules including vitamin E, vitamin C, vitamin A precursor, thiol-containing compounds e.g. glutathione (GSH). These antioxidant defence systems preserve homeostasis for normal cell functions at rest and under normal physiological conditions. However, during strenuous exercise, pathogenic processes and aging, ROS production may overwhelm antioxidant defence capacity causing cell and tissue damage [9, 10].

Chronic aerobic exercise has emerged as a promising means of reducing oxidative stress. Mechanisms responsible for beneficial effects of chronic aerobic exercise are training induced regulation of SOD [11] and CAT [4] and reduced mitochondrial reactive oxygen species [12]. It has been proposed that chronic high intensity interval training (HIIT) may elicit greater health benefits than traditional chronic aerobic exercise, so HIIT has gained importance, since it is more effective on developing aerobic capacity. While it provides fast and effective adaptation, it also shortens exercise time. Nowadays, HIIT and its other forms are most effective training methods used to improve aerobic and anaerobic capacity, cardiovascular system and metabolic functions [13, 14]. HIIT provides new and favorable contributions in respect to health and performance and positive adaptation for both sedentaries and athletes. When it is compared with traditional aerobic exercise, it has been drawing interest, since it uses time more economically and effectively, improves aerobic and anaerobic systems besides the metabolic functions and physical performance [15, 16]. High intensity training can produce oxidative stress and antioxidant elements of organisms are affected with this challenge [17]. Few studies have investigated oxidative stress in response to both aerobic and anaerobic exercise bouts [18, 19], especially oxidative stress, which is experienced following sporting competitions [20].

Apart from abovementioned effects, intermittent hypoxia (IH) occurs in many pathophysiological conditions. The molecular mechanisms associated

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with IH, however, have received little attention [21] The consequences of oxidative stress under hypoxic conditions, when physical effort is limited by the availability of oxygen to the working muscles, are of great interest to sport science [22-24]. Indeed, physical training under hypoxic conditions is frequently used to improve physical performance [25, 26] and training in hypoxic conditions has become an important element of preparing elite athletes [27, 28]. The training is thought to be most effective when it is performed at an altitude of 2, 000 to 2, 500 m [29, 30].

There have been studies concerning effects of HIIT and IH applications on antioxidant markers [12, 31]. These studies investigated acute effects and were applied to elite athletes and thus there is a lack of studies investigating effects of this training method on antioxidant markers of active individuals for a longer time. Herein, we evaluated the antioxidant status after 8 week wingate style HIIT protocols in untrained healthy men. Plasma samples were collected for the measurement of CAT, SOD, GPX and MDA activities and total antioxidant status as a general marker of antioxidant defences.

Material and Methods

Subjects

In this study, 16 recreationally active university students volunteers, aged 20-29 (23.50±2.52) were involved in this study. Only males were included to avoid any distortion in the hormonal response to physical exercise caused by sex differences. Anthropometric characteristics of the subjects are summarized in Table 1. The exclusion criteria for study were drugs and medicines intake as well as suffering from some illness and smoking habit. None of the subjects participated regularly in sport competitions and they did not engage in any form of vigorous exercise for 24 hours before the study was performed. They were instructed to maintain their normal dietary practices during the study and not to take any antioxidant containing vitamin tablets.

Table 1. Anthropometric characteristics of the subjects

Variables (n=16)	Mean±SD
Age (years)	23.50±2.52
Height (cm)	174.00±6.19
Body Weight (kg)	70.60±9.03

Physiological measurements

The body mass was measured using calibrated digital scales and height was measured using stadiometer. The age of athletes were accurately recorded as years. Blood samples were taken from the participants three times; the first one prior the training, the second one in 4th week and the third one after the training.

Exercise Protocol

16 participants were randomly assigned to normoxic or hypoxic groups and then they were completed 8-week high intensity interval training on normoxic and hypoxic conditions (2500 m) in the normobaric environment. The hypoxic conditions were provided with Hypoxica Submit II exercise package (Made in USA). All participants completed 8 weeks of wingate style cycling training, 3 days/week, consisting of incremental repeats 4 to 7 every two weeks × 30s all-out effort with 4 min rests.

Measurement of oxidative status

Erythrocyte MDA level were measured as previously described by Dahle et al. [32], SOD level was measured as previously described by Durak et al. [33], GPX level were measured as previously described by Paglia and Valantina [34], CAT level was measured as previously described by Aebi [35].

Statistical analysis

Results of all variables are expressed as mean and standard deviation. The Shapiro-Wilk Test of normality was used to determine if the data normally distributed. Baseline differences of antioxidant variables were calculated with Independent Sample T-Test between groups. Then the two way repeated measures ANOVA was used to compare differences in three measurement results using time and conditions factor (intraction effect: time×group). The post-hoc analysis was performed to specify pairwise differences. All analyses were set at p=0.05 significance level.

Results

The baseline measurements of SOD, CAT, GPX, and MDA presented no significant differences in normoxic and hypoxic groups ($p>0.05$). The interaction effect (time×group) for SOD ($p=0.230$), CAT ($p=0.736$), GPX ($p=0.517$), and MDA ($p=0.596$), revealed no significant change in repeated response (baseline, after 4 weeks and 8 weeks) (Table 2). Although 8 weeks of high-intensity interval training effected significantly only SOD and GPX ($p<0.05$), the normoxic and hypoxic conditions did not present any change between treatments. The post-hoc analysis showed that the high-intensity interval training effect differed 4 weeks and 8 weeks for SOD ($p=0.037$), baseline and 8 weeks for GPX ($p=0.014$) responses. The rate of nonsignificant increase on SOD was 13.5% in the hypoxic group, 8.65% in the normoxic group after 8 weeks (Figure 1). This trend was not same for GPX response in hypoxic condition. The GPX decreased by 2.33%. However, GPX was increased by 7.33% in the normoxic group (Figure 2).When we looked our study, we monitored that MDA levels increased both 4th and 8 th week. ($p<0.05$)

Discussions

To our knowledge, this is the first investigation to compare the differential effects of HIIT in hypoxia vs HIIT in normoxia on antioxidant status in a normobaric environment. There are studies stating that both methods changed oxidative stress markers [31, 36-38].

There are numerous reports that provide reasonable

Table 2. The baseline measurements.

Indicators	HIIT (Hypoxia)			HIIT (Normoxia)				
	Baseline	4 Weeks	8 Weeks	Baseline	4 Weeks	8 Weeks	Time× Treatment	d
SOD (U/ml)	1930.16 ± 1183.74	2046.95 ±745.15	2231.46 ±714.93	2449.82 ± 799.13	2099.72 ±1165.33	2681.93 ± 859.85	p=0.230	0. 20
CAT (KU/ml)	29691.75 ±5232.78	27724.50 ± 6578.55	28685.25 ± 8418.99	32848.50 ± 8687.06	28273.50 ±4599.50	31476.00 ±7156.07	p=0.736	0. 04
GPX (U/ml)	6.47±1.67	8.13±1.64	6.27±2.14	5.73±1.31	6.81±1.69	6.15±1.88	p=0.517	0. 09
MDA (nmol/ml)	263.12 ± 21.41	274.71 ± 33.56	275.72 ± 24.18	263.12 ± 60.22	255.05 ± 34.47	276.22 ± 51.55	p=0.596	0. 07

Notes. SOD: superoxide dismutase; CAT: catalase; GPX: glutathione peroxidase; MDA: malondialdehyde. n=16

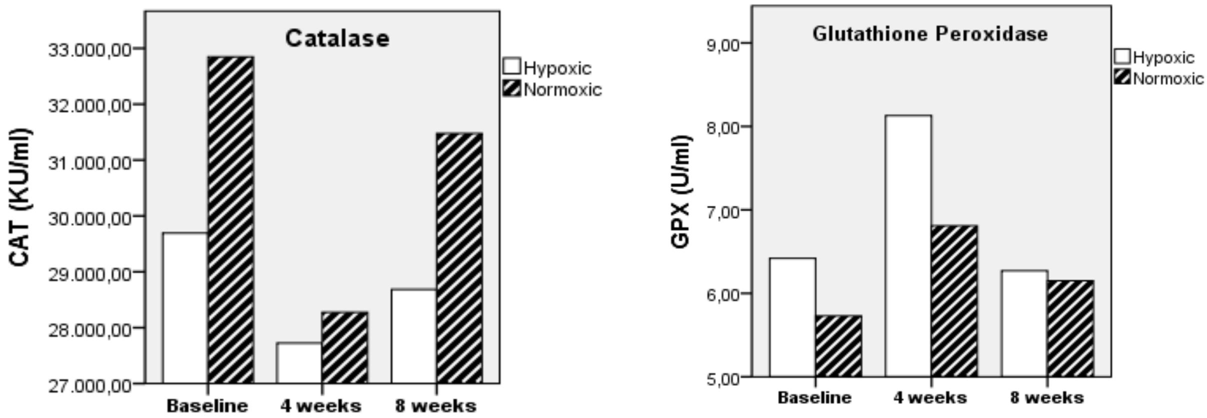

Figure 1. The oxidative stress status of CAT and GPX on moderately trained university students. Values are expressed as mean ± S.D. CAT: catalese; GPX: glutathione peroxidase; n=16.

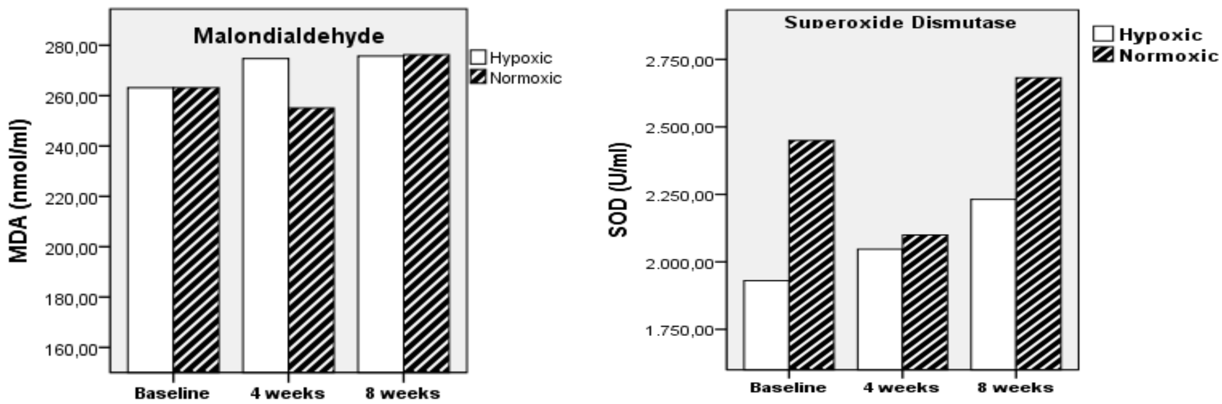

Figure 2. The oxidative stress of MDA and SOD on moderately trained university students Values are expressed as mean ± S.D. MDA: melondialdehyde; SOD: superoxide dismutase; n=16.

support to the notion that exercise increases the production of ROS [39]. Little is known, regarding the extend of oxidative stress when comparing aerobic and anaerobic exercise modes [40]. On the occurrence of exercise, stress is not clear. However, the principal factor responsible for oxidative damage during exercise is the increase in oxygen consumption [41]. It appears that anaerobic types of exercise, which involves less oxygen circulation throughout the body than aerobic exercise is associated with an increased ROS generation level through other pathways [42, 43] suggesting that oxygen consumption per se is not the major cause of exercise induced oxidative damage [41].

Different types of exercises may have different effects on oxidative stress [34]. Which is defined as a situation in which an increased level of ROS generation overwhelms the antioxidant defence capacity, resulting in oxidative damage to lipits, proteins and DNA [41, 43].

A review of literature on changes in oxidative stress markers and physical parameters following the long duration HIIT training in hypoxia indicates a lack of information in this subject area. For this reason, we investigated the oxidative status of moderately trained males during 8 week by completing HIIT program.

It was reported that the activities of antioxidant enzymes including SOD, CAT and GSH peroxidase (GPX) increased with an acute bout of exercise in skeletal muscle, heart and liver [38].

SOD, CAT, GPX and MDA activities in response to exercise are variable. When we looked at our study, we observed that interaction effect (time×group) for SOD , CAT, GPX and MDA revealed no significant in repeated response ($p<0.05$) (baseline, after 4 weeks and 8 weeks). SOD and GPX activities effected significantly by HIIT. But the normoxic and hypoxic conditions were not present between treatments. HIIT effect were differ 4 weeks and 8 weeks for SOD ($p=0.037$), baseline and 8 weeks for GPX ($p=0.014$) responses. This trend was not same for GPX response in hypoxic condition. However, GPX was increased by non significantly in the normoxic group. MDA levels increased both 4th and 8 th week.

Currently, there is limited information on the effects of HIIT on the development of oxidative stress in humans. Previous studies were short-term and applied on rats and in normoxic conditions. Similarly, Wozniak et al. evaluated the influence of exercise in high-altitude conditions (about 2000 m a.s.l.) on SOD and CAT activities in 10 kayakers and 10 rowers. They found a significant increase of SOD and CAT activities in erythrocytes after the 4th, 10th and 18th day of training [44]. It is known that continuous and intermittent efforts under hypoxic conditions increase oxidative stress [23, 24, 45]. Bailey et al. demonstrated that 60 min of simulated training under hypoxic conditions significantly increased the levels of serum lipid peroxides, with a simultaneous reduction of antioxidant enzyme activities [46]. Gonzalez et al. [47] and Pialoux et al. [48] reported diminished MDA levels in the plasma of swimmers after an acute hypoxic swimming test (10 min at 4, 800 m) as well as in cyclists who spent 13 days at an altitude of 2, 500 to 3, 000 m, and trained at 1200 m above sea level.

SOD is one of the main antioxidant enzymes that degrade superoxide radicals [46]. Increase in SOD enzyme activity corresponds with enhanced resistance to oxidative stress. Groussard et al. found that SOD activity decreased after a single sprint anaerobic exercise [40]. Not all studies reported decrease in SOD in response to exercise. It has been reported that 8-week moderate intensity of aerobic training did not elevate SOD activity. Furthermore, it has been revealed a decrease in SOD levels an acute bout of exercise in skiers participating in a graded treadmill test to exhaustion and elevated erythrocyte SOD activity immediately post exercise when the sprinters performed a sprint exercise [49].

CAT activity in response to exercise is variable. Following about of submaximal exercise a decrease in erythrocyte CAT activity reported in trained cyclists. Furthermore, it has been reported that sprinters who performed a sprint type exercise did not have altered erythrocyte CAT activity [49].

GPX activity is a key component of the glutathione homeostasis and its response to exercise is variable [35]. Higher in oxygen consumption during exercise activates the enzyme GPX to remove hydrogen peroxide. In response to an acute bout of HIIT, elevated erythrocyte GPX activity has been found after a sprint exercise but no change when runners performed an endurance exercise [49].

Conclusion

The present study is the first to report improvements in oxidative status after 4 and 8 week high intensity interval training. We speculate that changes in these parameters might represent an increase in ROS after high intensity interval training.

In comparison with other investigators, we believe the present study provided the first direct analysis of effect of high intensity interval training on moderately trained males' antioxidant status hypoxic conditions in a normobaric environment after training.

The results of this study also suggest that interaction effect (time×group) for SOD, CAT, GPX and MDA revealed no significant in repeated response. However, it was observed that 8 weeks of high-intensity interval training affected significantly only SOD and GPX. The normoxic and hypoxic conditions were not present between treatments. The limitation of our study was no standardization of dietary habits of the participants. It can be advised to monitor dietary habits of the participants and to apply the same applications to elite athletes for the future studies.

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Conflict of interest

There were no conflicts of interest.

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Dynamic balance performance of professional Turkish soccer players by playing position

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

Abstract

Purpose: Balance control has been regarded as a crucial factor in sports and indicated as an important element to be examined for the risks of injury. But it is unknown whether the dynamic balance changes according to the player positions in professional soccer players. To determine whether there were differences in the dynamic balance performance of the different positions of Turkish professional soccer players from within one squad.

Material: Twenty-four professional soccer players were divided into 4 groups by the coach, including goalkeepers (n = 3), midfielders (n = 6), defenders (n = 7) and forwards (n = 8). Prior the competition season, anthropometric characteristics of players were measured. Then, players were tested Y Balance Test (YBT) for the anterior (ANT), posteromedial (PM), and posterolateral (PL) reach distances and limb lengths bilaterally.

Results: The goalkeepers were heavier compared with the midfielders. Furthermore, the BMI of the goalkeepers were higher than midfielders and defenders ($p< 0.05$). There were no significant differences in the ANT, PM, PL, and COMP score between the groups ($p> 0.05$). The values for reach asymmetry were lower than four centimeters among groups in the all reach direction with regards to reach asymmetries, except normalized posterolateral direction.

Conclusions: The results of this study have shown that the YBT performance scores do not differ between the groups. Future studies are required to create specific norms related to dynamic balance performance and establish risk cut-off score for professional soccer players.

Keywords: neuromuscular control, screening, performance, postural stability.

Introduction

Soccer is a high demand sporting activity which is commonly investigated [1, 2] requires both technical and physical abilities as well as being high-intensity, intermittent sport [3]. It is also stated in most studies that it has risk of serious injury [1, 4]. The most common injuries in soccer involve 87% of lower extremities with ankle sprains, thigh muscle strains and knee sprains have previously been suggested [5, 6] and it is known that 58% of these injuries are caused by non-contact mechanisms [5]. Some of the neuromuscular risk factors that cause lower extremity injuries indicated in young male soccer players include limb dominance (asymmetry) and reduced dynamic stability [7, 8]. Decreased dynamic stability is regarded as an intrinsic risk factor considered for injuries [9].

Balance control is regarded as a crucial factor in sports and considered an important component of motor skills. The dynamic balance, defined as the ability of the individual to maintain the stability of the center of mass during movement, is indicated as an important element to be examined for the risks of injury [1]. The importance of balance control for muscle damage and injuries, especially during high-intensity activities, is emphasized in most studies. Tropp et al. [10] have found that the number of ankle injuries with poor balance is almost four times higher than those with normal balance and Watson, [11] has also reported that Gaelic soccer players and athletes with poor balance (pitchers) similarly have ankle injuries, almost two times more. It has been suggested that using an injury screening tool assessing dynamic balance performance may be a useful in determining athletes with risk of injury [12]. The evaluation of dynamic balance ability and stability is applied regularly in soccer [13, 14] and it is emphasized that these assessments should include movements similar to the dynamic actions in soccer [15]. One of the most promising ones is considered as the evaluation of the dynamic balance using the Y Balance Test [9].

Soccer players are categorised into four different groups according to the playing positions, including goalkeepers, defenders, midfielders, and forwards. These players in various positions have the required anthropometric characteristics for different position-specific physical performance and success [16]. It has been investigated whether these differences vary depending on player positions as well. Ostojic [18] has reported in the study conducted with professional Serbian players that the goalkeepers are most injured players during the season while those in other positions less likely to be injured. The high rate of injury in soccer players continues despite the scientific developments in the etiology of injuries, screening techniques and the determination of athletes who may be at greater risk [19]. Consequently, it is noted that the identification of athletes with muscle imbalance, decreased core stability and balance problems is important for preventing future injuries [20]. Additionally, Pau et al. [21] reports that the ability of balance in soccer players is a key factor in achieving optimum performance and reducing risk of injury.

