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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

ORIGINAL ARTICLE

Physical and physiological benefits of small sided recreational handball in untrained males: relationship of body fat with aerobic capacity

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

Abstract

Background and Study Aim Exercise and Recreation play major role in promotion of health and fitness. Recreational exercise or sports can be useful in physically inactive population. The aim of study was to investigate the effect of recreational handball on body fat percent, VO_2max, blood pressure and resting heart rate. Another purpose to find relationship between VO_2max and body fat percentage.

Material and Methods Twenty-four students were randomized into intervention (n=14) and control group (n=10). The intervention group was asked to play recreational handball for 12 weeks. Handball training was held twice a week for 30 minutes duration. The Control group performed their normal routine. Aerobic capacity measured using single-stage treadmill test. Body fat was measured with Omron Body Fat Analyzer. T-test was employed to find a significant difference in the two groups. For the relationship in aerobic capacity and body fat, Pearson Product Moment Correlation was used.

Results We found significant difference in body percent (t_{22} = 2.031, P = 0.054). No significant difference was seen in aerobic capacity (t_{22} = 1.578, P = 0.129), systolic blood pressure (t_{22} = -1.637, P = 0.116), diastolic blood pressure (t_{22} = -1.562, P = 0.133) and resting heart rate (t_{22} = 1.620, P = 0.120). Significant relationship was established between body percent and aerobic capacity (r= -5.23, n=14, p= 0.055) in the intervention group.

Conclusions It can be concluded that recreational handball was useful in eliciting good response with respect to reduction of body fat in intervention group. However, recreation handball sessions were not effective in reducing blood pressure, resting heart and aerobic capacity among untrained males. A significant relationship was observed in VO_2max and percent body fat.

Keywords: small sided games, VO_2max, team sports, blood pressure, resting heat rate

Introduction

Exercise and recreation play major role in promotion of health and fitness. Recreational exercise or sports can be useful in physically inactive population. Physical inactivity as per WHO, is a major risk factor for global mortality [1]. Low physical fitness level is result of sedentary lifestyle. Participating regularly in physical activity proved to be beneficial to individual health and supervised training interventions are an important took for preventing and treating lifestyle related diseases [2,3] There is a concern about poor adherence to prescribed exercise programmes specially in long term [4].

It has been reported that there are certain team games which can bring a sustainable training intervention that can effectively induce large range fitness and health benefits and that too in motivating environment, although not much research has been done in this area [5]. Further in Denmark and also worldwide, there is high dropout rate in response to traditional exercise regime [4, 6]. There is a need to strategize and identify new ideas and activities which can motivate individuals to remain fit and active providing long lasting changes in their lifestyle and prolonged physiological perspectives [7].

It has been found in recent studies that recreational handball has high aerobic and anaerobic demands and it is intermittent high-intensity exercise mode, similar to the competitive version [8]. Demands in recreational handball are similar to as described in for recreational soccer [9], which has shown that different populations have a positive impact on their health and fitness levels as a result of recreational soccer practice [10-12]. Team sports have the potential to motivate and attract varied populations and can also motivate individual for sustained participation which can bring in long term changes in lifestyles [7].

Therefore, recreational handball can be a good alternative for development of cardiovascular fitness. Since recreational handball is appealing mode of exercise with large many ex-players and fans across world [13], a greater number of studies are needed to use handball for promotion and enhancement of health and physical fitness. It appears that team games can increase well-being in individuals just like any other physical exercises [14], therefore, it is well expected on similar lines that recreational handball would be beneficial and would have similar effects in sedentary individuals.

Therefore, we studied the effects of small sided recreational handball on VO_2max, body fat percent, resting heart and blood pressure in untrained male. We also investigated the relationship of aerobic capacity and body fat percent.

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Materials and Methods

Participants

Participants were untrained male residing in campus of King Fahd University of Petroleum & Minerals. Total 24 participants were selected randomly following exclusion criteria. They were fully informed about the risk and written consent was obtained. This study was approved by Research Committee of King Fahd University of Petroleum and Minerals through project IN191046, 29 March, 2020. Exclusion criteria were the following: participants involved in regular physical activities with in previous one year, who were playing regular handball; participants on medications and suffering from cardiovascular diseases or obesity.

Procedure

Project was carried out for 12 weeks. Two groups were formed to study the effects. Group one was intervention with 14 participants. Group two was control with 10 subjects. Subjects were assessed and tested at the baseline and at the end of 12 week of intervention. Participants were advised not to involve in any other physical activities during the period of 12-week intervention. Twelve weeks of supervised small sided recreational handball was given to the participants in intervention group. There was total four teams. Each team consists of 4 players instead of regular seven. All games were played on handball court measuring 40x30m. All sessions were organized during evening hours. Frequency of sessions was twice a week for 30 minutes. Participants did warm up for 10 minutes which consists of jogging and handball drills. After finishing of each session participants performed cooling down exercise for 10 minutes. All the training sessions were supervised personally by the research team. Heart rate of participants in intervention group was measured by heart rate monitors during all handball training sessions.