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Previous studies have been conducted which aim to prevent injuries in female and male soccer players and evaluate dynamic balance through competing soccer and other branches [4, 2] and athletes in different levels [22]. However, it is unknown whether the dynamic balance changes according to the player positions in soccer. This study has hypothesized that dynamic balance ability is significantly different for each playing position in male professional soccer players. The purpose of this study, as a consequence, is to create specific norms related to dynamic balance, establish risk cut-off score for professional soccer players, help prevent future injuries through examining whether dynamic balance ability varies by the positions and provide useful information for coaches and athletes for post-injury trainings.

Material and methods

Subjects and Setting

24 male players of a second league professional soccer team (age: 24.3 ± 5.25 years) have voluntarily agreed to participate in the study. Athletes were divided into 4 groups by the coach, including goalkeepers (n = 3), midfielders (n = 6), defenders (n = 7) and forwards (n = 8). Criteria for participation in the study has been determined as having no conditions preventing the completion of the balance test, no high-intensity exercise performed before the study and being the team's player. The research protocol was carried out in accordance with the Declaration of Helsinki and approved by the Uşak University Institutional Ethics Committee — 10/17.01.2019). The measurements were performed in July, two weeks before the competition season began. Athletes were performed familiarization season before the measurements for balance test. The athletes were clearly informed about the procedure to be applied and verbally encouraged to perform maximal performance during the measurements.

Anthropometry

Athletes' demographic characteristics including age, body, body weight and body fat percentage were collected prior the dynamic balance measurements. Athletes were asked to wear thin clothes without shoes during the measurements; body height was measured in centimeters using Mesitaş portable height gauge (Germany) and body weight was measured in kilograms using electronic weighing scale with 0.01 kg precision. Body Mass Index (BMI) was calculated using the formula BMI= weight/height squared (kg/m^2). The body fat percentage was calculated with skinfold thickness measurement using a Harpenden Skinfold Caliper. Skinfold measurements were taken on 10 sites as indicated by Parizkova [23].

Dynamic Balance Ability Test

The "Y Balance Test" protocol was used to measure dynamic balance ability. The length of each participant's leg was recorded in centimeters in the supine position, measured from the anterior superior iliac spine to the distal portion of the medial malleolus. The dominant (kicking) limb was determined according to self-reported of the athletes [14]. The measurements were performed barefoot, on a hard surface in 3 directions and Anterior (ANT) was tested from the toe aligned to the origin while Posteromedial (PL) and Posteriolateral (PM) were based on the distance between heel and furthest possible point to reach. Participants were asked to perform fingertip light touch with their reach foot as keeping their hands on the iliac and heels on the ground during the trial. A short demonstration was performed by the experienced researcher on implementation of the test before measurement and the best 3 reaches were recorded in all directions after the participants were allowed to try at least 4 times [24]. Each participant was given a 2-minute resting time and then they were asked to perform 3 reaches in each direction after the completion of the test. It was considered as a failed attempt to transfer the body weight through the reach foot, ground the heel of the stance foot or remove hands from the hips and the measurement was repeated after the participant was orally informed. All reach distances were recorded in centimeters. After the data were collected, obtained scores were normalized using the formula: "Maximal Reach Distance/Limb Length) x 100 = Largest Reach Distance %" for each direction in order to eliminate the advantage of the limb length [24]. The total score (COMP) was calculated by averaging the normalized ANT, PL and PM scores. The average of the three recorded trials and COMP score have been used for analysis to ensure a reliable measurement of the dynamic balance [24].

Statistical Analysis

The SPSS 23 software package program was used for all data analysis. Nonparametric testing was preferred in statistical analysis due to lack of sample size. Kruskal-Wallis H Test was performed to determine whether there was a difference between the groups according to the normalized YBT reach distances based on the positions. The data were presented as median and interquartile range due to the use of nonparametric testing [25]. Significance level was set as $p<0.05$.

Results

The descriptive characteristics of soccer players by playing position are shown in Table 1. There was a significant difference between groups only in the body weight and BMI. The goalkeepers were heavier compared with the midfielders ($p< 0.05$). Furthermore, the BMI of the goalkeepers were higher than midfielders and defenders ($p< 0.05$).

The parameters of the YBT performance are presented in Table 2. There were no significant differences in the ANT, PM, PL, and COMP score between the groups ($p > 0.05$). The values for reach asymmetry were lower than four centimeters among groups in the all reach direction with regards to reach asymmetries, except normalized posterolateral direction. The goalkeepers and defenders have a difference greater than four centimeters in the normalized posterolateral reach direction between the legs, 4.09 and 5.93, respectively (Table 2).

Table 1. Age, body height, body mass, BMI, BF, leg length, and training age an of soccer players by position. Data reported as median and interquartile ranges (n= 24).

Parameters	All (n= 24)	Goalkeepers (n= 3)	Midfielders (n = 6)	Defenders (n = 7)	Forwards (n = 8)
Age (years)	24.3 (5.25)	23.3 (0)	22.7 (3)	25.1 (5)	25 (9.75)
Body Height (cm)	1.82 (0.02)	1.87 (0)	1.80 (0.05)	1.84 (0.11)	1.79 (0.04)
Body Weight (kg)	75.7 (12.2)	83.9 (0)*	72.5 (4.73)	76.5 (12.9)	74.2 (13.8)
BMI (kg/m^2)	22.9 (1.97)	24.1 (0)*	22.3 (1.33)	22.5 (1.2)	23.2 (4.45)
BF (%)	12.1 (2.28)	13.1 (0)	11.6 (1.7)	12.1 (2.4)	12.1 (2.95)
Leg Length (cm)	94.8 (5.75)	96.3 (0)	93.7 (4.5)	96.9 (13)	93.1 (7.75)
Training Age (year)	13.7 (5.75)	13.7(0)	12.2 (6.75)	15 (3)	13.8 (14)

Abbreviation: BMI: Body Mass Index; BF: Body Fat Percentage; * Significant difference in relation to midfielders ($p < 0.05$); * Significant difference in relation to midfielders and defenders ($p < 0.05$).

Table 2. Normalised reach distances (%) and reach asymmetries of soccer players by position. Data reported as median and interquartile ranges (n= 24).

Parameters	All (n= 24)	Goalkeepers (n= 3)	Midfielders (n= 6)	Defenders (n= 7)	Forwards (n= 8)
Anterior (%)					
Dominant Leg	68.1 (8.68)	69.6 (0.00)	66.6 (10.66)	64.1 (13.72)	72.2 (18.38)
Nondominant Leg	67.8 (9.00)	69.7 (0.00)	63.8 (14.14)	67.5 (13.39)	70.4 (13.51)
Reach Asymmetry	0.28 (7.05)	0.11 (0.00)	2.77 (9.85)	3.46 (3.22)	1.82 (5.40)
Posteromedial (%)					
Dominant Leg	117.1 (11.40)	118.2 (0.00)	116.7 (9.80)	113.6 (24.02)	120.1 (12.34)
Nondominant Leg	116.1 (12.21)	118.2 (0.00)	115 (11.95)	112.8 (26.38)	119 (20.18)
Reach Asymmetry	1.05 (5.06)	0.001 (0.00)	1.68 (4.72)	0.86 (4.18)	1.14 (5.72)
Posteriolateral (%)					
Dominant Leg	115.5 (11.18)	117.7 (0.00)	111.5 (9.13)	103.1 (16.84)	116.6 (20.04)
Nondominant Leg	112.9 (12.31)	113.6 (0.00)	110.9 (15.38)	109.1 (18.45)	117.6 (18.74)
Reach Asymmetry	1.37 (7.04)	4.09 (0.00)	0.67 (5.02)	5.93 (11.28)	0.95 (6.25)
Composite (%)					
Dominant Leg	98.9 (7.28)	101.8 (0.00)	98.3 (9.39)	93.6 (17.34)	103 (14.36)
Nondominant Leg	98.9 (10.31)	100.5 (0.00)	96.6 (12.47)	96.5 (20.65)	102.3 (16.28)
Reach Asymmetry	0.01 (4.20)	1.32 (0.00)	1.71 (4.46)	2.84 (3.30)	0.67 (3.06)

Discussion

The aim of this study is to examine the dynamic balance performances of a second league professional male soccer team and determine whether this dynamic balance ability varies by playing positions of the athletes. Contrary to our hypothesis, the results of the study have identified no differences in normalized dynamic balance performance by playing position among professional soccer players. Additionally, asymmetry was present only in the posterolateral direction among goalkeepers and midfielders.

The study demonstrates that there are no differences in normalized reach distances of all YBT scores among goalkeepers, midfielders, defenders, and forwards in the dominant and nondominant limb. It is known that athletes need specific physical activities and requirements as a result of playing in a special position in soccer and repeated trainings and there are studies indicating that numerous physical performances of the players as aerobic and anaerobic performance, agility, sprint ability and muscle strength vary by their position [16, 26]. However, to the author's knowledge, no studies were found in the literature evaluating dynamic balance abilities according to the playing positions. There are only two studies focusing on the positions. Pau et al. [21] examined static balance abilities in elite soccer players by playing position and Bizid and Paillard [13] examined the effects of position on postural control in offensive and defensive players of the national team. In addition, another study examining the effects of playing position (forwards/ backs) on dynamic balance performance was conducted by Jonstan et al. [27] among elite male Rugby players (under-20 and senior players) and they indicated that backs reached the longest distance in both age groups.

Postural control and balance abilities are built on a complex system that contributes to postural control, including visual, somatosensor and vestibular systems and there are studies which state that it is affected by various anthropometric variables [18, 28]. Ozunlu et al. [29] and Jonhston et al. [27] have indicated that increased body mass reduces the dynamic balance performance measured using Star Excursion Balance Test (SEBT) and YBT; Gribble et al. [30] have indicated that there is a significant relationship between the height and 6 of 8 SEBT directions; Tabrizi et al. [31] have reported that there is a significant relationship between the dynamic balance performance measured using YBT and body fat percentage, BMI and weight among handball, basketball, futsal and volleyball players aged between 20 and 30. There are studies that similarly analyze differences between age groups according to postural control [32, 33]. In the current study, a statistically higher value was obtained for weight and BMI in goalkeepers compared to midfielders and for BMI compared to defensive players. No significant difference was found in terms of age, weight, height, BMI, BF and limb length between groups according to the positions. The findings obtained in this study are inconsistent with the results of previous studies showing anthropometric differences according to the positions of professional footballers. It is considered in this study that there is no difference in the dynamic balance between the groups due to the lack of anthropometric differences.

Another finding also achieved in the current study is that reach asymmetry values are four centimeters higher than normalized posterolateral reach direction only among the goalkeepers and defensive players. All values are less than four centimeters in other directions and groups. This seems to be the most demanding among all three directions and may create a potential risk factor for lower extremity injury with regard to the destabilizing moment [34]. Plisky et al. [12] have indicated that the players with an anterior right/left reach range greater than 4 cm are 2,5 times more likely to have lower extremity injuries.

The primary hypothesis of this study is that the dynamic balance performance varies by position due to the requirement for specific physical activities and other necessities of the players as a result of different positions and repeated trainings. In addition, the study aimed to provide reference values for dynamic balance performances according to their positions. No such studies providing reference values for the YBT for professional soccer players based on their positions have been found in the literature. In this respect, future studies conducted with more participants and evaluation of YBT according to the positions are essential for clinicians and researchers to obtain normative values.

The limitations of the study should also be noted. The sample group of the study was relatively small (n = 24) and the measurements of the professional players of a single team were taken. Adding more participants will increase the external validity of this research. Additionally, the number of athletes in the compared positions were not equal. It can be concluded that these outcomes affect the results of the statistics. However, recent studies indicate that the data obtained among individuals may still be informative despite demonstration of a specific team and absence of equal distribution according to the player positions [26].

Conclusion

In conclusion, the results of this study have shown that no difference was found based on the position-related performance among players on the YBT score. Future studies are required to create specific norms related to dynamic balance performance and establish risk cut-off score for professional soccer players. Additionally, they should analyze the relationship between dynamic balance and value parameters such as lower body strength and range of motion (ROM). Furthermore, the reach asymmetry values less than four centimeters are acceptable conclusions for all positions in such cases as practical applications for the conditioning athletes to benefit from, values obtained in a position, prevention of injuries, pre-season screening and athlete selection.

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Conflict of interest

There were no conflicts of interest.

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Effects of mutual learning in physical education to improve health indicators of Ukrainian students

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Abstract

Purpose: The problem of research and increasing of motor activity modes remains relevant, since motor activity is one of the main factors determining health and the level of physical condition of population. The aim of study was to analyze the impact of the mutual learning program of physical education for improvement the physical and mental fitness of students in Ukraine.

Material: Four groups were used for the survey: 2 experimental groups (male, n=31; female, n=33), which received 64 lessons of physical education, which included intra-subgroup interaction, changing of students, and control of knowledge and skills of each other, and 2 control groups (male, n=32; female, n=31), which received a traditional physical education lessons. Assessment of the somatic health (Ketle index, Robinson index, lifetime index, strength index) and physical preparadness (running tests, trunk from the lying position, throw of a medball). Efficiency of processing, speed of figuring out the work and mental stability were determined using Schultz-Platonov tables.

Results: The results suggest about an increase in the functional capacity of cardiovascular and respiratory system among male and female of experimental group. The growth of the physical fitness results was set in lifting the trunk from the lying position to the sitting and throw of medball. After the experiment, positive changes in cognitive parameters were observed in female and male of experimental group. Among control group students, the results were significantly stable.

Conclusions: The results suggest that program increased the level of physical and mental fitness of students of both gender and had a significant impact on the indicators of cardiovascular system.

Keywords: physical education, students, mutual learning, health.

Introduction

Preserving and improving of population health, prolonging the period of active healthy life, reducing premature mortality and increasing the average life expectancy are recognized among the priority tasks. The current state of health of Ukrainian population is formed under the influence of a number of factors, namely: biological, socio-economic, environmental and lifestyle factors and is characterized by a combination of pathologies with varying severity and prevalence [1]. The problem of research and increasing of motor activity modes remains relevant, since motor activity is one of the main factors determining health and the level of physical condition of population [2, 3]. The only way out is to increase the daily motor activity and to include special aerobic exercises of moderate intensity [4].

The formation of a new ideology and a culture of health promotion of young people appears to be a challenge. Unless the solution to this problem is found, society can suffer quite noticeable and irreversible losses in human resources, which will undoubtedly negatively affect the productive infrastructure, well-being and quality of life [5]. The analysis of this problem is an urgent task of modern pedagogics and teaching practice, because health belongs to prior human values [6].

The high level of academic load of students, which is over 36–40 hours per week, its uneven distribution during the day and week, the disordered organization of extracurricular activities – all this negatively affects the efficiency of students' organism [7, 8]. Study [9] showed that 15–20% of the Ukrainian students have some deviations in their health.

The need for an additional muscular activity becomes more required [10]. Specialists [11-13] emphasize that in order to improve the health of students of higher educational institutions, it is, first of all, necessary to use means of physical culture, aimed at improving the development of motor qualities. However, the health effect of exercising requires a clear and regulated organizational system and regular monitoring of basic indicators of students' functional state [14, 15]. At the same time, the issues of ways of attracting young people to physical education, improving physical conditions and health conditions remain unsolved.

We assume that physical education classes with the use of athletic gymnastics and mutual learning will improve indicators of health, the physical and mental fitness of young persons.

Aim of Study. The aim of study was to analyze the impact of the mutual learning program of physical education for improvement the physical and mental fitness of students in Ukraine

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Material and Methods

Participants.

The study involved students of 1-st-3-rd courses aged 17–19 years. By random sampling, we have formed 2 experimental (male, n=31; female, n=33) and 2 control groups (male, n=32; female, n=31). Control groups (CG) were engaged in physical education in accordance with the traditional program of physical education, and those in experimental groups (EG) – in the program with the experimental program. This study was approved in advance by protocol proved by Lviv State University of Physical Culture. Each participant voluntarily provided written informed consent before participating.

Research Design.

All students attended obligatory (academic) physical education classes twice a week during the academic year (32 weeks). In both groups (CG and EG), classes were conducted by the same teacher of physical education. Duration of classes in both groups was 90 minutes. In both groups the priority was given to those means of physical education, which were of the highest health effect: athletics, athletic gymnastics, sports games.

The difference in classes in the conditions of forming experiment was in the methods and forms of organization of educational process (Table 1). We have introduced educational-methodical cards with the technique of exercises for mutual training of students, as well as developed tasks for cooperation in subgroups aimed at improving physical fitness of students. The section "Self-monitoring of Health" included a lecture session to introduce students to the measurement of heart rate, blood pressure, filling questionnaires on the state of health.

Students of CG underwent the usual scheme in academic groups and performed the same tasks. Students of EG were engaged in subgroups, which included changing of students, in constant interaction and control of knowledge and skills of each other, in addition, the tasks were separately worked out in microgroups. The subject-subjective interaction of students was based on the tasks of physical culture, taking into account the unity of the principles of harmonious development of personality and integration of targeted health and educational activities of students. The organizational structure of mutual learning was complex, which combined the group work of students (one teaches many), pair and individual ones. The program contained tasks of varying degrees of complexity for the gradual formation of ability to conduct classes by each student as a teacher; mutual learning of students while doing home tasks (assembling various complexes of exercises); students were involved in mutual analysis

Table 1. The program of mutual learning of students

Forms of classes	Contents of educational material	Methodological approaches to organization
Theoretical	Means and methods of physical condition restoration	Discussion and mutual analysis. Front, frontal-group method
	Presentation of favourite sport. Advertising for physical education and sports	Interpersonal surveys of students, discussion, mutual evaluation of material quality. Presentation (in microgroup of 3–5 people)
Practical	Medical-biological basis of a healthy lifestyle. Influence of physical exercises on activity of basic functional systems of the body	Interpersonal control of heart rate of students. Work in pairs and groups of three
	Mutual studying of athletic exercises performance technique with the use of educational-methodical cards	Mutual check-up of exercises perfomance. Group work (3–5 people)
	Mastering methods of assessing physical health. Methods of regulation of emotional state by physical exercises	Autotraining, relaxation. Mutual analysis and evaluation by participants of the subgroup (5–7 people)
	Development of underdeveloped physical qualities	Mutual control of exercises performing (microgroup 5–7 people, depending on the level of fitness)
	Preparation and performance of a game for the development of certain physical quality	Mutual control and analysis. Work in pairs and groups of three
Independent	Preparation for classes using educational-methodical cards on athletics	Selfcontrol, mutual control, work in microgroups of 3–5 people
	Compiling complexes of exercises and programs for development of physical qualities	Self and mutual analysis of the subgroup (5–7 people); brainstorming, round table, mosaic
	Using and analyzing self-monitoring cards	Self and mutual analysis. Individual method
	Compiling of exercise complexes for underdeveloped physical qualities	Search for methodical material, compiling teacher's notes. Work in microgroups (3–5 people)

of the exercises. Mutual studying also took place during extracurricular classes. Groups were formed depending on the level of development of individual physical qualities, which were of changing nature for the constant exchange of experience. Under supervision of teacher, students compiled exercise complexes to improve the underdeveloped physical qualities and, according to personally developed programs, engaged in training in their free time.

Students worked in groups of 5–7 people for the development of physical qualities and mastery of physical exercise techniques. At the beginning of the year, students were tested for physical fitness. Formation of groups was based on the levels of physical fitness and physical qualities that were not well developed. Among the members of microgroups, one leader of the group was chosen, who had higher than average or high level of fitness. Leaders of groups on the development of each physical quality changed groups for the harmonious physical development of students. Subsequently, students who showed the growth of physical qualities led the group. As the development of physical qualities among students of one subgroup was uneven, each participant of the experiment was in the role of both the leader and the student. At the end of academic year, physical fitness of students was retested.

Assessment of the somatic health and physical preparadness

The calculation of the Ketle index (body mass, kg × height^{-1}, cm), Robinson index (heart rate × blood pressure$_{max}$ × 100^{-1}), lifetime index (lungs capacity, ml × mass^{-1}, kg), strength (100 × dynamometry of hand, kg × body mass^{-1}, kg) and integral assessment of physical health level was carried out according to generally accepted methods [15]. General endurance was assessed by the 3000 m (male) or 2000 m (female) running test (scoring in minutes); for evaluating of strength endurance lifting the trunk from the lying position to the sitting one per 1 min was used (scoring in number of times); agility was tested by running 30 m in a “snake mode” between 5 racks; strength of muscles of the upper shoulder girdle was tested by throw of a medball (result *in meters).*

Cognitive indices

The effectiveness of cognitive processes was determined using Schultz-Platonov tables. A person under study was in turn offered five tables, which showed random numbers from 1 to 25. The task was to look for, show and name the numbers in order of their growth. The sample was repeated using five different tables. The results were determined on three scales – efficiency of processing the tables, speed of figuring out the work and mental stability.

Efficiency of processing (EP) was calculated by the formula:

$$EP = (T1 + T2 + T3 + T4 + T5) / 5,$$

where Tn is the time of working with a certain table.

Speed of figuring out the work (SF) was calculated by the formula:

$$SF = T1 / EP$$

A score of less than 1.0 was considered as indicator of good figuring out the work; the higher this figure than 1.0 was, the more the person under study needs preparation for the main work.

Mental Stability (MS) was calculated by the formula:

$$MS = T4 / EP$$

A score of less than 1.0 showed good mental health; the higher this indicator was, the worse psychological stability of the person under study.

Statistical Analysis.

The characteristics of subjects were described analyzed by mean value (M), mean square deviation (m). The normal distribution was checked by the Shapiro-Wilk test, for statistical verification of the hypothesis about the probability of differences between the indicators of different groups W-criterion of Wilcoxon was used; the level of significance was set at least to $p < 0.05$. Statistic processing was performed using SPSS software.

Results

There was no difference in the data of functional preparedness of male and female, both in experimental and control groups at the beginning of experiment ($p > 0.05$). The study of weight-height Kettle index gives the right to conclude that male and female of EG and CG do not have significant difference in the indices ($p > 0.05$) (Table 2).

There was an increase in lifetime index of male in EG; it became significantly higher than at the beginning of the experiment at 4.36 ml/kg ($p< 0.01$). At the same time, its value at the beginning of the experiment was considered to be lower than the average level, and at the end of experiment – as the average one. Among male of CG, the results of this index were lower than the average level, which was significantly confirmed ($p < 0.05$). Female of EG have a typical situation ($p < 0.01$), as well, which indicates an increase in the functional capacity of respiratory system.

Before the experiment the strength index value corresponded to a level below the average, and till the end of the experiment reached an average level. Among female of CG, the strength index remained unchanged ($p > 0.05$). Among female of CG no static changes were found at the end of the experiment ($p > 0.05$), we clearly observed statistical differences between female of EG and CG ($p < 0.01$) (Table 3).

After analyzing the value of Robinson index in male of EG and CG at the end of the experiment, a significant difference was found in the indices, as the index of EG students was above the index of CG students at 5.35 units ($p < 0.05$). In EG female, the functional capacity of cardiovascular system increased at 6.47 units ($p < 0.01$), in students of CG – the values of Robinson index were reliably stable ($p > 0.05$).

At the beginning of the experiment male and female students both of control (CG) and experimental (EG) groups did not show any significant differences regarding the level of physical fitness ($p < 0.05$). Practically in all exercises after the experiment, both male and female from

Table 2. Dynamics of indices of somatic health of students

Indices	Groups	M ± m (before experiment)	M ± m (after experiment)	pCG & EG
Male				
Kettle index	CG	385.43 ± 31.34	389.56 ± 32.05*	> 0.05
	EG	389.76 ± 22.77	390.79 ± 22.03	
Lifetime index	CG	50.80 ± 6.34	51.35 ± 6.18	< 0.01
	EG	52.49 ± 7.46	56.85 ± 5.72†	
Strength	CG	62.42 ± 10.35	63.70 ± 10.01	< 0.05
	EG	61.39 ± 9.49	67.99 ± 6.31†	
Robinson index	CG	90.94 ± 10.97	87.56 ± 10.32*	< 0.05
	EG	93.50 ± 10.53	82.21 ± 8.22†	
Female				
Kettle index	CG	367.57 ± 17.66	367.44 ± 17.74	> 0.05
	EG	358.07 ± 21.65	360.81 ± 20.83	
Lifetime index	CG	42.05 ± 3.57	43.97 ± 4.28*	< 0.01
	EG	42.81 ± 5.57	47.46 ± 4.58†	
Strength	CG	39.53 ± 5.61	41.56 ± 5.75	< 0.01
	EG	41.15 ± 6.55	47.46 ± 6.58†	
Robinson index	CG	87.78 ± 9.11	86.17 ± 8.53	< 0.05
	EG	87.81 ± 10.18	81.34 ± 8.98†	

Note. *p < 0.05, †p < 0.01

the EG experienced significant statistical positive changes (Table 3).

The growth of the results among female of EG was set in lifting the trunk from the lying position to the sitting one at 9.3%, and throw of medball from the sitting position with two hands from behind the head 12.2%, among male of EG in lifting the trunk from the lying position to the sitting one at 10.1%. Insignificant statistical changes occurred among female of EG in exercises: running "in a snake mode" 30 m (4.5%); among male – in throw of medball from the sitting position with two hands from behind the head (4.4%). The result of running at 3000 m among EG male improved by 3.8% (14 s), while those of CG improved at 0.7% (10 s). Among female of EG it has been noticed an increase in the results of running at 2000 m by 3.1%.

The results of throw of medball from the sitting position with two hands from behind the head among EG male increased by 4.4% (31 cm) ($p < 0.001$), while EG female improved the result by 14.3% (53 cm) ($p < 0.001$). Significant differences were detected between female of both groups ($p < 0.001$).

Among EG male, the overall level of fitness increased from an average level with 2.81 ± 0.70 to above the average one with 3.77 ± 0.88 points ($p < 0.001$). Among EG female level of fitness increased from 2.61 ± 0.79 to 3.58 ± 0.79 points, which corresponds to the average level ($p = 0.001$). There were no statistically significant changes in CG male and female.

After the experiment, positive changes in cognitive parameters were observed both in female and male of EG ($p < 0.05$) (Table 3). The efficiency of processing the tables among EG male at the beginning of the experiment was at satisfactory level, the average time for processing each table was within 51.85 ± 18.95 s. After the pedagogical experiment, the efficiency of processing was 41.89 ± 8.40 s ($p < 0.05$), which corresponds to sufficient level.

At the end of the experiment among CG male we have also revealed an increase in the efficiency of processing the tables ($p < 0.05$). Nevertheless, there were significant differences between EG and CG students: male of EG at 7.88 s faster processed the tables than those of CG ($p < 0.05$).

Analyzing the tendencies of spatial distribution and amount of attention among EG female, we have observed improvement in the efficiency of processing the tables at 9.26 s ($p < 0.01$), in CG – significant differences were not found ($p > 0.05$). The difference in rates between female CG and EG after the experiment was 8.51 ($p < 0.001$).

Speed of figuring out the work at the beginning of the experiment among female and male both in EG and CG was low (> 1.0). Among EG male results in the course of experiment increased by 0.12 s ($p \leq 0.01$), in CG – no differences were found. Among EG female we have revealed a statistically significant improvement in the speed of figuring out the work (at the beginning of the experiment the result was 1.07 ± 0.18, and at the end – 0.97 ± 0.10, $p < 0.01$). Among CG female, the results were significantly stable ($p > 0.05$) (Table 4). After the experiment among male of EG, the value of mental

Table 3. Changes in physical fitness and cognitive indices of students

Qualities	Groups	M ± m (before experiment)	M ± m (after experiment)	p	pCG & EG
Physical fitness					
Male					
General endurance	CG	14.30 ± 1.04	14.20 ± 0.91	> 0.05	< 0.05
	EG	14.10 ± 0.81	13.56 ± 0.67	< 0.05	
Strength endurance	CG	40.63 ± 4.53	43.22 ± 4.11	< 0.05	< 0.01
	EG	41.94 ± 4.10	46.68 ± 4.54	< 0.001	
Strength of muscles of the upper shoulder girdle	CG	6.96 ± 0.47	7.01 ± 0.45	> 0.05	< 0.05
	EG	7.00 ± 0.54	7.31 ± 0.53	< 0.001	
Agility	CG	5.15 ± 0.14	5.09 ± 0.16	> 0.05	< 0.01
	EG	5.11 ± 0.15	4.95 ± 0.14	< 0.001	
Female					
General endurance	CG	11.53 ± 0.81	11.51 ± 0.71	> 0.05	< 0.05
	EG	11.52 ± 0.67	11.16 ± 0.53	< 0.05	
Strength endurance	CG	38.03 ± 5.08	40.26 ± 3.74	< 0.05	< 0.05
	EG	38.70 ± 4.46	42.30 ± 2.72	< 0.001	
Strength of muscles of the upper shoulder girdle	CG	5.43 ± 0.66	5.54 ± 0.66	> 0.05	< 0.01
	EG	5.31 ± 0.53	5.96 ± 0.40	< 0.001	
Agility	CG	6.21 ± 0.29	6.10 ± 0.23	< 0.05	< 0.05
	EG	6.26 ± 0.28	5.98 ± 0.26	< 0.001	
Cognitive indices					
Male					
Efficiency of processing the tables	CG	51.61 ± 17.61	49.77 ± 19.22	< 0.05	< 0.05
	EG	51.85 ± 18.95	41.89 ± 8.40	< 0.05	
Speed of figuring out the work	CG	1.02 ± 0.25	1.01 ± 0.29	> 0.05	> 0.05
	EG	1.05 ± 0.25	0.93 ± 0.18	≤ 0.01	
Mental stability	CG	1.04 ± 0.17	1.07 ± 0.17	> 0.05	< 0.05
	EG	1.09 ± 0.20	0.99 ± 0.13	< 0.05	
Female					
Efficiency of processing the tables	CG	50.09 ± 9.78	50.01 ± 11.05	> 0.05	< 0.001
	EG	50.76 ± 8.52	41.50 ± 6.55	< 0.01	
Speed of figuring out the work	CG	1.09 ± 0.25	1.10 ± 0.23	> 0.05	< 0.01
	EG	1.07 ± 0.18	0.97 ± 0.15	< 0.01	
Mental stability	CG	1.03 ± 0.16	1.09 ± 0.17	> 0.05	< 0.01
	EG	1.06 ± 0.11	0.97 ± 0.10	< 0.001	

stability increased to 0.99 ± 0.13 ($p < 0.05$), and in CG – decreased to 1.07 ± 0.17, but statistically, changes in CG were not confirmed ($p > 0.05$).

Discussion

An assessment of the functional state of body and its reserve capacities is important for determining the effectiveness of physical education classes [16, 17]. Good functional state can be considered as a prerequisite for high physical working efficiency and potential ability of the body to adapt to physical activity [10, 18].

The Kettle index of CG and EG students is on the average level of completeness for both female and male [8]. However, an individual analysis of the results showed that in 11.3% of male there is a shortage of body mass, and 3.8% are overweight, whereas in female the figures are 14.2% and 10.6%, respectively.

The level of musculoskeletal system functions reserve of female in EG is estimated to be lower than the average, an increase in the strength index was noted ($p < 0.01$), but the initial data were too low. According to Robinson index (in a state of rest), we characterized reserves criteria and economization of cardiovascular system functions. Reduction of this index indicates an improvement in the work of the abovementioned system. Characteristics of the functional capacity of cardiovascular system of EG male (Robinson index) was at a level higher than the average, in CG male– indices also significantly improved ($p < 0.05$) and corresponded to the average level [8].

As a result of the experiment, the values of this index for EG female were higher than the average level, and in CG those values were the average. The study of the dynamics of Robinson index results shows that due to the implementation of aerobic exercises, we observe the improvement of the cardiovascular system both in male and female of EG [18, 19].

After the experiment, positive progress was observed among students of EG viewing the level of physical fitness. The progress of CG students did not have such a distinctive character and was the result of natural human development [20]. Improvement of physical fitness indices among students of EG was achieved, first of all, due to the use of means and methodical techniques aimed at attracting students to self-study and mutual studying during academic classes on physical education. They included compilation, conducting and performing of exercise complexes, analysis of exercise techniques and adjustment of loading according to heart rate figures. Also, during independent performing of exercise complexes while extracurricular forms of physical education, which contributed to the deepening of knowledge, abilities, skills, positive changes in motivation to regular physical activity, and thus increase in the volume of motor activity of students.

Strength indices have increased among students due to the use of exercises with weights, overcoming resistance of the partner, with equipment and on gymnastic devices. Among male of EG, increase in results of strength endurance (in lifting the trunk from the lying position to the sitting one) increased by 11.3% from the average to above the average, and among EG female – 9.3% from below the average to the average. Such increase can be explained by the fact that strength is the fastest growing quality, but if one does not maintain the level achieved by systematic exercising, it will soon be lost [21].

The results of the experiment confirm the effectiveness of the program in terms of improving cognitive indices. After the pedagogical experiment, a positive growth of indices was established, in particular, the efficiency of processing corresponded to sufficient level.

Conclusions

The results suggest that experimental program of mutual learning can help to improve the fitness level and adaptation abilities of an organism. The program had a significant impact on the indicators of the cardiovascular system and mental abilities of students of both gender. These findings also indicate that such pedagogical program with the special emphasis on mutual learning could serve as an effective health-preserving means of physical education.

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Conflicts of Interest

The authors declare no conflict of interest.

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PHYSICAL EDUCATION OF STUDENTS

Effect of long-term training adaptation on isokinetic strength in college male volleyball players

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Abstract

Purpose: Most of this study focused on endurance, power, and anthropometric measurements but no research declared isokinetic strength changes during two years. The purpose of this study was to assess the effect of resistance exercises on two seasonal alters in isokinetic strength of knee muscles at different angular velocities, in college volleyball players.

Material: Thirteen college volleyball players, (age: 21.75 years, body mass: 78.60 kg, and height: 187.0 cm) participated in the study. All college volleyball players take part in the two-year (8 month each year) volleyball-specific training and competitions. The measurement of peak isokinetic concentric knee extension and knee flexion torque in both legs were taken at 2 angular velocities of movement, low at 60° s^{-1}, and intermediate at 180° s^{-1}.

Results: The pre- and post-test values of the peak isokinetic strength found that statistical significance difference, at 60° s^{-1} and 180° s^{-1} for knee extensor-flexor both dominant and non-dominant in favor of post-tests. Significant enhances were observed in the baseline dominant knee extensor-flexor muscle strength (extensor knee strength 60° s^{-1}: 19.0%, 180° s^{-1}: 20.5%, flexor knee strength, 60° s^{-1}: 33.4%, 180° s^{-1}: 31.4%) respectively. Non-dominant knee extensor-flexor muscle strength increased significantly over the two-year period (extensor knee strength 60° s^{-1}: 21.3%, 180° s^{-1}: 23.0%, flexor knee strength, 60° s^{-1}: 37.4%, 180° s^{-1}: 33.9%) respectively.

Conclusions: As a result, our data suggests that the two-year planned program of specific volleyball and resistance training can increase the knee muscle extensor-flexor strength and H:Q ratios of volleyball players. Especially, at a 60° s^{-1} and 180° s^{-1} angular velocities, whilst the knee muscle extensor-flexor strength and H:Q ratios for dominant and non-dominant legs were increasing, also H:Q ratios disproportion were decreasing. Therefore, these alters indicated that regular specific-volleyball and resistance training can increase knee muscle extensor-flexor strength and H:Q ratios for dominant and non-dominant legs.

Keywords: volleyball, strength, training, hamstring, muscle imbalance.

Introduction

Volleyball is a sport that involves intermittent activity that incorporates active or passive phases of playing and training. Volleyball games and training demand activities such as turning, altering pace, vertical jumping (VJ) and being generally agile where players use explosive strength [1, 2]. VJ is a principal feature of spiking, blocking, and serving. Fontani et al. said that the average number of jumps during in a 5-set match ranges from 65 to 136 [3]. In terms of the average number of jumps during a volleyball match, we have side hitters (65 jumps), opposite hitters (88 jumps), and blocker hitters (97 jumps). Setters are the players with a highest number of jumps (136 jumps). Rapid permutations are also essential when defending and receiving in order to adapt the body position to the ball position in a short time [1, 3]. In addition, the intensity of volleyball matches requires robust contractions to maintain the balance, movement and control of the body. All these activities are mainly characterized by quick or short displacements and vertical jumps. Therefore, the players require well-developed explosive force and power. Muscle strength is one of the key elements in accomplishing sports performance on the part of athletes. Previously research has also shown that, apart from talent, jumping performance in volleyball is a significant result of knee extension and flexion strength. The strength of hamstrings (H) and quadriceps (Q) is of vital importance for sport performance and injury prevention. Therefore, volleyball players' injuries might arise from imbalances or lack of strength in terms of muscle strength ratios [4-6]. In the literature, *characteristic concentric (hamstring: quadriceps) H:Q ratios range from 0.5 to 0.8, with a higher ratio at faster angular knee velocities during isokinetic testing* [7]. In respect of muscle strength in the dominant versus the non-dominant leg, it has been asserted that there is an increased proportion of injury when a discrepancy of 15% or more in knee flexor-extensor strength exists in collegiate athletes [8, 9]. Also, it has been proposed that H:Q ratios and bilateral leg strength differences may indicate that leg muscle strength demands are sports-specific [10]. College athletes who train for a large number of hours on a weekly basis may present an asymmetry in muscle strength profiles due to specific technical skill requirements in particular sports such as volleyball and basketball [11]. For instance, sports requiring significant jumping and running place a higher demand on the motor abilities of the H-Q strength ratios [12]. Therefore, attempts to strengthen weak hamstring and quadriceps muscles and improve the strength balance between them, appear to be a significant issue for trainers. In fact, players who are exposed to strength training can improve their muscular strength. Some researchers have

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discovered that technical and tactical training, games, conditioning and all other activities, combined with strength training, affect the strength levels of players [4, 13].

There are some works in which researchers have looked into pre-season physiological and physical changes over a period of 6-8 weeks. Most of these studies are focused on endurance, power, and anthropometric measurements [14, 15, 16], but a limited amount of research has identified isokinetic strength changes [17, 4]. However, no research has examined the isokinetic strength changes at different angular velocities in college volleyball players during two competitive seasons. Thus, the purpose of this study was to assess the alterations in the isokinetic strength of knee muscles at different angular velocities in college volleyball players over two seasons. We hypothesized that regular training (a) would improve H:Q strength ratios, (b) would increase both the dominant and non-dominant extensor and flexor knee muscle strength of college volleyball players when suitable training programs were chosen.