Measurements and Testing Protocols

Age, weight, height, percent body fat was recorded at the baseline. Body fat percentage was measured using Omron body sensor. Hear rate for participants in handball training was measured by Polar FT7 Heart Rate Monitor. Blood pressure and resting heart rate was checked and recorded after resting in supine position for at least 20 minutes using Omron Blood-Pressure Monitor. VO_2max was tested prior to exercise training programme by single stage treadmill walking test. It is test for submaximal aerobic fitness which estimates VO_2max. It was suitable for people with less risk, who were healthy, non-athletic adults with age range from 20-59 [15].

Statistical Analysis

Collected data were presented as means and standard deviation. Data were assessed for normality by Shapiro Wilks test. Baseline measurements were checked for any group differences before intervention using T Test. Between groups differences in delta values (post minus pre-values) were tested by Independent T Test. P-value for significance was set at 0.05. SPSS for Windows, version 26.0, was used for statistical analysis.

Results

Participant's mean age was 19.78±1.05 years and 19.60±0.96 years in intervention and control groups ($P = 0.664$) respectively. No adverse complications were reported. There were no significant differences at baseline between two study groups (table 1).

Handball Sessions

From initial enrolment of 26 participants, two participants withdrew from the intervention (small side handball) during the study period. Two participants in control group did not appeared for post intervention measurements. All participants were able to play vigorous game of small sided handball (Mean Average heart rate 168.32±8.60 beats/ minute) for 30 minutes duration (Mean duration of play 28.09±2.63 minutes). Mean Attendance in the intervention group during study period was 94.64% which shows the enthusiasm and interest of participants in recreational handball (Table 2).

Body Fat Percent and Aerobic Capacity

Analysis of data revealed improvement in body fat percent. T Test found significant difference in body fat percent ($t_{22} = 2.031$, $P = 0.054$), with mean body fat percent was 16.74±5.29 and 14.35±4.14 in IG and CG respectively. We did not observe any significant improvement in VO_2max after 12 weeks of intervention between two groups ($t_{22} = 1.578$, $P = 0.129$), where mean VO_2max was 35.28±2.49 and 36.96±3.60 in IG and CG respectively (table 3, Fig.1).

Resting Heart Rate and Blood Pressure

With regard to both blood pressure and resting heart rate, no significant difference was observed post

Table 1. Comparison at Baseline between Intervention and Control Group (T Test)

Variable	Intervention Group (n=14)		Control Group (n=10)		P Value
	Baseline	12 Week	Baseline	12 Week	
Body Fat Percent	16.98±5.26	16.74±5.29	14.2±4.21	14.35±4.14	0.180
Systolic Blood Pressure (mmhg)	114.35±6.47	114.28±7.46	114±11.37	110.8±9.75	0.923
Diastolic Blood Pressure (mmhg)	71.92±5.90	72±6.64	69.1±5.74	65.3±2.86	0.254
Resting Heart Rate (bpm)	76.42±9.59	73.78±9.39	77.3±6.66	78.2±6.74	0.807
VO2 Max	34.53±2.49	35.28±2.87	36.96±3.60	36.38±3.51	0.64

Descriptive Statistics, Data shown as Means ± SD, *significant difference at .05

Table 2. General Characteristics of Participants

Variable	Intervention Group (n=14)	Control Group (n=10)
Age (years)	19.78±1.05	19.60±0.96
Height (m)	1.71±0.04	1.73±0.03
Weight (kg)	70.16±12.58	64.36±10.94
BMI (kg/m²)	23.76±4.27	21.43±3.28
Average Heart Rate (b/m)	168.32±8.60	
Maximum Heart Rate (b/m)	191.68±6.33	
Playing Time (min)	28.09±2.63	
Attendance (%)	94.64	

Data shown as Means ± SD and %

Table 3. Comparison of Physical Parameters after 12 weeks (Difference between Post and Pre-Scores, Independent T Test)

Variable	Intervention Group (n=14)	Control Group (n=10)	P Value
Body Fat Percent	0.24±0.46	-0.15±0.47	0.054*
Systolic Blood Pressure (mmhg)	0.07±4.58	3.2±4.66	0.116
Diastolic Blood Pressure (mmhg)	-0.07±6.84	3.8±4.46	0.133
Resting Heart Rate (bpm)	2.64±5.78	-0.9±4.45	0.120
VO2 Max	0.75±2	-0.58±2.08	0.129