Material and Methods

Participants

A total of 16 college male volleyball players from Turkish National Volleyball 3rd League were tested following the end of competitive seasons. In order to be included in the study a) players had to play in the Turkish National Volleyball 3rd League, b) not having any medical disability which might affect the result of the study (this question asked all players), c) not having chronic injuries and diseases, d) not having lower extremity injuries within two years. Excluding criteria were: a) having any chronic injuries during the seasons, b) missing deliberately at most five training days. Following these procedures, thirteen players (age: 21.75 years, body mass: 78.60 kg, and height: 187.0 cm) met the criteria for further analysis. Before conducting the experiment, all participants were informed on the risks of the study and gave informed consent. The study was approved by the Ethics Committee of the Inonu University and met the conditions of the Helsinki Declaration. All college volleyball players take part in the two-year (8 month each year) volleyball-specific training and competitions.

Isokinetic Tests

Knee extensors and flexors isokinetic strength of the dominant-non-dominant leg was measured with Biodex 3 isokinetic dynamometers (Biodex Medical Systems, Inc., Shirley, NY, USA 2000). The first season pre-test measurement of isokinetic strength was taken in the first week of volleyball training. The first season post-test measurement was done in the last week of the first season. The second season pre-test measurement of isokinetic strength was taken in the first week of volleyball training of the second seasons. The second season post-test measurement was done in the last week of the second season. Before testing, the participants were informed about the machine's specific details and they warmed up for 15 minutes. The measurements of peak isokinetic concentric knee extension and knee flexion torque in both legs were taken at 2 different angular velocities of movement (low: 60° s^{-1} and intermediate: 180° s^{-1}). Calibration adjustments of dynamometers were approved regularly in line with the recommendations of the manufacturing company during the data collection period. Subjects were placed safely in a chair at a sitting position for the test. In order to immobilize upper body movements for the subject, he or she was restrained with both a cross-wise pectoral girdle and lap belt. Trunk/Thigh angle was arranged to be 85° and the leg to measure was contacted by means of a belt on the shaft which was on the dynamometer axis. Subjects were asked whether or not they were comfortable. 90° anatomic position of the knee was observed with a goniometer and a joint range of movement (ROM) was 70° [from 90° to 20° knee Xexion (0° = full extension)]. Participants started the test with a warning beep from the dynamometer and ended the test with the same noise. Testing conducted from slowest to highest speeds. Players were given five times to warm up at submaximal concentric contractions for both leg and then performed the maximal concentric contractions five times. During all isokinetic tests, players were allowed to rest for 3 minutes between sets and 15 seconds between serials.

Training procedures of two seasons

The 1st volleyball-training season lasted 40 weeks, including 13 weeks of pre-season training, 20 weeks of in-season training and 7 weeks post-season training. The 2nd volleyball-training season lasted 40 weeks to be completed, including 12 weeks of pre-season training, 16 weeks of in-season training and 12 weeks post-season training. Both training seasons was paused due to Festival of Sacrifice (1 week) and the mid-seasons break (1 week).

Volleyball training procedures included both seasons volleyball training activities (technical and tactical training, games and matches) and conditioning (strength, agility, coordination, plyometric, stretching, flexibility, endurance and strength development) during the pre-season, in a season and as well as post-season. The average duration of practice sessions was 90-120 min. All specific volleyball training procedures indicated in table 1.

Statistical Analysis

Statistical analysis procedures started with *"Skewness and Kurtosis"* scores, visual explanations of histogram plots and *"Kolmogorow Smirnov"* tests within normality analysis in order to test whether data were homogenous. The testing times of volleyball players were evaluated by *"Repeated Measures"* analysis, which was used to test for significant differences between tests. All statistical analyses were calculated with SPSS 17.0 software program and the significance level is recognized as $p<0.05$. The reliability of each isokinetic test was evaluated by intra-class correlation coefficient (ICC) as suggested by Weir 2005 [18]. The ICC values were found to be highly repeatable (ICC= between 0.91 – 0.96).

Results

Changes in primary peak isokinetic extensor-flexor strength measures over the examined time period (two year) are presented in Tables 2, 3. A significant ($p<0.05$) improvement in the knee strength of quadriceps and hamstrings were registered. The pre- and post-test values of the peak isokinetic strength found that there was a statistically significant difference, at 60° s^{-1} and 180° s^{-1} for knee extensor-flexor in terms of both dominant and non-dominant legs in favor of post-tests ($p=0.00$, Tables 2, 3). Significant enhancement was observed in the baseline dominant knee extensor-flexor muscle strength (extensor

Table 1. Overview of two season volleyball specific training outline.

Type of activity	Exercise	Set x repetition	1-RM%	Days
Resistance training	Barbell bench press Machine long pull Dumbbell shoulder press Standing barbell curl Machine leg extension Machine leg curl Barbell half squat	2x 8-10 (20 weeks, Aug, Sep, Oct, Nov, Dec) 3x10-12 (20 weeks, Jan, Feb, Mar, Apr, May)	60 70	Tues., Thurs
Specific volleyball training	Exercise	Section	Duration (min)	Days
	Stretching and flexibility	Warm up, cool down,	15	Every day
	Sprint and agility	Before technical training	10	Tues., Thurs
	Plyometric	Before technical training	12	Wed.
	Technical training	Main training	20	Wed., Fri
	Tactical preparation	After technical training	15	Wed., Fri
	Games	After tactical training	20	Friday
Match Days		Competitions		Satur., Sun
Regeneration Day		Jogging, Pilates, sauna	55	Mon

Table 2. Changes in different angular velocity peak isokinetic knee strength of quadriceps for both legs.

Extensor Peak Torque (Nm) n=13				
	60° s^{-1}		**180° s^{-1}**	
Times	Dominant	Non-dominant	**Dominant**	**Non-dominant**
1st Pre-test	228.33±19.15	218.66±15.64	184.75±16.29	171.00±16.61
1st Post-test	254.50±18.95* *p=0.00	248.53±15.75* *p=0.00	206.50±14.21* *p=0.00	193.08±14.61* *p=0.00
2nd Pre-test	239.66±16.55	235.33±14.86	194.16±12.94	181.75±13.49
2nd Post-test	271.75±18.14*† *p=0.00, †p=0.00	265.25±16.66*† *p=0.00, †p=0.00	222.50±15.28*† *p=0.00, †p=0.00	210.41±15.69*† *p=0.00, †p=0.00

*: differences between pre- and post-test, †: differences between post- and post-test

Table 3. Changes in different angular velocity peak isokinetic knee strength of hamstring for both legs.

Flexor Peak Torque (Nm) n=13				
	60° s^{-1}		**180° s^{-1}**	
Times	Dominant	**Non-dominant**	**Dominant**	**Non-dominant**
1st Pre-test	127.66±17.74	121.16±16.24	104.91±15.17	101.91±15.86
1st Post-test	155.16±15.28* *p=0.00	148.56±14.00* *p=0.00	122.41±13.96* *p=0.00	120.83±13.04* *p=0.00
2nd Pre-test	144.00±16.55	136.00±14.13	116.50±13.06	111.08±12.53
2nd Post-test	170.08±16.74*† *p=0.00, †p=0.00	166.50±15.91*† *p=0.00, †p=0.00	138.00±12.76*† *p=0.00, †p=0.00	136.16±13.04*† *p=0.00, †p=0.00

*: differences between pre- and post-test, †: differences between post- and post-test

Table 4. Changes in H:Q for both legs.

H:Q (%) **n=13**	**60° s⁻¹**		**180° s⁻¹**	
Times	**Dominant**	**Non-dominant**	**Dominant**	**Non-dominant**
1st Pre-test	39.30±3.50	38.70 ±4.10	46.50±5.55	43.75±5.85
1st Post-test	49.90±3.10*	48.50±3.90*	57.40±6.95*	55.80±5.00*
	*p=0.00	*p=0.00	*p=0.00	*p=0.00
2nd Pre-test	47.00±4.25	44.35±4.10	53.25±6.60	51.05±6.55
2nd Post-test	57.75±4.15*†	58.45±5.65*†	66.00±7.10*†	62.15±6.70*†
	*p=0.00, †p=0.00	*p=0.00, †p=0.00	*p=0.00, †p=0.00	*p=0.00, †p=0.00

*: differences between pre- and post-test, †: differences between post- and post-test

knee strength 60° s^{-1}: 19.0%, 180° s^{-1}: 20.5%, flexor knee strength, 60° s^{-1}: 33.4%, 180° s^{-1}: 31.4%) respectively. Non-dominant knee extensor-flexor muscle strength increased significantly over the two-year period (extensor knee strength 60° s^{-1}: 21.3%, 180° s^{-1}: 23.0%, flexor knee strength, 60° s^{-1}: 37.4%, 180° s^{-1}: 33.9%) respectively. A comparison of the H:Q ratios of both dominant and non-dominant legs found a significant difference in mean values at 60° s^{-1} and 180° s^{-1} in favor of post-tests (Table 4). Significant improvements were monitored in the baseline dominant and non-dominant H:Q ratios (H:Q dominant 60° s^{-1}: 46.94%, 180° s^{-1}: 41.9%, H:Q non-dominant 60° s^{-1}: 51.0%, 180° s^{-1}: 42.1%) respectively.

Discussion

The primary finding of this research is that isokinetic strength performance increased at the end of training and match seasons over a two-year period. Our study has indicated great changes in isokinetic strength values at different angular velocities. The findings of this study demonstrated that regular resistance and specific-volleyball training may improve extensor-flexor knee muscle strength and the H:Q strength ratio of male college volleyball players. Although previous research has investigated countermovement jumping and spike jumping [16] of volleyball players, and extensor-flexor knee muscle strength and H:Q [4] of football players, no studies have investigated the effect of long-term training adaptations on isokinetic strength values in volleyball. The results of this research are original in that our study investigates just such an effect. This research provides coaches and players with the basis of a rationale to prioritizing:

1) implementing resistance training at least twice a week,

2) carrying out sprint and agility training at least twice a week,

3) performing plyometric training at least once a week.

One study declared the effect of pre-season strength training on improving knee muscle strength values [14]. Another study reported that a combination of football and strength training (3 times a week, 85% of 1 RM) increased power strength [19]. Eniseler et al. asserted that implementing football specific-football training during the season improved the strength values of football players [4]. Our current findings support previous results that show the significance of knee muscle strength in volleyball players. The results indicate the need to: (a) perform strength training at least twice a week, and (b) perform specific-volleyball training at least three times a week. Another possible clarification to ensure a significant alteration might be that college volleyball players have very low pre-season knee extensor-flexor knee muscle strength levels. Improvements in knee muscle strength values after two specific volleyball training and competition seasons might arise mainly from significant increments in the neural adaptation of muscles as a result of a specific training regimen [4]. Behm and Sale asserted that high velocity training adaptations might improve substantial neural conformations [20]. However, strength and conditioning coaches should be aware of the debate that neural adaptations may be restricted to the early stage of strength training [21]. Moreover, such conformations may progress throughout the later stages of the strength training period [4, 22]. As a consequence of our study, we would recommend that during the season, a planned program of specific-volleyball and resistance training might improve the knee muscle strength of volleyball players.

In this research, the outcomes indicate that specific-volleyball and resistance training were influential in decreasing the disproportion between dominant and non-dominant legs. This could be helpful to volleyball players in increasing their performance and, most substantially, minimizing the risk of injury in the lower limbs. It has been suggested that strength disparities of the knee is one of the most significant risk factors for lower limb injuries in amateur and competitive athletes [8, 11, 23]. The H:Q ratio should be between 0.50 and 0.80, depending on varying knee-angles and angular velocities [7, 24, 25]. In this study was found values of H:Q (60° s^{-1}) ratios for the dominant leg in the 1st pre-season was 39.30%, and in the 2nd pre-season it was 47.00%. For the non-dominant leg in the 1st pre-season it was 38.70%, and in the 2nd pre-season it was 44.35%. The values of H:Q (180° s^{-1}) ratios for the dominant leg in the 1st pre-season was 46.50%, and in the

2nd pre-season it was 53.25%. For the non-dominant leg in the 1st pre-season it was 43.75%, and in the 2nd pre-season it was 51.05%. The results of this study have been shown that there are no suitable reference H:Q values in the literature [7, 24, 25]. However, the H:Q values of college volleyball players found that there were suitable reference values after two years of specific-volleyball and resistance training (for 60° s^{-1}**:** 2nd post-season 57.75% dominant, 2nd post-season 58.45% non-dominant, for 180° s^{-1}: 2nd post-season 66.00% dominant, 2nd post-season 62.15% non-dominant). In summary, in the current research, there was a statistically significant increase in H:Q ratios in terms of both 60° s^{-1} and 180° s^{-1}. On the other hand, the H:Q disproportion decreased significantly. The previous studies' findings indicate the significance of H:Q ratios in athletes and the reliable correlation between developing H:Q and decreasing lower limb injuries [8, 9]. In the present study, H:Q ratios increased after two year specific-volleyball and resistance training. In addition, trainers should consider increasing H:Q ratios as a significant training priority in volleyball players.

As a result of this research, our data suggests that a two-year planned program of specific volleyball and resistance training can increase the knee muscle extensor-flexor strength and the H:Q ratios of volleyball players. In particular, at 60° s^{-1} and 180° s^{-1} angular velocities, whilst the knee muscle extensor-flexor strength and H:Q ratios for dominant and non-dominant legs were increasing, the H:Q ratios disproportion were also decreasing.

Conclusion

Throughout the pre-season period, trainers should aim to increase their players' muscular strength. This is necessary in particular to minimize disproportionate H:Q ratios in volleyball players. Regular resistance and specific-volleyball training is a method that enhances the muscle strength situation. We also suggest that performing regular specific-volleyball and resistance training can increase knee muscle extensor-flexor strength and H:Q ratios for dominant and non-dominant legs. The changes in knee muscle extensor-flexor strength and improvements in the H:Q ratios can be realized in already well-trained volleyball players. These outcomes provide the trainers with the basis of a rationale for prioritizing:

1) implementing resistance training at least twice a week,

2) carrying out sprint and agility training at least twice a a week,

3) performing plyometric training at least once a week.

Volleyball players should be encouraged to improve their knee muscle extensor-flexor strength and H:Q ratios for dominant and non-dominant legs. This can be preventing lower limb injuries on the part of volleyball players.

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Conflicts of interest

There no conflicts of interests.

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PHYSICAL EDUCATION OF STUDENTS

Effects of electromyostimulation training on jumping and muscle strength in football players

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Abstract

Purpose: Electromyostimulation is a popular training to increase muscle strength during the last years. The aim of this study was to investigate effects of electromyostimulation training on jumping and muscle strength in football players.

Material: Volunteered 23 football players between the ages of 18 to 24 were divided into experimental and control groups with simple random sampling. Both groups continued to regular training. Experimental group had additional electromyostimulation training for 6-week, 3-time a week, and 20min a day. Pre- and post-training squat and countermovement jumps, peak torques of dominant and non-dominant knee extensor and flexor muscles were tested. Angular velocities of isokinetic dynamometer were 60, 180, and 300°s^{-1}. Pre- and post-test comparisons within the groups were analyzed.

Results: There were no significant differences between pre- and post-test for isokinetic knee strength parameters at all angular velocities of experimental group. However, control group had significant pre- and post-test differences in dominant and non-dominant knee extension and flexion peak torque values.

Conclusions: Electromyostimulation and regular training in-season had no effect on the isokinetic strength parameters. On the other hand, the regular training in-season has increased isokinetic strength. Electromyostimulation training additional to regular training may have detrimental effects on outcomes of concurrent training in football players.

Keywords: electromyostimulation, squat jump, countermovement, jump, isokinetic, strength.

Introduction

The electromyostimulation (EMS) through the skin cause changes in neuromuscular transmission speed during the voluntary contraction [1]. In this method, the nerves and muscles are stimulated at various intensities and frequencies via electrodes on the skin using electrical currents. The effectiveness of EMS is related to the intensity of electrical currents applied during training. The key factor in the effectiveness of EMS is the maximum tolerable application of current intensity to maximize muscle tension. EMS is also known as neuromuscular electrical stimulation. When it is applied in sufficient, it causes a significant increase in maximal voluntary contraction ability. Therefore, EMS is used in athletes as a part of strength training to increase knee extensor strength [2, 3], enhance squat jump (SJ) [2, 4, 5] and countermovement jump (CMJ) [5, 6].

The interest in EMS has increased after Kots claimed that force gains of up to 40% in elite athletes [7]. It is used a training program in short-time with high-frequency electrical muscle stimulation. Although there was muscle strength development in EMS, the development of muscle strength was not more than that of in voluntary exercise [8]. Strength development in traditional strength training often occurs because of dynamic movements during the muscle contraction including the agonist-antagonist coordination. It is necessary that EMS has to be performed in more repetition at the angles of each muscle movement. However, in traditional strength training (e.g; leg press), different muscle groups (gluteal, hamstrings, quadriceps) can contract at the same time. The pain that cannot be tolerated during the EMS training is the most important reason for hindering the strength development.

EMS creates a proprioceptive input in the extremity because of the afferent and efferent stimulation [9]. If EMS is combined with voluntary contractions, it constitutes a statistically significant increase in muscle strength in healthy individuals [10]. However, it must be run with at least 60% of maximal voluntary contraction for the formation of muscular development [11]. The replication of this situation via EMS can only be managed by increasing the stimulation intensity up to tolerated by the muscle.

EMS training produces knee extensor strength development [2, 3, 12,] and vertical jump improvement [13]. However, Porcari et al. showed that it did not enhance knee extensor and flexor strength. The studies based on a single joint including knee [2, 3, 12, 13], elbow [10], and shoulder [14, 15], and the lower third of the sternum [16] support that the EMS training produces strength development. On the other hand, detailed studies involving strength development based on multi-joint is necessary.

The examination of effects of EMS on muscle strength will be significant benefits from performance training in those who do explosive strength based exercises. It is important because EMS constitute a new variation instead of traditional dynamic strength training. The purpose of this study was to investigate effects of EMS training on jumping and muscle strength in football players.

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Material and Methods

Participants

Twenty-three male football players between the ages of 18 to 24 who didn't have any leg injuries last one year volunteered to participate in this study. The participants were divided into 2 groups with simple random sampling. Ten football players sat off the experimental group (EG) (age= 20.2±2.1 year, training age= 98.4±32.4 month, body height= 173.6±6.1 cm, body weight= 65.0±5.6 kg). The other 13 players sat off the control group (CG) (age= 21.9±0.3 year, training age= 84.9±22.7 month, body height= 177.2±5.4 cm, body weight= 69.9±7.1 kg). Both groups were supposed to perform regular training but EG also perform EMS. The players were free to discontinue the study at any time. They signed in their statements of informed consent after the procedures and probable risks had been explained to them. Osmangazi University Ethical Advisory Committee approved the study (2010/214) prior to the commencement of testing. The players were randomly participated into the test protocols.

Procedures

EG performed EMS in addition to regular training at the frequency of 100 Hz, the current width of 400 µs. A stimulator device (Compex 3 Professional, Medicompex SA, Switzerland) was used with self-adhesive electrodes placed on dominant leg (D) and non-dominant leg (ND). The electrodes were placed on motor points of quadriceps muscles (vastus medialis, vastus lateralis, rectus femoris). The current intensity in this frequency was increased until it initiated the muscle contraction. CG performed regular training. The EMS training was performed 30min a day, 3 days a week that lasted in 6 weeks. Each participant was familiarized with training and testing procedures within one week before the training and testing. After the familiarization, each participant participated in one test a day that lasted about 30 min. After anthropometric measurements, SJ and CMJ were tested by the digital wireless device (Freejump, Rome, Italy). The device fixed on athlete's lumbar area. The peak torques to be exhibited on the muscles of D and ND knee joints were determined by using isokinetic testing device (Humac Norm Testing & Rehabilitation System, Stoughton, USA). The peak torques were tested with three different angular velocities (60, 180, and $300^{o}.s^{-1}$). Pre- and post-training differences depending on these two types of training on jump and muscle strength were investigated. The average of the two measurements in anthropometric measurements were evaluated for descriptive statistics. The best test performance obtained from two trials that were performed in jump tests were evaluated for statistical analyses. The isokinetic tests were performed 5 times for each knee joint at 3 different angular velocities. The highest torque values of these 5 trials were evaluated for statistical analyses.