Data shown as Means ± SD, *significant difference at .05

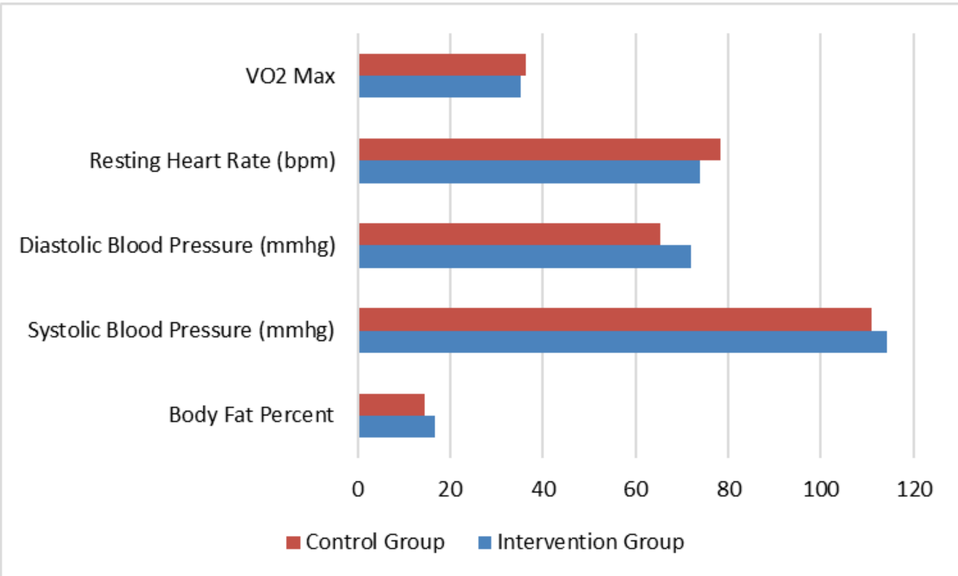

Figure 1. Mean Scores after 12 weeks of Intervention

intervention between two study groups. Systolic blood pressure did not show any significant difference (t_{22} = -1.637, P = 0.116), where systolic blood pressure post 12 week was 114.28±7.46 and 110.8±9.75 in IG and CG respectively. Diastolic pressure also did not show any significant improvement (t_{22} = -1.562, P = 0.133), where mean diastolic pressure post intervention was 72±6.64 and 69.1±5.74 in IG and CG respectively. T Test did not reveal any significant difference in resting heart rate between two groups (t_{22} = 1.620, P = 0.120), where mean resting heart rate after 12 weeks was 73.78±9.39 and 78.2±6.74 in IG and CG respectively (table3, Fig.1).

Relationship of Aerobic Capacity with Body Fat Percent

We found significant relationship of body fat percent with aerobic capacity (r= -5.23, n=14, p= 0.055) in the intervention group after 12 weeks of supervised handball programme. However, no relationship was seen between body fat and aerobic capacity (r= -0.096, n=14, p= 0.799) in the control group (table 4).

Table 4. Relationship between VO2Max and Body Fat Percent

Group	VO_2Max	Body Fat Percent	Correlation
Intervention Group	35.28 ± 2.87	16.74 ± 5.29	0.055*
Control Group	36.38 ± 3.51	14.35 ± 4.14	0.791

Data shown as Means ± SD, *Correlation is significant at the 0.05 level (2-tailed)

Discussion

Body fat in our study reduced significantly post 12 weeks of recreational handball. Our results are similar to previous study on small sided recreational basketball [16], where body fat was reduced. Another previous study on football have shown significant reduction in body fat after 12 weeks of football intervention [17]. Our results were also supported by another study where body fat percent was significantly decreased after 3 months of half-court basketball game [18]. Small sided recreational football was effective in reducing fat percent in experimental group after 16 weeks of intervention [19]. Higher attendance percentage (94.64%) was one of the strong aspects of this study which shows the enthusiasm among participants. This was also supported by other study which stated that students in university are more likely to appear and participate in physical activities which are social in nature and is not carried out in structured settings [20].

We have observed some improvement in aerobic capacity of intervention group. But this improvement not statistically significant. Although there were no baseline differences in two groups, but higher VO_2max was seen among participants in the control group compare to intervention. Our intervention was also carried for only two days a week. Results of our study are contrary to previous study of similar nature done on recreational basketball, where significant difference was seen in aerobic capacity after 12 weeks of intervention [16]. Considering nature of handball game and intensity of games in present study, it was expected to see improvement in VO_2max, but our results did not fall in line with VO_2max was significantly improved following 3 a side basketball [18]. There are number of previous studies done on small sided football that have shown improvement in aerobic fitness in untrained males [19, 21-23].

Interestingly we did not see improvement in blood pressure and resting heart rate between two study groups. Contrarily in previous study resting heart rate reduced 10-15 beats per minute after 12 weeks of badminton sessions [24]. Our results were not in line with other studies where resting heart rate was reduced after 3 months of small sided basketball [18], lower resting heart rate reported after 16 weeks of recreational football [19]. Blood pressure also failed to show any significant improvement in present study. Our results were supported by previous study where blood pressure did not show any significant after small sided basketball [18], no change observed in blood pressure after 12 weeks of small sided basketball training [16]. On contrary both systolic and diastolic blood pressure was significantly reduced in previous study on recreational football [19].

We have observed high intensity throughout all handball sessions. Intensity in our study was 87.8% of HRmax, which was very similar to previous study [16] on small sided basketball (88% of HRmax), small sided football [19] with 86.8% of HRmax. There were other studies also that examined intensities in sports among healthy adults with an average heart rate of 82% ± 2 of HRmax [22], 89% ± 2 of HRmax [25], 83% of HRmax [21] and 82% ± 2 HRmax [23].

The intervention group in our study have shown a significant relationship in VO_2max and body fat. This relationship was negative, means with increase in VO_2max there was a decrease in body fat percent. Our results were supported by pervious study [26] where negative relationship was seen between VO2max and body fat percent. Few more studies observed negative relationship between body mass and VO_2max per unit of body mass 27, 28].

Conclusions

Small sided recreational handball games were useful in eliciting good response with respect to reduction of body fat in intervention group. Body fat was reduced significant after 12 weeks of intervention. On the other hand, recreation handball sessions were not effective in reducing blood pressure, resting heart and aerobic capacity among untrained males. However, a significant relationship was observed in VO_2max and percent body fat.

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Conflict of interest

The authors report no conflict of interest.

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ORIGINAL ARTICLE

The effects of ankle kinesiotaping on postural control in healthy taekwondo athletes

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

Abstract

Background and Study Aim Although Kinesiotape is widely used by athletes, information about its effect is unclear. Its effect on postural control might directly affect an athlete's performance. In this study, it is aimed to find out whether ankle Kinesiotaping in taekwondo athletes affects postural control.

Material and Methods Twenty-four healthy university students – taekwondo athletes (12 females, 12 males) were included in the study voluntarily (Age 21.00 ± 1.53 years; height 173.33 ± 7.29 cm; body weight 63.41 ± 9.41 kg). Kinesiotape was carried out to the dominant ankle of the participants. Kinesiotape was applied supportively to peroneus longus, peroneus brevis, and tibiofibular ligament. All participants were taken to postural control measurements twice with Kinesiotape (KT) and without KT. Postural control was measured using the Biodex Balance System with eyes open (EO) and eyes closed (EC). Overall Stability Index (OSI), anterior-posterior sway (AP) and medio-lateral sway (ML) scores were used in the evaluation of postural control. Wilcoxon test was used to compare balance scores under EO condition, and the t-test was used for dependent groups to compare balance scores under EC condition.

Results In EO condition, no significant difference was found between OSI, AP, and ML scores of the taekwondo athletes with KT and without KT ($p > 0.05$). In EC condition, no significant difference was found between OSI, AP, and ML scores of male taekwondo athletes with KT and without KT ($p > 0.05$). It was found that Kinesiotape in EC condition decreased OSI and AP sway scores in female taekwondo athletes ($p < 0.05$).

Conclusions It was determined that ankle Kinesiotaping of taekwondo athletes did not change the postural balance in EO condition. In EC condition it did not change the postural sway of male taekwondo athletes, but it improved the postural control performances of female taekwondo athletes.

Keywords: balance, muscle performance, lower extremity, female, students.

Introduction

Taekwondo, which became a more popular sport after being an Olympic Sport in Sydney 2000 Olympics, is a traditional Korean martial art and martial sport [1, 2]. Taekwondo athletes should have a high level of aerobic capacity, anaerobic power, muscular strength, flexibility, and agility [3]. To achieve the best possible results in competitions, taekwondo athletes must have their own postural features in terms of balance and postural control as well as muscle symmetries [4]. Dynamic kicking techniques in Taekwondo require balance along with motoric features such as strength, speed, endurance, flexibility, and coordination [5]. Taekwondo athletes must provide dynamic stability on the support legs to perform fast and irregular movements with the foot they use while kicking [6]. Patti et al. [7] argue that balance in taekwondo control provides more effective stimulation for sensory-motor regulation compared to tennis. In Taekwondo, the lower extremities are the most affected body part of injuries [5] and 46% of the athletes reported that their lower extremity injuries recurred once more [8]. The most common injury in taekwondo athletes is ankle sprain [8].

When the centre of gravity stays within the limits of stability, two different strategies or combinations of strategies are used to move the centre of gravity while maintaining the previous position of the feet on the support surface [9]. Postural balance strategies consist of hip strategy and ankle strategy [10]. Compared to other sports branches, martial arts athletes use the ankle joints much more often. The success of these athletes in maintaining a balanced position predicts a good control of the lower extremity [11].