Training Design

Regular Training: All participants took part in the study played in an official league match in each week. They performed regular training, which was followed by a resting day after the match in the official season. Players were performed speed, strength, endurance training on the first day and third training day of the regular weekly training. The training week was followed by technical and tactic-specific football training for 60 min on the second and fourth day. Speed training [2 x (4 x 40 m)] was performed with 3-4 min among reps and 4-6 min between sets. Strength training involved the maintenance training. It was consisted of 7 exercises (half squat, bench press, lat pull down, leg extension, leg curl, shoulder press, and calf raise). Each exercise was 90% intensity, 3 x 3 reps with 3-5 min among the sets and. There were 4-6 min recoveries after each exercise. Endurance training involved the extensive tempo (135-140 $beat.min^{-1}$). It was consisted of 10 x 200 m with the recovery until the heart rate decreases 120 $beat.min^{-1}$ among repetitions. All players performed soccer-specific basic techniques and shooting training lasting in 40 min before every match day. This was the last training on the fifth day of weekly training.

Electromyostimulation Training: EMS training was conducted on the knee extensor muscles 3 days a week (18 sessions) for 6 weeks. EG participated in EMS training in addition to the regular training sessions. EMS training was on the first, third and fifth training days before the match after the resting day for six weeks. Each session lasted in 20 min. Five min cycling on a bicycle ergometer and 5 min free dynamic stretching were used for warm-up. Five min EMS application was conducted on the quadriceps muscles of D and ND (vastus medialis, vastus lateralis, rectus femoris) as 35 isometric contractions. EMS was conducted with a stimulator generating biphasic symmetrical square wave signal (Compex 3 Professional, Medicompex SA, Switzerland) at the frequency of 100 Hz. The stimulator has the current width of 400 µs as previously recommended [4, 8]. The work cycle of the stimulator was adjusted to 1.5s increased current and 0.5s decreased current. Contraction time was 10s and resting period was 3s. Every athlete sat on a chair and while their knees were in 90° flexion position. Chronaxie value was determined on an individual basis, and the current level was adjusted to their maximum tolerability. The motor points of the muscles were determined by using the motor point pen. Three positive electrodes (5 x 5cm) were placed as close as possible to the motor points of vastus medialis, vastus lateralis and rectus femoris muscles. Three negative electrodes (5 x 10 cm, 5 x 5 cm) were positioned as close as possible to the head of the thigh (femoral triangle). The goniometer was used to standardize the knee and hip angle.

Anthropometric Measurements

Each participant was kindly asked not to drink much water the night before the anthropometrical measurements were taken. The measurements were taken on an empty stomach as described by Lohman et al. [17]. The body height of each participant was measured with ±0.1 mm sensitivity through stadiometer (Holtain, UK). It was taken as cm in a way that the participants were barefoot, heels together, their feet opened to each other at an angle of 60°. The body weight evenly distributed on both feet. Arms and palms on both sides were united to the body.

The body was united to the vertical table of stadiometer in anatomical stand position. Eyes were focused over in the inspiration phase, the head in the frontal plane. Table of head top were placed as close as possible to the vertex point. Body weight was taken with 0.1 kg sensitivity in kg. The participant was only with his shorts and barefoot in anatomical position on the laboratory bascule (Seca, Vogel & Halke, Hamburg). His eyes were focused over. His weight evenly was distributed on both sides of his feet.

Jump Tests

A jumping measuring system (Freejump, Sensorize, Rome, Italy) with light machinery having computer software was connected to the belly through wireless waist belt. It was capable of measuring the jumping height of the participants in SJ and CMJ tests was used. After each jump, the participants had a rest for 5min. Participants performed two trials for each jump test and the better jump heights in the trials were evaluated statistically. The participants performed SJ in the position of knees flexed until they felt a comfortable starting position, semi-squatting position. The position normally occurs at a knee angle of about 85° [18] and they maintained their posture at least two to three seconds. This prevented the pre-stretching of muscles from any preliminary downward movement before jump. CMJ was performed in an upright standing position, hands kept on the hips following a preliminary downward movement by flexing the knee. The movement was approximately to the same knee angle as the starting position in SJ.

Isokinetic Strength Tests

The peak torques in concentric/concentric knee extension and flexion of D and ND were tested by isokinetic dynamometer (Humac Norm Testing & Rehabilitation System, USA). The angular velocities of $60^{o}.s^{-1}$, $180^{o}.s^{-1}$, and $300^{o}.s^{-1}$ were used. Isokinetic dynamometer was calibrated at the beginning of each test day as specified by CSMI [19]. Each athlete freely warmed up before the test. The attachments of the dynamometer were set according to the anatomical structure of each participant. The mobility of the knee joint was positioned at 0-90° for knee extension and flexion test. The participant was placed on a two-position seat of the dynamometer as specified by CSMI [19]. The axis rotation of the dynamometer's arm was adjusted to the level of lateral femoral epicondyle. The pad was placed to the proximal of lateral malleolus, which was fixed on the attachments of the lower leg. The preventive belts from movements of the body and quadriceps were tightened. The reference way is that three fingers can be inserted between the body and the quadriceps. During the test, each participant held the handles on each side of the seat of the dynamometer. Athletes were asked to perform maximal 5 times knee extension and flexion with 60 s rest intervals in the three angular velocities as recommended Davies et al. [20]. The highest torque values at each angular velocity were considered as the peak torque values. In order to adapt to angular velocity of each test and avoid form probable injuries, three training repetitions were done. The test was started after 30 s resting period. Each participant was encouraged verbally (push/pull) during the test with regard to the number of the repetitions left.

Statistical Analysis

SPSS 22 (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis of the data. Wilcoxon t test was used to determine pre- and post-test differences within the group. Probability level for statistical significance was set at p□0.05. Differences in means/standard deviation (Sd), defined effect size Cohen's *d,* was calculated for groups between pre- and post-tests. Thresholds for small, medium, and large effects were 0.20, 0.50, and 0.80, respectively [21].

Results

Results for the jumps and isokinetic knee strength parameters for EG and CG are presented in Table 1 and 2. No significant differences in pre-test results for all parameters could be found between groups.

As shown in Table 1, there are no statistically significant pre- and post-test differences in SJ and CMJ.

Table 2 described that there were no statistically significant differences between pre- and post-test at all angular velocities of EG ($p>0.05$). However, at $60^{o}s^{-1}$, statistically significant differences were founded between D leg pre- and post-tests of CG in EPT, FPT, and EFR (d= 0.86, 1.42, and 0.85; $p<0.01$, <0.05, and <0.05, respectively), ND leg EPT and FPT (d= 1.61 and 1.88; $p<0.01$). CG had statistically significant pre- and post-test differences at $180^{o}s^{-1}$ for D leg EPT and FTP (d= 1.65 and 2.22, $p<0.01$, respectively), ND leg EPT and FTP (d= 1.92, and 195; $p<0.01$). CG also had statistically significant pre- and post-test differences at $300^{o}s^{-1}$ for D leg EPT, FTP and EFR (d= 1.32, 2.12, and 0.67; $p<0.01$, respectively), ND leg EPT and FPT (d= 1.62 and 1,85; $p<0.01$).

Table 1. Pre- and post-test results for SJ and CMJ for EG (n=10) and CG (n=13). Data are reported as mean±SD.

Jump	Group	Pre-test	Post-test	d
SJ (cm)	EG	31.9±2.9	31.8±2.7	0.04
	CG	36.3±6.1	37.3±6.1	0.16
CMJ (cm)	**EG**	34.8±2.7	35.2±2.6	0.15
	CG	39.1±6.4	39.9±6.5	0.12

Table 2. Pre- and post-test results for isokinetic knee strength parameters at different angular velocities for EG (n=10) and CG (n=13). Data are reported as mean±SD.

Angular velocity	Leg	Knee Parameters	Group	Pre-test	Post-test	d
60°.s-1	D	EPT (Nm)	EG	207±43	224±73	0.28
			CG	213±44	263±69**	0.86
		FPT (Nm)	EG	148±32	164±54	0.36
			CG	141±24	197±50*	1.42
		EFR	EG	0.73±0.14	0.74±0.10	0.08
			CG	0.67±0.09	0.76±0.12*	0.85
	ND	EPT (Nm)	EG	198±41	199±60	0.02
			CG	191±40	275±62**	1.61
		FPT (Nm)	EG	138±29	137±36	0.03
			CG	132±18	199±47**	1.88
		EFR	EG	0.71±0.10	0.70±0.12	0.09
			CG	0.72±0.15	0.73±0.09	0.08
180°.s-1	D	EPT (Nm)	EG	134±25	145±43	0.31
			CG	140±25	195±40**	1.65
		FPT (Nm)	EG	112±22	121±25	0.38
			CG	108±17	165±32**	2.22
		EFR	EG	0.85±0.15	0.87±0.14	0.14
			CG	0.78±0.14	0.86±0.12	0.61
	ND	EPT (Nm)	EG	135±32	147±45	0.30
			CG	128±25	192±40**	1.92
		FPT (Nm)	EG	109±23	117±27	0.32
			CG	106±11	158±36**	1.95
		EFR	EG	0.82±0.11	0.80±0.13	0.17
			CG	0.85±0.16	0.83±0.12	0.14
300°.s-1	D	EPT (Nm)	EG	102±20	105±28	0.12
			CG	108±23	145±32**	1.32
		FPT (Nm)	EG	90±14	91±20	0.06
			CG	86±13	131±27**	2.12
		EFR	EG	0.89±0.12	0.88±0.10	0.09
			CG	0.81±0.14	0.91±0.16**	0.67
	ND	EPT (Nm)	EG	101±20	108±36	0.24
			CG	98±16	138±31**	1.62
		FPT (Nm)	EG	85±12	92±20	0.42
			CG	86±15	123±24**	1.85
		EFR	EG	0.84±0.90	0.89±0.12	0.47
			CG	0.90±0.20	0.91±0.12	0.06

Notes: *p<0.05; **p<0.01; D: Dominant; ND: Non-dominant; EPT: Extension Peak Torque; FPT: Flexion Peak Torque; EFR: Extension/Flexion Ratio.

Discussion

In this study, no statistically significant pre- and post training differences in SJ and CMJ for both groups were found. However, the increase trends of SJ and CMJ in CG group and also CMJ in EG were observed. In terms of CMJ-SJ_{dif}, the increase trend in the EG and decrease trend in the CG were observed. Gregory and Bickel [22] explained that motor unit excitation in low strength levels provided fast motor unit activation with new stresses by EMS. Malatesta et al. [23] found that jumping in volleyball players were improved after 4 weeks by a weekly 36min short-term training. Maffiuletti et al. [2], Brocherie et al. [3], Malatesta et al. [23], Maffiuletti, et al. [24] indicated that EMS training could improve the jumping performance. They also indicated that 40-50Hz frequencies could provide jumping acquisition. Deley et al. [25] reported that EMS to quadriceps muscles were combined with jumping and sprint provides a better force development. In this study, EMS in addition to the regular training had no statistically significant pre- and post-training differences in SJ, CMJ. However, when examining the averages, the increase trend was observed in CMJ (34.8±2.7cm vs. 35.2±2.6cm). Although Malatesta et al. [23] found an increase in SJ and CMJ after 4-week

EMS training, they didn't find any increases after 10-days of EMS training. Jubeau et al. [26] explained their result appeared after EMS as the early (increasing muscle activation and EMG activity) and late adaptation (an increase in the amplitude of the spinal reflex and decrease in co-activation) of the nervous system. Maletesta et al. [23] indicated that EMS caused the increase in neural drive or preferable activation of rapid muscle fibers. They explained that it also improved explosive movements by taking the control of the neuromuscular properties optimum situation in the complex dynamic movements. Gulick et al. [27]'s study supported Maletesta et al [23]'s study that the vertical jumping showed an increase with the jumping training performed together with EMS application for 6 weeks.

The order of motor unit excitation in the voluntary muscle contraction is based on the stimuli intensity. The progresses are to a large motor unit from a small motor unit. In addition, sub-maximal voluntary muscle contraction only excites small muscle units. As independent of the current intensity with EMS, the large motor units are excited before the small motor units. This situation depends on the mass of the dendrites and their morphological organization in the area exposed to stimulation [28]. According to Knaflitz et al. [29], EMS has a tendency to reverse the motor unit excitation during voluntary contraction. He stated that also EMS prefers to stimulate the fast twitch fibers in the large area of the fiber. Paillard et al. [13] indicated that EMS application provides better synchronization during muscle movement of the fast twitch fibers. They showed that the muscle power is improved and when the EMS application is combined with the sport-specific training involving the voluntary muscle movements. Besides, it develops specific neuromuscular adaptations that can be transferred to the complex movement such as vertical jump. In this study, it was found that EMS application had no statistically significant effect on SJ. In terms of CMJ, while there was no a significant difference, the increase trend was observed after EMS application. Deley et al. [25] indicated that a 6-week EMS in addition to gymnastic training resulted in significant increases in SJ and CMJ (respectively, 20.9±8.3%, 20.4±6.2%, $p<0.05$). Maffiuletti et al. [6] reported that an increase was detected in 2-3 weeks after the end of EMS application in CMJ. They also stated that this increase could be maintained by the other training techniques such as plyometric training. The explained reason was the lack of anaerobic power development in the first month of EMS application. According to Gregory and Bickel [22] motor unit excitation by EMS was slightly different from normal muscle activation (not selective, sizes were fixed, and gave temporarily synchronization, relatively provided fast motor unit activity in low strength levels). Maffiuletti et al. [24] stated that EMS training in a short-term period in well-trained athletes brings about a new form of stress. He explained that this stress involves the adaptive changes such as increased muscle activation to the central nervous system.

In the study of Billot et al. [30], 3-5 weeks of EMS training did not statistically increase SJ and CMJ. Malatesta et al. [23] and Herrero et al. [31] indicated that a 4-week EMS training did not increase in SJ and CMJ. In addition to this, Brocherie et al. [3] found that a 3-week of EMS training statistically significant decreased jumping in hockey players. Maffiuletti et al. [2] stated that the short-term EMS application caused to tiredness and excessive training. It also required a recovery period to allow an increase in jump performance after the EMS application.

There were several studies that were shown long-term applications of EMS were changed the jump performance [2, 22-25, 30, 31]. However, there were no statistically significant differences in the jumping performances in these studies. These reasons that were not possible to a certain conclusion about the optimal EMS to be applied to increase the jumping performance.

No statistically significant pre- and post-training differences were found in isokinetic knee extensor and flexor strength parameters at 3 angular velocities in EG. There were statistically significant pre- and post-training differences in the parameters of D and ND leg isokinetic knee extensor and flexor strength at 3 angular velocities in CG. The results of the current study supported the studies of Halback and Straus [32], and Bax et al. [33]. Also Paillard et al. [13] didn't found significant difference between a combined training (stair climbing and local EMS application) and local EMS training in isokinetic quadriceps strength. In addition to this, Locicero [34] indicated that the knee isokinetic strength changed related to EMS was not more than that of occurred in the conventional strength training. Unlike this study, Deley et al. [25] stated that 6 weeks of EMS application in addition to gymnastic training significantly increased isokinetic knee extensor torque values (at 60 and 240^{o}.s^{-1}) (respectively 35.3±11.8%, 50.6±7.7%; $p<0.05$). In Kemmler et al. [35]'s study, the whole body EMS training caused an increase in the strength of the leg extensors. Nobbs and Rhodes [36] expressed that muscle contractions with EMS were associated with strength production capacity in the voluntary isometric contractions. Cauraugh and Kim [37] found that EMS with 50Hz provided more than 30% increase of isokinetic strength at 200^{o}.s^{-1} for the fast twitch fibers. They indicated that the strength increases in fast twitch fibers came from the increase in the motor unit excitation frequencies by high intensity workouts. The reason is that EMS activated efferent of motor units. They also speculated that EMS training could excite the fast twitch fibers thanks to an increase in their myelination.

Conclusion

In conclusion, EMS and regular training in-season had no effect on the isokinetic strength parameters. On the other hand, the regular training in-season increased isokinetic strength. The intervention in regular training might be a detrimental effect on the outcome of the football players' concurrent training. CG showed improvements on many of the isokinetic strength test results, which were not apparent in the EG. In the future studies, the physiological responses of the players especially the measurement of internal traffic structure about post activation potentiating for explosive activities in competitive sports in accordance by Gołas et al. [38, 39] to the extended training and the effects of EMS in different amplitude and frequency can be examined.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Analysis on the effects of folk dance training on players' spatial expectation levels

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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 investigate the effects on spatial perception and spatial anticipation levels the effects of control and study groups with 16 week training folk dancing training.

Material: 120 voluntary college students with no folk dancing background, 60 of which is female has participated in the study. The study group had folk dancing training of 16-week whereas control group has not done any training. Brixton Spatial Expectations test was administered to control groups at the first, eighth and sixteenth weeks of the training. Validation of which has previously been done "Prospects Brixton Spatial Test" has been used in the study. A statistical analysis of the data obtained was done with available statistical software (IBM SPSS Statistics 19, SPSS inc., An IBM Co., Somers, NY) and the significance level was taken as 0.05 and 0.01. Similar results were obtained between experimental and control groups in this study.

Results: There were not significant differences between groups in terms of measurement time as well as in gender. As a result: Short-term training of folk dancing seems to have no impact on the level of spatial perception.

Conclusions: To have a significant effect, a long-term folk dance training is required. In addition, level of spatial perception on folk dance training has no significant difference in terms of gender.

Keywords: Turkish folk dances, spatial perception, brixton test, visual-spatial perception, physical activity.

Introduction

Folk dance as a concept is act and music integration supported with anonymous folk music that includes units of sound creating an aesthetic effect and excitement through the rhythmic and balanced figures as being organized in a euphonious way [1]. Turkish folk dances can be an important activity in terms of meeting the need for acting [2]. Within folk dances, there are exercises possible to develop the physical skills such as strength, balance, flexibility, and coordination. Turkish folk dance has a rich variety of figure diversity. Therefore, it can affect the physical characteristics of dancers and their abilities such as perception, interpretation and decision making depending on the speed of acting and the period [3]. One of the important aspects in folk dances includes staging, choreography, and orientation. Orientation in terms of folk dances is shortly defined as directing the dancers on the stage [4]. To achieve this, dancers are obliged to know all imaginary points and lines on the stage at different shapes. By the help of these points and lines, choreograph and easily establish contact with the dancers. Planning of the stage and determination of the orientation points organizes the acts of the dancers. So these provide dancers' reaching to the targets easily [5]. Staging trainings performed in folk dances also requires a mental study at the same time.