Postural control includes various physiological systems, including sensory units, muscle reflexes, and central nervous system [12]. Any disruption between components of this mechanism or interactions between components can disrupt postural balance [13]. Human upright posture is protected by the central nervous system through the integration of complex afferent and efferent control signals based on body orientation and movement information provided by vestibular, visual, and somatosensory systems [14].

Sports involvement requires high levels of control as voluntary movements, and external perturbations constantly threaten body stability in activities performed at high speeds [15]. Balance control, which allows the performance of activities ranging from maintaining static positions to complex dynamic activities, is vital for life

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[16]. Ankle, which is a tactile sense organ that keeps body weight in balance [17], plays an important role in posture and locomotion [18]. Peroneus muscles combined with the tibialis muscles support and stabilized the ankle joint [19]. Studies have shown that the peroneus longus muscle plays an important role in maintaining balance [20]. Ankle and foot injuries are common among athletes and physically active people. The most common residual discomfort, ankle sprain, is characterized by the instability of postural oscillation [21].

It is suggested that Kinesiotaping (KT) is an intervention that can improve postural control [22]. Studies have shown that Kinesiotape improves flexibility and increases postural balance as well as functional performance of individuals [23]. KT method can be used not only to prevent the progression of acute and chronic athletic injuries, but also to prevent the occurrence of musculoskeletal injuries and to improve performance [24]. Kinesiotape is completely different from existing sports medical tapes [25]. In addition to improving athletic performance, KT is a very useful method for preventing and treating a large number of musculoskeletal disorders [24]. It increases awareness in the ankle position by stimulating KT mechanoreceptors applied to the ankle. Also, the KT can increase the sense of joint position in the ankle [26].

KT provides a full range of motion for the muscles and joints applied by lifting the skin with different pulling forces to increase the gap between the skin and muscle [27]. The goal of KT is to change the underlying tissue for a long-term effect [28]. The general principle in KT is an activation of the affected area, removal of pathological changes that occur, and restoration of physiological functions. By applying KT, it may be possible to reduce pressure and stimulate certain receptors and nerve endings in a particular area to increase blood flow of damaged tissues and reduce edema [29, 24, 30].

KT reduces pain [31], increases efficiency in sports, accelerates lymph and venous transformation, and improves muscle performance [32]. It has also been seen that KT provides an increase in the bioelectric activity of the muscle [33]. This mechanism is thought to improve microcirculation between the dermis and epidermis. In addition to improving microcirculation, KT increases the activity of the lymphatic system and endogenous analgesic mechanisms; and by affecting muscle function it supports joint function. Furthermore, KT is reported to improve proprioception with normalization of muscle tone, correction of in appropriate position, stimulating effect on skin receptors [34]. However, in some studies, it was concluded that it did not develop proprioception [35, 36]. It has been suggested that by increasing the sensory input, it reduces delay in postural reflexes and improves dynamic balance by increasing postural stability [32]. Therefore, in this study, it was aimed to find out whether the KT applied to the ankle joint of healthy taekwondo athletes has an effect on postural control.

Material and Methods

Participants

The study included 24 healthy university students – taekwondo athletes (12 females, 12 males) who had not suffered from lower extremity injury in the last six months, and who did not have motor control problems, neurological disorders or vestibular disorders. The average age of the participants is 21.00 ± 1.53 years, their average height is 173.33 ± 7.29 cm and their average body weight is 63.41 ± 9.41 kg. Participants who voluntarily agreed to participate in the research were informed about the research. The participants were asked to sign the voluntary consent form. This research, approved by the Ethics Committee of the [Blinded for review], was conducted in accordance with the Helsinki Declaration.

Test procedure

The participants were randomly taken to postural control measurements in two experimental conditions (with KT / without KT). All subjects participated in balance measurements with and without KT. The participants were randomly divided into two groups with equal numbers of males and females (6 females + 6 males = 12 for a group). To randomize the measurement sequence, a group was first applied with KT and then taken into postural control measurement. In the other group, postural control measurement was taken first and then KT was applied. Approximately 40-45 minutes after the application of KT, the participants were taken to postural control measurements.

Postural control

Biodex Balance System (BBS, Biodex Medical Systems Inc., Shirley, NY) was used to detect postural control (fig. 1).

Figure 1. The measurement of postural balance.

This system is a tool that measures and records the ability of subjects to maintain their postures under dynamic stress. The BBS, which has a movable platform of 55 cm in diameter with a 360-degree movement width, has difficulty levels that can be adjusted from 12 to 1. The high scores obtained from BBS express impaired balance performance [37, 38, 39]. Postural control measurements of participants were performed under two separate experimental conditions, eyes open (EO) and eyes closed (EC). Before the measurements, participants were allowed to experience sufficiently to get used to the measurement tool. Participants joined in measurements with their sportswear. Participants were asked the question "which foot do you use to hit a ball?" and the answer was accepted as the dominant leg, and postural control measurements were performed on the dominant leg in a single-leg stance. Participants were asked to stand on the moving platform of the BBS and stand with one foot-on the dominant foot-with their feet in the center of the platform and cross their arms with their hands touching their shoulders. The non-dominant leg was positioned not to touch the ground. In this experimental position, participants were asked to maintain a balanced posture on the measuring device, they were allowed to receive feedback from the screen of the measuring device, and the foot coordinates were recorded in the measuring device. These coordinates were accepted as reference points in all postural oscillation measurements.

Participants were taken to postural control measurement first in EO and then in EC condition. During this measurement, the difficulty level of the measuring tool was set to "Level 8" for the EO condition and "Static Level" for the EC condition. During the postural control test, the participants were asked to maintain the test positions first and then look at the screen of the measurement tool to provide a balanced posture. During both the EO and EC conditions, participants were asked to maintain their balanced positions for 20 seconds during the test. During postural control tests, the screen of the BBS was closed under EO condition and the subjects were asked to look at a marked spot for 20 seconds- which was in their eye alignment and on the wall about 1 m away; and in the EC condition, they were asked to close their eyes during the test. At the end of the test period, the test measurement tool was completed automatically and the subjects' 3 sway scores were recorded: Overall Stability Index (OSI, Overall Stability Index), Anterior-Posterior Index (AP), Medio-Lateral Index (ML). Participants who could not maintain their posture during the test were re-measured. A 2-minute rest was given between EO and EC measurements.

Kinesiotaping (KT) application

KT application was applied to the dominant ankle of the participants. KT application was performed by a certified physiotherapist in accordance with the technique. KT was applied supportively to peroneus longus, peroneus brevis, and tibiofibular ligament [40]. A 5 cm wide kinesio tapes (Kinesio® Tex) were used for taping (fig. 2).

Statistical Analysis

The normality distribution of the data was carried out by the Shapiro-Wilk test separately for all subjects, female and male subjects. Wilcoxon test was used to compare balance scores in EO condition that did not meet normal distribution conditions. To compare the balance scores under the normal distribution of EC conditions, a t-test was applied for dependent groups. IBM SPSS Statistics (Version 22 for Windows; IBM, Armonk, NY, USA) was used in the analysis of the data. Data results were evaluated at .05 significance level and 95% confidence interval.

Figure 2. KT application.

Results

Descriptive statistics of 24 taekwondo athletes are given in Table 1. In Table 2, postural sway scores of taekwondo players with KT and without KT are presented.

It was seen that OSI scores in EO condition were not affected by the application of KT and in females (Z = -0.315; p = 0.753), males (Z = -1.227; p = 0.220) and all subjects (Z = -0.635; p = 0.525) no statistically significant difference was detected between measurements. Comparing AP sway scores under EO condition; it was observed that the application of KT for females (Z = -1.341; p = 0.180), males (Z = -1.207; p = 0.227) and all subjects (Z = -0.290; p = 0.772) did not have a significant effect and there was no statistically significant difference between repeated measurements. Similar results were determined in the scores obtained for ML sway under EO condition and it was determined that KT did not cause a statistically significant change in ML scores (Z = -1.357; p = 0.175 for females, Z = -0.669; p =0.503 for males, Z = -1,441; p = 0.150 for all subjects).

The postural sway scores of taekwondo athletes measured with KT and without KT under the EC condition are presented in Table 3. Statistical analysis results indicated that OSI scores of female taekwondo athletes were affected by the KT application under EO condition, and OSI scores were significantly lower in the group without KT (t = -3.672; p = 0.004). As a result of the comparison of male taekwondo athletes and all taekwondo players, OSI scores were not significantly different between the measurements with and without

Table 1. Subjects' physical characteristics.

Variables	Gender	Mean ± SD
	Female	20.58 ± 1.44
Age (year)	Male	21.42 ± 1.56
	Total	21.00 ± 1.53
	Female	57.72 ± 5.33
Body Weight (kg)	Male	69.12 ± 9.28
	Total	63.42 ± 9.42
	Female	168.92 ± 5.86
Height (cm)	Male	177.75 ± 5.83
	Total	173.33 ± 7.29
	Female	6.71 ± 1.98
Sport Experience (year)	Male	8.25 ± 2.05
	Total	7.53 ± 2.10

Table 2. Postural control scores with KT and without KT in EO condition (Mean ± SD).