During the acting of the folk dances, dancers are obliged to control several factors at the same time. These factors include both physical and mental dimensions. Physically, the dancers are obliged to act the figures used during the dance in a balanced way appropriate to the property of the figure according to a specific order. Performing the figures at the same moment, transition from one dance to another or one figure to another, successful acting of the sections with high difficulty level during the dance depend all upon the physical skills of the dancers. All of the performed acts require a high level physical skill. Furthermore, dancers' acting in harmony with the music is also fairly important. Another dimension in acting of the folk dancers is folk dance's requiring a mental activity. When considered mentally, dancers are within two important activities while they are on stage. The first one is controlling the position on stage while thinking the figures and figure transitions and order of the figures (choreography order). And the second one is making place and direction predictions according to the choreography lines and the distance with the other dancers according to the dance and determining the position required to be on according to the orientation lines on the stage. The brain acts as a kind of synchronizer helping us to direct our moves, and providing the orientation of the body and harmony of the figures with the music. The situations such as jumping, leaping, balance and spatial awareness requires calculations in Sensorimotor system of the brain. [6]. All these reveal that folk dances reveal a mental process related to visual-spatial perception beside the physical activity in acting.

Visual-spatial perception is expressed as a way of perception changing according to the situation individuals are in. Spatial perception has a vital importance in organisms' providing adaptation to the environment and maintaining the presence [7, 8]. Organisms react to the stimulus threating their presence and resources necessary for maintaining the presence perceiving the spatial

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location of both their own position and the spatial location of other living and non-living beings in a specific area [9].

Hypothesis: There are several factors requiring visual-spatial perception in the folk dances. In this sense, it is considered that folk dances can positively affect spatial perception. *Purpose:* The purpose of this study was to investigate the effects on spatial perception and spatial anticipation levels the effects of control and study groups with 16 week training folk dancing training.

Material and Methods

Participants: Totally 120 university students including 60 female and 60 male studying at different departments of Gaziosmanpaşa University were included into this study.

The experimental groups included the students in different departments of Gaziosmanpaşa University. While choosing the students in this group, the students were regarded not to be participated into any folk dance trainings before. Experimental male group included 30 participants with 22.43±3.04 age average, 172.43±4.07 height average, and 68.03±6.05 bodyweight average. And the experimental female group included 30 participants with 21.40±1.28 age average, 164.87±4.45 height average, and 59.23±9.18 bodyweight average.

The control group participants included the students studying at Gaziosmanpaşa University, Vocational Health School. Control male group included 30 participants with 23.20±2.66 age average, 173.47±4.73 height average, and 68.03±6.05 bodyweight average. And the control female group included 30 participants with 21.40±1.28 age average, 164.87±4.45 height average, and 69.40±8.80 bodyweight average.

The research was approved by Gaziosmanpaşa University, Faculty of Medicine Ethical Committee on 12.12.2011. Furthermore, all volunteers who participated into the research were informed with consent form, and necessary permissions were taken from the relevant university.

Research Design: In the research, 16-week folk dance training program was prepared in order to implement to the experimental group. The trainings were worked out for 2-hour periods for 3 days in a week. During the first 8 weeks of the trainings, folk dances of Tokat local area were taught. After the ninth week, orientation and choreography trainings on the stage were performed. Especially during the on-stage trainings, orientation live and stage information were taught. Trainings of the experimental groups were worked out in sports hall of Gaziosmanpaşa University. No trainings were worked out with the control group. The volunteers in this group maintained their normal daily activities. Brixton Spatial Anticipation Test was performed to the volunteers in the experimental and control groups at the first, eighth, and sixteenth week of the trainings, and the results were recorded.

Brixton spatial anticipation test includes 55 pages and is performed manually. There are 10 circles including 5 at the top and 5 at the bottom on the pages. One of the circles on each page has blue color. These colored circles are listed in a specific system. According to this rule, position of the colored circle on each page changes. Tested individual is asked which numbered circle will be the blue colored circle on the other page. According to this, tested participant tries to make correct prediction. Wrong and correct answers are recorded as scores [10, 11].

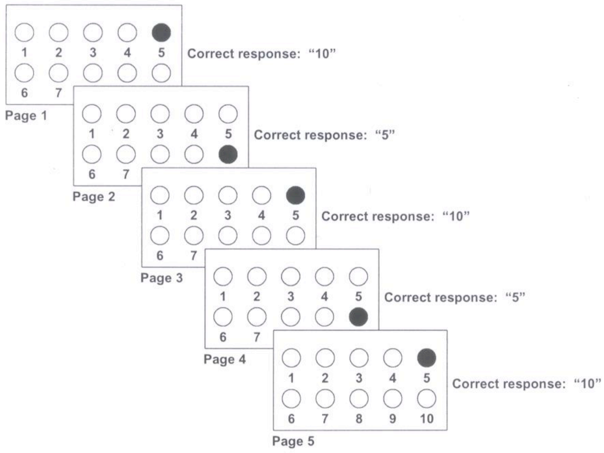

Fig. 1. Brixton Spatial Anticipation Test Order [12].

Statistical Analysis. For the comparison between the gender groups, significance test for the difference between the two averages was used. In situations when the number of the independent group was three and more, one-way variance analysis was used to compare the groups in terms of just one variable. After the significantly determined variance analysis, Tamhane's T2 test developed for the situations without homogenous distribution of the variances was used for the comparison. When there are repetitions on individuals, significance test between the two pairs was used. When calculated lower than 0.05, it was accepted as statistically significant. The calculations were made using the ready statistical software (IBM SPSS Statistics 19, SPSS inc., an IBM Co., Somers, NY)

Results

In the comparison made between the first measurements of the female groups, no significant difference was found between the experimental female group and control female group. And in the comparison made between the first measurements of the male groups, no significant difference was also found between the experimental male group and control male group. No significant difference was found between the experimental female group and control female group in the comparison made between the second measurements of the female groups. Significant difference was not also found between the experimental male group and control male group in the comparison made between the second measurements of the male groups. Significant difference was found between the experimental female group and control female group in the comparison made between the third measurements

Table 1. Intergroup Comparison of the Female and Male Groups in Terms of the First, Second and Third Measurement Variables

1st Measurement			
Female Groups	**X±SD**	**t**	**p**
Experimental Female	21.67±6.10	1.080	0.284
Control Female	23.40±6.32		
Male Groups			
Experimental Male	26.07±6.93	1.472	0.159
Control Male	23.83±5.04		
2nd Measurement			
Female Groups	**X±SD**	**t**	**p**
Experimental Female	19.00±6.63	1.958	0.055
Control Female	22.00±5.14		
Male Groups			
Experimental Male	22.97±6.15	0.568	0.572
Control Male	22.20±4.10		
3rd Measurement			
Female Groups	**X±SS**	**t**	**p**
Experimental Female	16.43±6.66	2.599	**0.012***
Control Female	20.30±4.70		
Male Groups			
Experimental Male	18.40±4.30	0.854	0.397
Control Male	19.23±3.18		

*: Significance Test was used for the difference between two averages. The level of significance was accepted as 0.05.

Table 2. Comparison of Experimental Female and Male Groups in Terms of Measurement Time

Female Groups	**n**	**X±SD**	**t**	**P**
First measurement	30	21.67±6.10	3.508	**<0.001***
Second measurement	30	19.00±6.63		
First measurement	30	21.67±6.10	6.295	<0.001*
Third measurement	30	16.43±6.66		
Second measurement	30	19.00±6.63	4.074	**<0.001***
Third measurement	30	16.43±6.66		
Male Groups				
First measurement	30	26.06±6.93	4.206	**<0.001***
Second measurement	30	22.96±6.15		
First measurement	30	26.06±6.93	6.737	**<0.001***
Third measurement	30	18.40±4.29		
Second measurement	30	22.96±6.15	4.758	<0.001*
Third measurement	30	18.40±4.29		

*: Significance test for the difference between the two pairs was used. The level of significance was accepted as 0.05.

of the female groups ($p<0.05$). In the comparison made between the second measurements of the male groups, no significant difference was found between the experimental male group and control male group.

As result of the comparisons made between the measurements of the experimental female groups, significant differences were determined between the first measurement and the second measurement, between the second measurement and the third measurement, and between the first measurement and third measurement ($p<0.05$). And as result of the comparisons made between the measurements of the experimental male groups, significant differences were specified between the first measurement and the second measurement, between the second measurement and the third measurement, and between the first measurement and third measurement ($p<0.05$).

At the end of the comparisons made between the measurements of the control female groups, significant difference was determined between the first measurement and the second measurement ($p<0.05$). Significant differences were also found between the second

Table 3. Comparison of Control Female and Male Groups in Terms of Measurement Time

Female Groups	**n**	**X±SD**	**t**	**P**
First measurement	30	23.40±6.32	2.132	**0.042***
Second measurement	30	22.00±5.13		
First measurement	30	23.40±6.32	3.932	<0.001*
Third measurement	30	20.30±4.69		
Second measurement	30	22.00±5.13	4.378	**<0.001***
Third measurement	30	20.30±4.69		
Male Groups				
First measurement	30	23.83±5.03	4.242	<0.001*
Second measurement	30	22.20±4.09		
First measurement	30	23.83±5.03	9.472	**<0.001***
Third measurement	30	19.23±3.18		
Second measurement	30	22.20±4.09	8.383	<0.001*
Third measurement	30	19.23±3.18		

*: Significance test for the difference between the two pairs was used. The level of significance was accepted as 0.05.

Table 4. Comparison of Number of Errors According to the Measurements of the Groups in Terms of Gender

Groups	**Gender**	**n**	**X±SD**	**t**	**P**
First measurement	Female	90	19.30±6.98	0.606	0.545
	Male	90	20.01±8.67		
Second measurement	Female	90	17.48±6.66	0.848	0.397
	Male	90	18.37±7.38		
Third measurement	Female	90	15.54±6.41	0.112	0.911
	Male	90	15.64±5.50		

*: Significance test for the difference between the two pairs was used. The level of significance was accepted as 0.05.

measurement and the third measurement, and the first measurement and third measurement ($p<0.05$). As result of the comparisons made between the measurements of the control male groups, significant differences were proved between the first measurement and the second measurement, second measurement and the third measurement, and first measurement and the third measurement ($p<0,05$).

In comparison of the groups' error averages, no significant difference was determined between the female groups and male groups according to the first, second and third measurements in terms of gender.

Discussion

When folk dances are considered in terms of their acting properties apart from their social and cultural properties, these can be noticed to have a very rich acting structure. It is certain that folk dance trainings performed regularly and systematically have effects at different dimensions on the organism [13]. The reason for these effects is the training programs worked out heavily before the staging performance of the folk dances. Because there are limited number of studies carried out upon how folk dance trainings can affect the dancers physically, physiologically, and mentally, it is hard to obtain concrete data.

In literature review, it was determined that there were no studies at national or international levels related to "spatial perception and spatial anticipation in folk dancers." The mental dimension of folk dances is an important topic to be investigated. In reference to this point, this study was carried out in order to make a clarification for the literature primarily. In this sense, our research was completely original, and will make significant contributions for the subsequent studies on the same topic. Furthermore, because there were limited number of scientific studies related to this topic, the comparisons were made with the researches carried out upon the same quality but in different sports branches.

According to the data obtained from the research, it was noticed when general total error averages of the groups was considered that experimental and control group error averages in all three measurements and error averages of the female and male groups were in parallel with each other.

When the comparison results made between measurement period intervals of the female and male groups (experimental and control groups) were analyzed, differences were determined between the first measurement and second measurement, second measurement and the third measurement, and the first measurement and the third measurement. Paired comparison results between the first, second and third measurements of the experimental and control groups were not parallel to our expectations. In order to say that 16-week training period had effect upon the experimental groups, it was necessary to have a change in the control groups. Obtaining similar results in both of the control and experimental groups revealed the view that long-term folk dance trainings did not affect spatial anticipation level in dancers. And this was considered to be arisen from awareness levels' being affected due to the short interval between the measurements. Namely, it was regarded that the volunteers high possibly remembered the measurement order of the previous test between the measurements. In order for the awareness level not to have an effect, the period between the measurements was considered to be kept longer.

In a research carried out by Memmert et al., the relationship between visual attention and expertness of 40 (20 Female 20 Male) senior handball players with 24 age average and 10 sports age and 40 (20 Female 20 Male) junior handball players with 25 age average and 2 sports age was compared. In the research, it was concluded that visual attention of the senior handball players was better rather than the visual attention of the junior players [14].

In a study carried out by Jansen and Lehmann, spatial cognition level of the football players was investigated. Into the study, totally 40 volunteer university students including 20 football players and 20 sedentary with 24 age average participated. Mental rotation test was performed to the volunteers through computer software. It was found in obtained findings that football players had better spatial cognition levels rather than the ones who did not play football. In the same study, mental rotation levels of totally 40 gymnasts including 20 female and 20 male with 23 age average were investigated, and it was concluded that the gymnasts had better mental rotation levels rather than the non-gymnast ones [15].

In a research carried out by Özel et al., the relationship between sporting and spatial perception of Physical Education and Sports department students was investigated. It was found in the study that mental rotation properties of the sportsmen were better rather than the others. Moreover, mental rotation levels of the sportsmen playing in open skill-based sports branches such as basketball, football, badminton, wrestling, judo and table tennis were determined to be better than the mental rotation levels of the sportsmen playing in closed skill-based sports branches such as cycling, swimming, archery, and javelin throw. And general mental rotation properties were observed to be increased after long-term sportive activities [16].

In their research, Somon and Hassam investigated the effect of mental image training upon the skills and performances of football players at different levels. In the study, the image use scale developed by Hall, Rodgers and Barr was used. It was found in the research that there was an increase at motivation and performances of the 362 football players trained with mental imaging. Furthermore, it was revealed that image use levels of the elite football players were better rather than the image use levels of the non-elite football players [17]. According to the data obtained in these studies, mental imaging and mental rotation properties of the expert sportsmen were noticed to be better rather than the individuals not doing sports. Folk dance trainings worked out for a short period were considered as not being efficient upon the spatial perception levels of the dancers.

In the studies investigating the relationship between the spatial ability and gender, various and conflicting results were obtained. Whereas performance of the males was determined to be higher in some studies, no difference between the genders was concluded in the others. Different evaluations were made related to these obtained conflicting results [18].

Whereas Okagaki and Frensch found difference in favor of males in complex mental rotation tasks, no gender difference was found in mental rotation measurement performed with the shapes used in Tetris game at a simple level. Similarly, no gender difference was determined in computerized spatial imaging tasks [19].

Kaufman investigated whether the gender difference in mental rotation and spatial imaging abilities was valid for the running memory or not. In the research, difference according to the gender was obtained in terms of spatial imaging and mental rotation abilities [20].

Nemeth and Hoffman investigated success and gender relationship in terms of the Engineering faculty students using Mental Cutting Test (MCT). A significant difference was obtained in favor of the male students in the study [21].

In their research, Subrahmanyan and Greenfield analyzed the effect of gender upon the spatial abilities of the group including 28 male and 33 female. Performance of the males was found to be higher rather than the females in the beginning, and at the end of the study, males were determined to be more successful [22].

In their research, Hromatko and Butkovic performed spatial relationships and mental rotation test to 201 university students with 28 age average. In the study, a difference was determined in terms of the gender, and spatial abilities of the male students were higher rather than the spatial abilities of the female students [23].

In the research, Yıldız performed "Spatial Visualization Test" and "Mental Rotation Test" to the group including 56 females and 52 males. According to the obtained data, no significant difference was found in terms of the gender according to "Spatial Visualization Test" and "Mental Rotation Test" performances [18].

In their research, Linn and Petersen investigated the categorization of spatial abilities in terms of the gender differences. According to the research results, they found that there was no difference between the genders in the same age categories [24]. These researches supported the data we obtained in our study.

In the studies carried out upon the spatial abilities, it could be noticed that there were various and conflicting results related to the gender difference, and these results were associated with the various reasons. Using different age groups and different measurement tools could be efficient upon obtaining these different results. In this study, when the comparisons between the three measurements in terms of general group and gender factor were investigated, no difference was specified between the change at time levels and genders. Having no difference between the genders in terms of time levels was a parallel result to ours.

Conclusion

The results of this study proved that mental dimensions of the 16-week folk dance trainings were noticed to have no effect on spatial anticipation levels of the folk dancers. It was considered that long-term folk dance trainings should be worked out in order to have an effect. Furthermore, folk dance trainings affected spatial perception and spatial anticipation at the same level in terms of gender; namely, there was no difference in terms of female and male folk dancers.

Conflict of interest.

The authors state that there is no conflict of interest.

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PHYSICAL EDUCATION OF STUDENTS

Physical performance characteristics of university male tennis players in division I and II

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

Abstract

Purpose: The purposes of this study were to examine the physical performance characteristics of Division-I (D-I) and Division-II (D-II) university male tennis players and to evaluate whether these characteristics could be determinative on the divisional differentiation.

Material: Twenty athletes who compete in D=I (n=10) and D-II (n=10) of Turkey university tennis league (n=10) and also ranked in top-ten in their division voluntarily participated in this study.

Results: Measurement of agility, upper and lower body explosive powers, fatigue index, aerobic and anaerobic powers was conducted on two non-consecutive days. Significant differences were observed in physical performance characteristics powers between the groups (p<0.05). D-I players had significantly greater anaerobic power, agility, vertical jump height, upper and lower body explosive powers, and lower fatigue index level than D-II players. However, aerobic power did not differ between groups.

Conclusions: It may be possible that these results allow us to suggest that physical performance characteristics should be regarded as one of the important discriminative factors in determining the competitive level of university male tennis players.

Keywords: tennis, aerobic power, anaerobic power, agility.

Introduction

Tennis is characterized as a racket sport with an intermittent movement profiles involving short rallies in which each rally that lasts 4-12 seconds with 20- 90 seconds rest intervals sprinkled with brief breaks. These movements are repeated dozens of times by the athletes at a short high intensity to almost every direction [1], and sustainability of those movements in 1-5 hours' tennis matches require well-developed physical performance characteristics [2]. Physical performance characteristics such as change of direction speeds, upper and lower body explosive powers, muscular strength, endurance, aerobic and anaerobic powers are considered as important variables contributing to the performance of the tennis competition. Although success in modern sports depends on various factors such as psychological readiness, technical and tactical ability, physical performance characteristics should be taken into consideration as the cornerstone of technical and tactical performance in tennis. [3]. For example, the upper and lower body explosive powers are important components for an effective execution for ball acceleration during service or technical strokes [4]. However, aerobic and anaerobic powers are regarded significant indicators that players are able to resist to fatigue during 1-5 hour game actions [5].

A few studies comparing divisional or age-related differences in tennis have highlighted to demonstrate the importance of the relationship between physical performance characteristics and player levels. Gelen et al. [6] reported that physical fitness profile such as strength, speed, jump and anaerobic power of adult male tennis athletes depicted divisional differences. Kuroda et al. [7] concluded in their study that agility for juniors and endurance for seniors were the discriminative physical performance variables to determine the competitive levels among tennis players. Similarly, Roetert et al. [8] indicated that agility is the only predictor to differentiate competitive levels in younger tennis players. In a recent study, Ulbricht et al. [4] found that national selected tennis players had better physical performance characteristics than their regional counterparts.

The researchers studying on the identification of the physical fitness profiles of athletes reported that it was generally necessary to determine both the basic and specific physical performance characteristics of athletes for the sake of selection of players for a particular sport or discipline and organization of training process [9]. As far as we know, up to this date, no study has been conducted on the university male tennis players' fitness profiles. Therefore, in this study, it was aimed to make a comparison of physical performance characteristics of the male tennis players who were competing in Division I and II of Turkey university league. In addition, it was to evaluate whether physical performance characteristics were determinative on the divisional differentiation.