Subjects	Groups	OSI	AP	ML
Female	With KT	1.64 ± 0.49	1.08 ± 0.45	1.02 ± 0.38
	Without KT	1.78 ± 0.69	1.38 ± 0.64	0.88 ± 0.41
Male	With KT	1.91 ± 0.36	1.18 ± 0.32	1.25 ± 0.26
	Without KT	1.85 ± 0.86	1.03 ± 0.34	1.28 ± 0.90
Total	With KT	1.78 ± 0.44	1.13 ± 0.39	1.13 ± 0.34
	Without KT	1.81 ± 0.76	1.20 ± 0.53	1.08 ± 0.71

NOTE: OSI - Overall Stability Index; AP - Anterior-Posterior Index; ML - Medio-Lateral Index.

Table 3. Postural control scores with KT and without KT in EC condition (Mean ± SD).

Subjects	Groups	OSI	AP	ML
Female	With KT	2.26 ± 0.55*	1.59 ± 0.57*	1.23 ± 0.34
	Without KT	2.77 ± 0.64	2.23 ± 0.62	1.33 ± 0.42
Male	With KT	2.43 ± 0.56	1.64 ± 0.52	1.40 ± 0.33
	Without KT	2.35 ± 0.57	1.66 ± 0.60	1.33 ± 0.28
Total	With KT	2.34 ± 0.55	1.62 ± 0.53*	1.32 ± 0.34
	Without KT	2.56 ± 0.63	1.95 ± 0.66	1.33 ± 0.35

NOTE: OSI - Overall Stability Index; AP - Anterior-Posterior Index; ML - Medio-Lateral Index; * Significantly lower than without KT.

KT (t = 0.378 and p = .713 for males; t = -1.628 and p = .117 for all subjects). When the sway scores in the AP direction under the EC condition were examined; a statistically significant difference was found between the measurements with and without KT of female taekwondo athletes (t = -4.154; p = 0.02) and all subjects (t = -2.543; p = 0.018). There was no significant difference between AP sway scores of male taekwondo athletes (t = -0.099; p = .923). On the other hand, it was determined that there was no effect of the Kinesiotaping on ML direction sway scores in EC condition in females, males and all taekwondo athletes (t= -0.964; p = .356 for females, t = 0.643; p = .533 for males and t = -0.100; p = .921 for all subjects).

Discussion

In this study, the effect of the ankle KT of taekwondo athletes on postural balance in EO and EC conditions was examined. The effect of KT was determined by comparing the measurements of postural sway while the dominant ankle was in two experimental conditions with KT and without KT.

These results indicated that there was no change in postural control performances of both female and male taekwondo athletes in the EO condition with KT and without KT. In other words, it might be said that the KT does not have an effect on the balance abilities of taekwondo athletes in EO condition.

In EC condition, it was found some changes between balance scores in KT and without KT. It was seen that OSI and AP sway in female athletes were decreased by the application of KT in EC condition. However, no change was observed in male taekwondo athletes.

Many studies have investigated the effect of KT applied to the ankle on postural control [41-47]. In these studies, it is seen that various taping methods are used and the participants have different features. Also, the timing of measurement after KT application varies. As a result of these variations, it is difficult to agree on the influence of the KT.

Nakajima and Baldridge [42] reported that KT applied to the ankle in healthy males had no effect on dynamic postural balance, whereas in healthy females, a short-term effect was not observed, and yet, postural balance improved 24 hours after the application of KT. Participants did not remove KT for 24 hours. Another study in healthy individuals reported that KT applied to the ankle did not improve proprioception [35]. Fayson et al. [45] also concluded that KT did not affect the stabilization time in healthy females. In elder healthy females, no change in postural balance was observed immediately after and after 48 hours of KT application [43]. Contrary to these results, Semple et al. [48], measured postural stability with and without KT measuring instrument (Biodex Balance System) used in this research and determined that KT reduced the OSI, AP, ML scores of the participants who were semi-professional rugby players, namely, increased their postural stability. There are other studies reporting that the KT develops postural balance in healthy individuals [46, 47, 49]. Vinken et al. [50], who examined the effect of KT in terms of performance of active dancers (2 males, 13 females) in terms of postural control and dance-specific routines, reached the conclusion that although the development of postural control was observed, the performance was limited in the performing of modern and classical dance routines. They emphasized that athletes could use KT for comfort and amenity, but the impact of functional performance still requires scientific evidence.

Although Hettle, Linton, Baker, and Donoghue [51], reported that the ankle KT application did not improve the reach of the Star Excursion Balance Test according to an investigation in athletes with chronic ankle instability, Alghamdi and Shawki [41], announced that it improved balance control in a similar sample. Unlike other studies, Jackson et al. [44], maintained the KT application for 48 hours and examined its effects for up to 72 hours. In the participants with chronic ankle instability, they demonstrated that balance improved 48 hours after the application of KT and this improvement continued 72 hours later.