Material and Method

Participants.

Twenty single male players who were depicted descriptive demographic characteristics in table 1 and ranked on the first top ten (the ranking of players was based on the points in tournaments of their divisions) in Division I (D-I, n=10) and division II (D-II, n=10) of Turkey university tennis league, participated voluntarily in this study. In prior to the tests, experimental procedures

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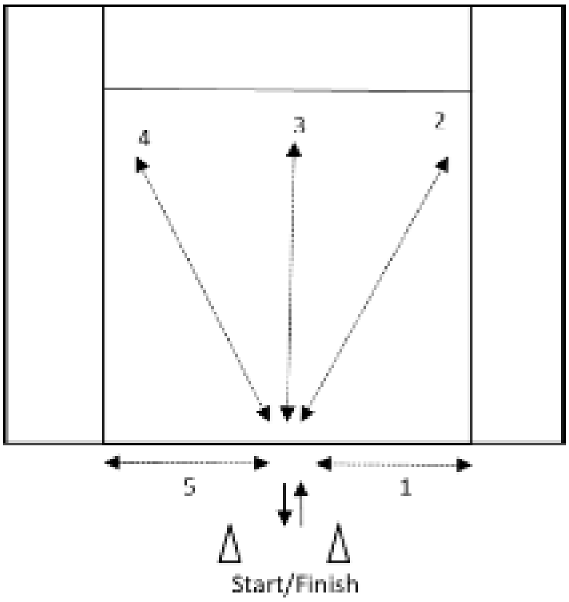
Table 1. Demographic Characteristic of University Tennis Players

Divisions	Age (Years) Mean±sd	Sports Experiences (Years) Mean±sd	Body Height (cm) Mean±sd	Body Mass (kg) Mean±sd
D-I	22.±2.1	8.3±0.9	176.6±3.6	74.2±2.6
D-II	22.3±1.4	7.9±1.1	175.1±3.2	74.5±1.5



Sprint numbers 1 and 5 represent a distance of 4.11 m whilst numbers 2, 3 and 4 each measure 5.49 m.

Fig. 1. Spider Agility Test

and risks and possible discomforts related to this study were explained to the players. Informed written consent was obtained from each player to participate in this study which was approved by the university ethical committee for human research.

Participants were requested whether they had prior experience with the tests used. Therefore, the testing protocol was explained in detail to the athletes who hadn't been tested previously on several occasions. The tests were carried out over three separate consecutive days that following the end of the competition season for both groups and the athletes were allowed their standard warm up prior to tests. Athletes were asked to participate in the tests by wearing match clothes and to avoid alcohol consumption and excessive physical practices that could affect test performance for 24 hours, and eating and drinking two-hour prior to tests.

Research Design.

Aerobic Power (VO_{2max}) Test: The athletes ran in a straight line to axis upon completing, and proceeded according to the given sound signals. The test was finished when the players stop or fail to reach the end lines concurrent with the audio signals on two consecutive occasions. Estimated VO_{2max} values were calculated using the method of Leger et al. [10].

Anaerobic Power Test: Anaerobic power was determined with the RAST (*Running Anaerobic Sprint Test*) protocol. Players performed six 35-m maximal sprints with a 10 sec interval between each sprint. Each sprint time was measured by two photocell equipment. The power in each sprint was then calculated by the formula that was determined by Zagatto et al. [11].

Vertical Jump and Explosive Power Test: The vertical jump heights of the athletes were tested by using the Vertec tool. Three repetitions with 60- second rest interval were carried out, and the best data were formulated to determine explosive power values as watts [12].

Overhead Medicine Ball Throw: The players stood in a standing position with feet parallel to each other slightly apart, and the players hold a 3-kg medical ball with both hands and bring it to the back of the head, and then they threw it as forward as possible in facing direction. The farthest distance that the player threw the ball was measured and the best performance of two efforts was recorded.

Spider Agility Test: A rectangle (30 by 46 cm) was marked off behind the centre baseline. Five tennis balls were positioned on the court one on each numbered corner. The player started with one foot in the rectangle after starting from the timing gate. The player was requested to complete all sprints as outlined figure 1, retrieving each ball and to place each one in the rectangle one at a time, moving in a counter clockwise direction [13]. The best performance of the two non-consecutive trials (3 min rest) was recorded.

Statistical Analysis.

After calculation of the means and standard deviations (SD) of all variables, data analyses were performed using an independent t-test to determine whether there were significant differences between tested values of division I and II's players. The level of significance was set at p<0.05.

Results

Basic statistical characteristics of division I [D-I] and division II[D-II] groups are shown in table 2. No significant differences were found in maximal aerobic and anaerobic power between D-I and D-II. However, D-I player had more developed agility, vertical jump height, upper and lower body explosive power, fatigue index, mean and minimal anaerobic power than D-II (p<0.05).

Figure 2 shows the percentage of differences between division I and II. The highest significant difference (17%) as observed in the fatigue index. The percentage of differences in the agility (5.62%), vertical jump height (5.38%), lower body explosive power (5.74%), the distance of medicine ball throws (6.74%), mean (9%) and minimal anaerobic (12.7%) power was also significant. However, although the percentages of differences in maximal aerobic and anaerobic power were 3.5 and 4.2% respectively, these values were not statistically significant.

Discussion

To our knowledge, this is the first study that has examined the physical performance characteristics of Turkish university male tennis players in the different divisions. The main findings of this study were that division I male tennis players achieved statistically better scores than the division II in agility, upper and lower explosive power, fatigue index and mean and minimum anaerobic power (p<0.05). However, no significant differences were observed in maximal anaerobic and aerobic power.

Tennis is a sport that characterizes with brief rest periods following high or maximal intensity efforts. The intense efforts that requires to use a-lactic anaerobic energy sources (ATP-PCr) are related to the anaerobic power [1]. In this study, the RAST test that is formed as six repeated 35-meter sprint with 15 seconds recovery between sprints was used to determine the anaerobic power. Maximal anaerobic power was calculated by formulating the best 35-meter sprint and body weight of the athletes [11]. There was no significant difference between the best sprint times and body mass of the athletes in division I and II. So, the difference in maximal anaerobic power (4.2%) was not statistically significant. In contrast, the greatest significant difference between divisions I and II were observed in mean (9%) and minimal (12%) anaerobic power, and fatigue (17%) index

Table 2. Physical Performance Characteristics of Players in Division I and II

Variables	Divisions	Mean	SD.	Difference	T	P
Agility [sec]	*D-I*	15.83	.84	-.55	3205	**<0.05**
	D-II	16.72	.91			
Vertical Jump Height [cm]	*D-I*	46.6	2.4	2.38	2494	**<0.05**
	D-II	44.2	1.8			
Lower Body Explosive Power [watt]	*D-I*	1971.54	156	107	2557	**<0.05**
	D-II	1864.03	97			
Medicine Ball Throw [m]	*D-I*	12.36	.65	.78	2306	**<0.05**
	D-II	11.57	.86			
Mean Anaerobic Power [watt]	*D-I*	527.35	38	43.5	2573	**<0.05**
	D-II	483.76	37			
Maximal Anaerobic Power [watt]	*D-I*	619.89	43	25	1222	>0.05
	D-II	594.83	48			
Minimal Anaerobic Power [watt]	D-I	527.35	38	62	4007	**<0.05**
	D-II	483.76	37			
Fatigue Index [watt/t]	D-I	5.51	.81	-.94	2430	**<0.05**
	D-II	6.45	.92			
VO_{2max} [ml/kg/min]	*D-I*	51.39	2.4	1.74	1750	>0.05
	D-II	49.64	1.9			

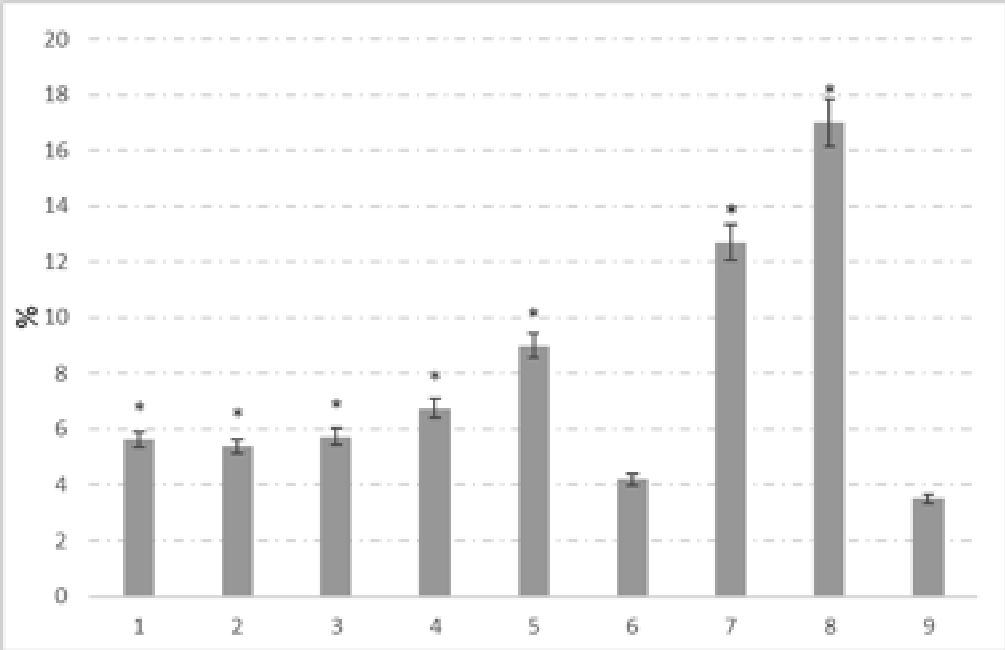


Fig. 2. Percentage of differences between D-I and D-II: 1 – agility; 2 - vertical jump height; 3 - lower body explosive power; 4 - medicine ball throws; 5 – mean anaerobic power; 6 – maximal anaerobic power; 7 - minimal anaerobic power; 8 – fatigue index; 9 – anaerobic power; * - statistically significant ($p<0.05$).

($p<0.05$). The reduction in high intense sprint activities towards the end of the game could be a result of fatigue [14]. It has been speculated that this type of fatigue may be in relation to a decrease in muscles' glycogen levels or phosphagen stores, or decreases of muscle buffer capacity [15]. Bishop et al. [16] reported that the RAST induces a greater depletion of phosphagen stores during the first three sprint intervals. Thus, minimal anaerobic power indicates using lactic anaerobic energy metabolism which has the substantial influence on that physiological variable of fatigue. This could be explained by the inadequacy of fatigue resistance in repeated sprint of D-II players when compared with D-I's. During a tennis match that lasts at least 1.5 hours, the players have to perform sprint activities in different parts of the court within each 4-10 seconds rally [1]. Higher anaerobic power and lower fatigue index could be regarded as an indication that players could perform the ability of repeated sprints that reduced towards the end of a high-intensity period of the game [17]. This result suggests that anaerobic power may be a determining physical component of differentiation between divisions in the university tennis league.

This study showed that agility scores of D-I athletes were higher on average 5.62% than D-II's, and this result also indicated a significant statistical difference between the groups ($p<0.05$). This result was supported by the finding of Kuroda et al. [7] who pointed out significant differences between superior and average junior tennis players' spider agility test scores. A tennis player needs to perform to different regions of the court by moving in different multi-directions so that he or she can able to hit the ball during the match. Thus, agility is regarded as one of the physical characteristics and a determinant factor of these game actions that most influence the level of competition of tennis players [8]. Therefore, this result suggests that agility may be an important indicator of the divergence between divisions of university male tennis players.

The medicine ball throws and vertical jump height formulated with body mass results showed that the D-I group was able to express greater upper (6.74%) and lower body (5.74%) explosive power of shoulder and leg extensor than the D-II group, respectively. The results for the lower body explosive power could be associated with vertical jump heights. Given that vertical jump-height was significantly different between two groups of the tennis players. During the game, a tennis player executes average 2.5-3 strokes per rally, and most strokes are implemented within a distance of 2.5 m or 4.5 m where the player's movement pattern with sprinting speed that depending on player's ability of the lower explosive power as well as the ability of the change of direction speed [4]. So higher body explosive power in D-I tennis players may contribute to greater leg drive in tackles during the ball stroke in order to increase the ball more speed. The upper explosive power is needed when hitting the ball, and there is a strong relationship with the upper explosive power and the serve or the stroke velocity in tennis [18] as well as many factors such as technical, mechanical that affect service or stroke velocity [19]. However, the stroke velocity can not only be related to the ball speed, because it often depends on the combination of several factors such as stroke technique, elasticity or coordination [20]. Nevertheless, it should be taken into account that the higher upper body explosive power will able to contribute to a tennis player gaining more points or won the game.

Related with, Ulbricht et al. [4] reported that there was a positively strong correlation between player's level and upper explosive power.

Although tennis game is based on the movements such as short sprint, striking the ball, change of direction running that requiring anaerobic energy sources, aerobic conditioning is needed to avoid fatigue and aid in recovery between rallies or sets, and it may also help to promote continuous success in tennis game. For this reason, it has been reported that an elite male tennis player for upper-level competition performance should have maximum oxygen use capacity within the range of 44-69 ml/kg/min [5]. In this study, it was found that the estimated VO_{2max} values of the male tennis players were 51.39 and 49.64 ml/kg/min for D-I and D-II, respectively, and this result was seen to be consistent with the literature criteria. This study also showed that there was a difference of 3.5%, which is not significant between the VO_{2max} of the groups. Kovacs [1] argues that there may not be a significant difference between elite and sub-elite tennis players in terms of aerobic capacity because of the specific nature of tennis game which requires more anaerobic energy use. Aerobic capacity differences may not be often seen between divisions of those sports athletes where anaerobic energy use is more intense, but it should be taken into consideration that VO_{2max} values of such racket sports athletes may have significant differences related to the intensity of the training or competition [21]. These results could be explained by the fact that players competing with the sport of anaerobic content would not be able to make any specific training to improve their aerobic variable.

As a result, in this study was observed a significant difference in physical performance characteristics between D-I and D-II university male tennis players, with mean and minimal anaerobic power, fatigue index, agility, vertical jump height, upper and lower body explosive power increasing as the division level increased. However, maximal aerobic and anaerobic power values did not differ between divisions. Thus, it can be concluded that higher mean and minimal anaerobic power, agility, vertical jump height, upper and lower body explosive power, and lower fatigue index were as common discriminator variables to determine the difference between divisions of university male tennis players. Furthermore, the significant differences in physical fitness profiles between D-I and D-II players suggest that well-developed anaerobic power, fatigue resistance, change of direction speed, lower and upper body explosive power, as well as the technical skills, tactical knowledge and psychological readiness may contribute to be higher standard of elite level tennis league players. In contrast, this study did not indicate that aerobic power data was a determining factor of the divisional differences in the levels of D-I and D-II male tennis players. Therefore, further research is needed to identify whether aerobic power is a determining variable for male tennis players' levels according to the divisions.

Conclusions

It is important to have knowledge on the divisional differences of the fitness profile required by a particular sport to form the norm for that sport and to classify and evaluate the players according to the performance level. The physical performance characteristics play an important role in determining players' potential for success in tennis and can be a decisive factor that may make a difference between divisions in a tennis game. Therefore, the determination of the success-related physical performance variables in tennis may be valuable both scientifically and practically.

Conflict of interest

The authors have declared no conflict of interest.

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Circular training as a means for improving physical skills in future security specialists in higher education institutions of Ukraine

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

Abstract

Purpose: The battle training of military students is ineffective when limited to the knowledge of military equipment and ability to use it. The research theoretically and experimentally justifies how circular training can improve physical skills in future security specialists in HEIs of Ukraine.

Material: The experiment involved a group of 7 respondents (aged between 21 and 23) of the Institute of the Department of State Guard of Ukraine. The methods of circular training were used to improve physical skills in future security specialists in HEIs of Ukraine.

Results: The system of CrossFit training improves physical fitness of students and strengthens their motivation towards physical education and sport. Also it familiarizes them with modern approaches to organizing independent physical training. Circular training, in turn, contributes to the kinetic and emotional density of training, making it more diverse and engaging. Moreover, it enhances individual initiative and, therefore, increases motivation towards physical education.

Conclusions: Circular training gives positive results and successfully improves general physical fitness of military students.

Keywords: CrossFit program, physical fitness, physical training, military personnel, WOD Complex.

Introduction

The armed conflicts and geopolitical challenges indicate that the national security of Ukraine is essential to social and political life of this country. The defence of national interests is a prerequisite for the state survival. Thus, the state leaders and the public pay special attention to the combat readiness and defence capabilities. Due to recent events in the near abroad, the reforming of the Armed Forces of Ukraine is accelerating. In this regard, physical training of personnel in the development of a new form of the Armed Forces of Ukraine is a top-priority. It is a comprehensive system aimed at training healthy servicemen able to solve military professional tasks. A special place is given to physical training of future officers in the Institute of the Department of State Guard of Ukraine [1, 2, 3].

In addition, the battle training of military students is ineffective when limited to the knowledge of military equipment and ability to use it [2, 4]. The successful completion of combat mission largely depends on law-enforcement officers and other military formations. The effective use of all military power of military equipment contributes to this process, too [5, 6]. However, there is no experimental data how to improve physical skills of military students [7, 8, 9]. In this regard, the problem of developing a technique for improving the physical qualities of military personnel is relevant. This will optimize the educational process in the context of guard activity. It will also enhance the efficiency of fulfilment of operational and combat tasks of servicemen.

Many believe that one can improve motion qualities through providing a higher quality of pedagogical management [1, 10, 11].

CrossFit training is promoted as both physical exercise philosophy and a competitive fitness sport. They include interval training, weightlifting, plyometrics, powerlifting, gymnastics, calisthenics, strongman, etc. [12, 13, 14]. This training is practiced by the members of over 13,000 affiliated gyms. Interestingly, most of them are located in the United States, as well as people who do daily workouts [15].

It is proved [2, 16, 17] that those methods and tools aimed at improving physical skills can intensify the educational and training process.

The research *aims* to theoretically and experimentally justify how circular training can improve physical skills of future security specialists in HEIs of Ukraine.

Material and methods

Participants.

The experiment involved a group of 7 students from the Institute of the Department of State Guard of Ukraine.

Research Design.

Relevant research methods were used to solve certain problems. They include analysis; pedagogical observation; pedagogical testing; pedagogical experiment; questioning; anthropometry; questionnaire; mathematical statistics. To increase the effectiveness of the training process, a special programme for physical training was designed. It is based on the methodology which incorporates the CrossFit method.

CrossFit has already proven to be rather effective. The number of military units abroad that use it for the training of fighters is steadily increasing. Many believe

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that the CrossFit with its various loads can enhance the effectiveness of such training.

The main advantage of the programme lies in its universality. Trainings are constructed cyclically, so that the type of load constantly changes due to high-intensity functional exercises. The programme combines strength exercises with bars and weights, exercises on the crossbar, jumps, running, etc. CrossFit is aimed at making a person stronger, more endurable, more coordinated and agile. This is provided by a variety of exercises, which makes the programme both interesting and challenging. It is maximally functional and varied, based on the Workout of the day (WOD). The latter is a day's task, which allowed it to be included in the programme of physical training of students. The list of daily exercises combine strength exercises, gymnastics, cardio loads. They can also include their mixed variations and directions in accordance with the physical training programme. We have defined the concept of WOD:

1. Performance of a certain work (without fixed time).
2. Performance of a large amount of work for a fixed time.
3. Performance of a fixed work for a minimum amount of time.

The WOD can include from 2 to 10 exercises and from 3 to 10 circles, namely, the more exercises, the less circles, and vice versa. The approximate WOD content for students covers gymnastics and athletic training:

WOD Complex (8 consecutive exercises in 4 rounds):

1. Pull-ups;
2. Push-ups on cross bars;
3. Shuttle run 10x10m;
4. Lifting legs from the position of hanging on the crossbar;
5. Pushing up;
6. Simultaneous lifting of the body and legs from the position of lying on the back;
7. Step-test;
8. Jump up from place.

Physical training based on CrossFit has more significant advantages than the interval (circular) training. It is an intensive method of specialized training implying a temporary change of workstations. Each station includes exercises (or special movements) for a specific muscle group for a certain period of time. Stations can be power (simulators), gymnastics (apparatus), aerobic (running, swimming, jumping), mixed. The interval training aims to prepare the body for a limited period of time to perform the work of high intensity. It is rather necessary for sports competitions. In addition, this type of training has a strict time limit for the number of circles (attempts, rest). It must be noted that high-intensity training with maximum functionality is especially in demand. Training and practice built on the CrossFit training system can diversify the learning process. They can also enhance the motivation of military personnel towards physical training and extracurricular physical activities.

It is rather essential to optimize professional training of future security specialists in HEIs of Ukraine. This constantly puts forward new and more complex methodological problems [18, 19]. One of them is to improve the quality of managerial teacher activity in the training process. It is related primarily to choosing the optimal control strategy.

To solve this problem, we have developed a methodology for improving physical skills of future security specialists in Ukraine [16]. We have also conducted a pedagogical experiment to identify the effectiveness of the proposed methodology.

The training sessions lasted 2.5 months. The duration of the training session is 80 minutes. Every 15 minutes are spent on the physical training program using the CrossFit method.

The level of physical fitness (PF) was evaluated based on the results of pull-ups, push-ups, shuttle run 10x10m (SR), lifting to the crossbar, pushing up. The parameters of students' functional state were registered based on the heart rate (HR).

The effectiveness of the proposed methodology was determined due to comparing all registered before the beginning of the experiment: 1) before the experiment; 2) after 5 weeks of training; 3) after the experiment.

At the end of the experiment, the control index was reassigned for the students of the Institute of the Department of State Guard of Ukraine.

Statistical Analysis.

Standard statistical methods (Statistica 10.0 [20], Excel 16 programme) were used to process the experimental material.

Results.

The methodological basis of this research is the position and principles of system and complex approaches [19]. From these positions, professional activities of future security specialists depend on a number of interrelated factors. It is characterized by high physical activity and psychological stress. In addition, it requires that the personnel should demonstrate permanent moral, political, military, mental and physical fitness to perform official duties. As a result, physical training of students, future officers and officers is fundamental for successful professional activities.

The analysis of the final control indexes during shows that there is a statistically significant change in the functional indexes of the servicemen (table 1).

A statistically significant reduction of HR at rest at the end of the experiment indicates bradycardia and the economy of the heart functioning and its hypertrophy.

The graphical representation of HR during the experiment reflects the positive nature of adaptive changes in the heart functioning. Indeed, HR is linearly and reliably reduced from the beginning to the end of the experiment.

Correlation analysis shows that the values of HR at rest are statistically interrelated with its importance in muscle activity (table 2).

The analysis of reliable interrelations shows that the increase in HR at rest accelerates the cardiac reactivity to physical activity. During warming-up and physical

Table 1. The main indexes characterizing the functionality of a WOD complex (3 circles) during 15 minutes before, during and at the end of the pedagogical experiment

period	Statistical parameters	Heart rate in different states, bpm-1: before warming-up	After warming-up	after loading: 10 sec.	1 min.	3 min.	Increase of heart rate, %: during the warming-up	during the loadings	during the testing of warming-up
1. Beginning of experiment	X	**75.4**	**156.0**	**189.1**	**152.6**	**120.6**	**107.1**	**151.2**	**21.3**
	±*m*	1.31	1.56	2.15	1.47	1.61	3.15	5.92	1.99
	±σ	3.21	3.83	5.27	3.60	3.95	7.72	14.50	4.88
	n	7	7	7	7	7	7	7	7
2. During experiment	X	**72.9**	**152.0**	**182.9**	**146.0**	**115.3**	**108.9**	**151.4**	**20.6**
	±*m*	1.23	3.59	1.32	1.33	1.22	6.25	4.89	2.70
	±σ	3.02	8.79	3.24	3.27	2.98	15.32	11.97	6.62
	n	7	7	7	7	7	7	7	7
3. At the end of experiment	X	**68.6**	**142.3**	**176.0**	**140.6**	**110.9**	**107.6**	**156.9**	**23.8**
	±*m*	1.13	2.42	1.33	1.31	1.14	3.49	3.75	1.93
	±σ	2.76	5.94	3.27	3.21	2.79	8.55	9.19	4.72
	n	7	7	7	7	7	7	7	7
t_{1-2}		**1.43**	**1.02**	**2.49**	**3.31**	**2.61**	**-0.27**	**-0.02**	**0.21**
p		>0.05	>0.05	<0.05	<0.02	<0.05	>0.05	>0.05	>0.05
t_{1-3}		**3.97**	**4.76**	**5.19**	**6.10**	**4.92**	**-0.12**	**-0.82**	**-0.91**
p		<0.01	<0.01	<0.01	<0.001	<0.01	>0.05	>0.05	>0.05
t_{2-3}		**2.56**	**2.24**	**3.65**	**2.90**	**2.65**	**0.18**	**-0.90**	**-0.98**
p		<0.05	>0.05	<0.01	<0.05	<0.05	>0.05	>0.05	>0.05

Table 2. Interrelations of heart rate in different states before and in the process of muscular activity

Indicators:	Heart rate after warming-up	Heart rate after loading (10 sec.)	Heart rate after loading (1 min. recovery)	Heart rate after loading (3 min. recovery)	Increase of heart rate during warming-up (%)	Increase of heart rate during loading (%)	Increase of heart rate during testing of warming-up (%)
Heart rate before warming-up	0.610*	0.558*	**0.582***	**0.597***	-0.418	**-0.872***	-0.343
Heart rate after warming-up		**0.617***	**0.719***	**0.604***	**0.464***	-0.251	**-0.770***
Heart rate after loading (10 sec.)			**0.940***	**0.908***	0.074	0.112	0.023
Heart rate after loading (1 min.)				**0.887***	0.164	0.038	-0.154
After loading (3 min.)					0.016	-0.005	-0.029
Increase of heart rate during warming-up (%)						**0.556***	**-0.507***
Increase of heart rate during loading							**0.433***

*- statistically reliable interrelations.

loading, they are r=0.610, p<0.05 and r=0.558, p<0.05 respectively. In case of the decrease, its size decreases during the experiment and loading. This reflects the growth of economization in the functioning of the body and the heart. Given the absolute values of the decrease in HR before and during the experiment, it increases during the loading and vice versa (r=-0.872, p<0.0001).

The graphical and mathematical model of this dependence is presented in the following figure (Figure 1).

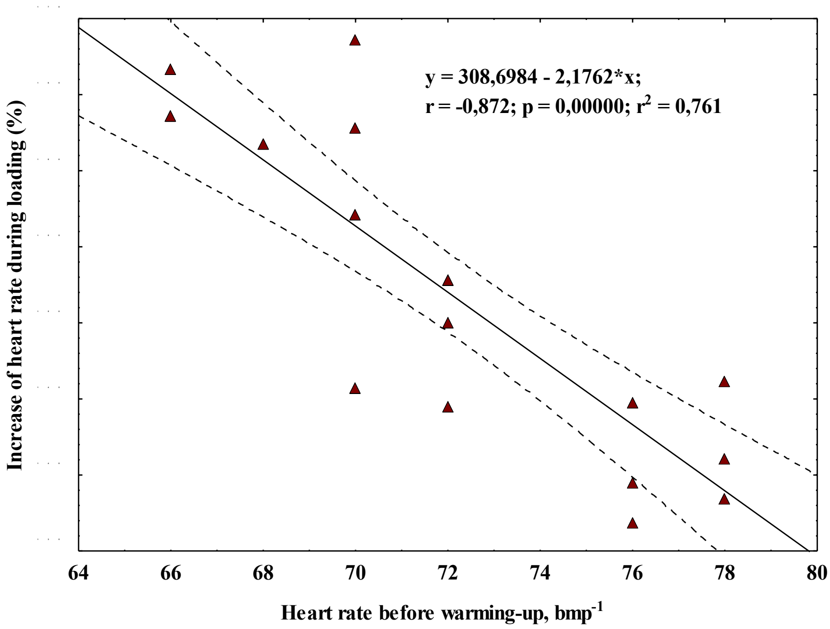

Figure 1. Regression model of dependence of Increase of heart rate during loading (%) from heart rate before warming-up.

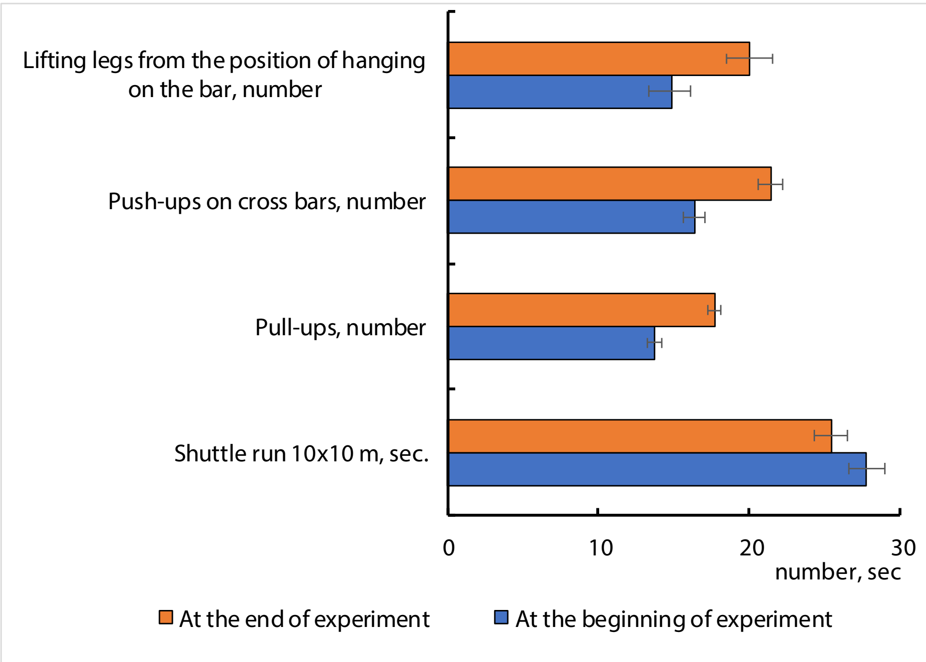

Figure 2. Indexes of physical fitness of the students before and after the pedagogical experiment

The experimental programme was aimed at increasing the level of physical fitness in the students. Therefore, the changes and interrelations between its indicators and the level of functional fitness were also analyzed.

The results of the students' physical fitness before and after the experiment are presented in Figure 2. They indicate the improvement of their physical skills due to the proposed training programme.

The data presented in Figure 2 reflect the most dominated and statistically significant changes during pull-ups (29.2%, $p<0.01$) and push-ups (30.5%, $p<0.05$).

The result in shuttle run has significantly improved (-8.3%, $p<0.01$). It integrally reflects the improvement of movement coordination when transferring an object with maximum speed. It also reflects an improvement in the quality of dexterity.

When lifting legs from the position of hanging on the bar, only a positive trend emerged. It reflects the increased strength endurance during the experiment. The inauthenticity of the obtained results can be explained by a small selection of students and a high variation of the test results. They are as follows: 32.8% and 34.2%, accordingly, before and after the experiment.

The correlation analysis of the interrelations between physical fitness indexes and the level of HR in different states shows some relevant results. Thus, the results of pull-ups and the time of the shuttle run are most strongly interrelated with all the indexes (Table 3).

The value and direction of the correlation coefficients presented in Table.3 indicate some relevant results, too. Indeed, the lower heart rate at rest state, during and after physical loading is, the higher result in pulling up is. The correlation coefficients range from - 0.638 to - 0.885 ($p<0.01$).

Statistically reliable interrelations were detected between the result in shuttle run and values of HR in different states. The higher the pulse values are before, during and after the loading, the longer the execution time of the shuttle run is. It means the worse test result.

The indexes of physical fitness reveal a close interrelation between them. It is not related to the interrelation of the result when lifting legs from the position of hanging on the bar and result in shuttle run.

The most closely connected push-ups on cross bars and lifting legs from the position of hanging on the bar. The high correlation coefficient between them ($r = 0.922$, $p <0.01$) proves these tests to be equivalent. They reflect the level of strength endurance of the students.

The mathematical model of this dependence can be expressed as follows:

$$\mathbf{y = -4.9924 + 1.1845 * x},$$

where: **y** – is lifting legs from the position of hanging on the bar, number; **x** - push-ups on cross bars, number.

Characteristically, the result of push-ups is closely interrelated with heart rate in a rest state, that is, before loading (Figure 3).

The theoretical regression line, location of pull-ups individual values, magnitude and direction of the correlation coefficient ($r = -0.885$, $p<0.00001$) indicate that functional status and level of the students' physical fitness are closely interrelated. Thus, improving their functional state in the dynamic of the pedagogical process determines the growth of speed and strength fitness.

Discussion.

We have managed to establish that the effectiveness of general physical fitness can be enhanced using the CrossFit training system. It includes the simultaneous practice of interval training, aerobic endurance, weightlifting, plyometrics, powerlifting, gymnastics, gaming sports [5, 14]. It is known that the CrossFit Physical Training System is a brand-name fitness technique created by Greg Glassman. Moreover, it is a registered trademark of CrossFit organization, Inc., founded by Greg Glassman and Lauren Jenai in 2000 [5].

The improved results of physical fitness at the end of the experiment and the reduced HR at rest during and after physical loading proves the CrossFit method [5, 21] effectively enhances the functional state and physical fitness.

It is found that the servicemen have a statistically significant difference in functional indexes as a result of the registered control indexes during the experiment.

The HR before warming-up has decreased on average by 10% ($P<0.01$). This indicates the presence of bradycardia and hypertrophy of the heart [22]. After a warming-up, the HR has decreased on average by 10% ($P <0.01$), after loading – by 7% ($P>0.05$), after 1 minute of rest –by 8% ($P< 0.01$), after 3 minutes of rest – by 8%.

The evaluation of the effectiveness of circular training proves an undoubted advantage of circular workouts.

The revealed changes, dependencies and model characteristics reflect the positive specificity of adaptive reorganization in the physical and functional fitness using the CrossFit method for 2.5 months.

The materials of our studies clarify and complement the results of studies of Ukrainian [6, 8, 18] and foreign [12, 13, 21] authors.

The elaborated models are the basis for developing an assessment system of physical fitness, differentiated

Table 3. Interrelations of indexes of physical fitness among themselves and with the level of HR in different states before and during muscular activity

Indicators:	Pull-ups, number	Push-ups on cross bars, number	Lifting legs from the position of hanging on the bar, number	Shuttle run 10x10 m, sec.
Heart rate before warming-up, bpm^{-1}	-0.885**	-0.679**	-0.673*	0.506
Heart rate after warming-up, bpm^{-1}	-0.735**	-0.441	-0.424	0.649*
Heart rate after loading (10 sec.), bpm^{-1}	-0.638**	-0.525	-0.405	0.809**
Heart rate after loading (1 min.), bpm^{-1}	-0.655**	-0.430	-0.347	0.810**
Heart rate after loading (3 min.), bpm^{-1}	-0.658**	-0.560*	-0.484	0.828**
Pull-ups, number		0.751**	0.819**	-0.535*
Push-ups on cross bars, number			0.922**	-0.561*
Lifting legs from the position of hanging on the bar, number				-0.460

Note: * p≤ 0.05; ** p≤ 0.01.

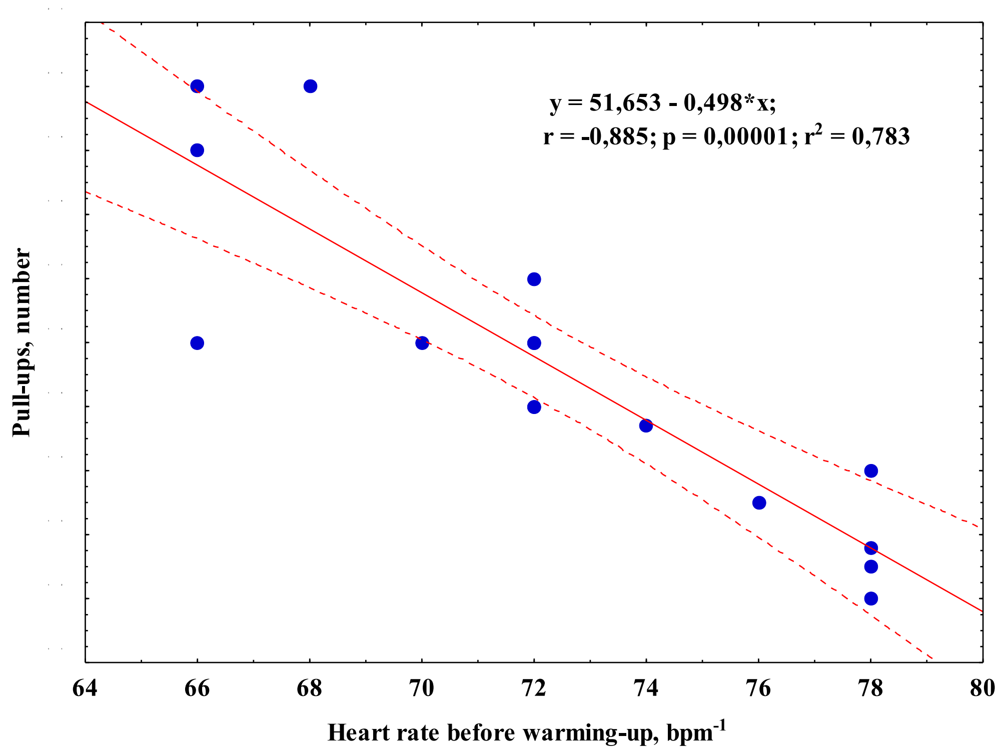

Figure 3. Regression model of dependence of result at pulling up on a crossbeam from heart rate at rest.

according to different criteria (training period, physical state during muscular activity, etc.).

The CrossFit method can optimize the training process in accordance to the main task of the period or stage of training. It can also provide optimal load dynamics, expedient combinations of different means and methods of training. In addition, it allows complying with the factors of pedagogical influence and achieving the necessary continuity in the development of various abilities.

Conclusions.

Thus, the CrossFit training positively affects the level of students' physical fitness, strengthens their motivation to physical education and sports activities. It also promotes the acquisition of knowledge about modern approaches to organizing physical training, skills and abilities of independent physical training.

Circular training in the CrossFit method increases the motional and emotional density of workouts. It makes workouts more diverse and interesting for students giving space for individual opportunities and personal initiative. Thus, it increases the motivation towards physical education.

The physical training with circular workouts gives positive results and contributes to the successful development of general physical fitness.

The prospects for further research include increasing the efficiency of the training process using CrossFit workouts and developing the evaluated and predictive models of fitness of military personnel.

Conflict of interest.

The authors state that there is no conflict of interest.

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