It was observed that the KT applied to the ankle in female volleyball players did not affect the agility and jump performance, and also did not affect the balance scores using as measured by the Balance Error Scoring System, but this test performed in EC condition reduced the scores obtained on the foam surface, that is, fewer errors were detected on the foam surface [56]. Błaszczyk et al. [53], reported that females need higher muscle activity to maintain their body balance during a stable stance. In this study, as a result of the application of ankle KT, it was determined that there was no change in the postural control performances of male taekwondo athletes in the EC condition, while the postural control in the female taekwondo athletes improved in the EC condition. This result suggests that in conditions where the control of the balance is difficult and especially the visual system is obstructed, the KT applied to the ankle of female athletes might change the postural sway and show better postural performance due to the support it provides to the ankle. However, there is a need for new studies examining the effect of the KT in terms of the gender variable and sensory systems that affect balance control as to why this development does not occur in male athletes. KT application may have an effect that facilitates factors such as intermuscular, intramuscular coordination and even muscle co-contraction as well as sensory inputs [50]. Murray and Husk [27] have suggested that KT may cause an increase in joint position sensation as a result of the stimulation of cutaneous receptors, and reported that this may support healing and improve functional dynamic balance. There are studies reporting that 10 minutes after the application of the KT, it causes changes in blood flow [54] and has an effect on balance performance for up to 72 hours. However, it is controversial when the effects of postural control start or exactly what effect it has.

Conclusions

As a result, it is determined that the KT applied to the ankle of taekwondo athletes does not change the postural balance in EO condition, it does not change postural control in male taekwondo athletes in EC condition, but it improves the postural control performances in female taekwondo athletes. It can be said that the application of KT to the ankle does not limit the postural performance of taekwondo athletes and improves postural control under conditions where there is no visual input.

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Conflict of interest

The authors have no conflicts of interest that are directly relevant to the content of this study.

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ORIGINAL ARTICLE

The acute effect of different massage durations on squat jump, countermovement jump and flexibility performance in muay thai athletes

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

Abstract

Background and Study Aim Muay thai is a combat sport in which the competitors kick, punch, knee, elbow and growl with their opponents. The strength of the leg muscles can increase the intensity of the kick and its flexibility is a well-known issue for this sport. Determining the most appropriate method for these issues provides important gains to the athletes. One of the methods applied to achieve these gains is acute massage applications. The aim of the study is to evaluate the acute effect of different massage times on squat jump, countermovement jump and flexibility performance.

Material and Methods Twelve healthy male muay thai athletes (age, 19.83± 1.46 years; height, 175.33± 7.91 cm; body mass, 65.16 ±13.36 kg) participated in the study, who exercised three times a week. The study consists of a single group. The study consists of 4 different massage duration protocols. These protocols consist of no massage (NM), five minutes massage (5MMSG), ten minutes massage (10MMSG) and fifteen minutes massage (15MMSG). Counter movement jump, squat jump, sitting and lying flexibility were measured after each massage period, respectively. All protocols were continued on consecutive days.

Results There was a significant main effect for flexibility (F = 10,872 ; p = 0.00), countermovement jump (F = 4.719 p=.008) and squat jump (F = 6.262 p=.002) performance. The best flexibility, countermovement jump and squat jump performance detected immediately after 5MMSG was respectively 35,16 ± 6,33; 37,17 ± 4,18 and next, 36,05 ± 4,68.

Conclusions As a result, it is recommended that different massage durations are effective in improving physical performance, and 5MMSG before competition is recommended for athletes and coaches to get more performance.

Keywords: combat sports, passive warm up, sit and reach

Introduction

As in numerous sports, strength-endurance parameters are one of the important physical parameters that determine success in combat sports [1]. Muay Thai, recognized as the national sport of Thailand and popular all over the world, is a type of kickboxing that allows kicks, punches, knees and elbows and is expressed as the "eight limb art" [2]. As in similar combat sports with muay thai, the main technical and tactical actions involve hitting the opponent [3], and reactive power, which defines an athlete's stretch-shortening cycle abilities, can be considered the basis for force generation in muay thai [4, 5]. In order to compete at a high level in combat sports such as Muay Thai, the athlete must develop strength, endurance, muscle strength, anaerobic and aerobic abilities [6]. According to Guidetti et al., [7] strength performance is among the important indicators in defense sports. While Muay Thai athletes work to increase their striking strength, they need to improve their ability to use these strokes regularly [8]. If the time available for strength development is less than 0.3 seconds, as in Muay Thai, it is assumed that it should focus on improving the speed of strength development [9, 10, 11]. Since the rate of strength development represents a function of neuromuscular activation [12] and an individual's ability to accelerate objects [9], many researchers recommend ballistic training to improve this quality [13-16].

It is known that before training or competition, athletes apply different warm-up protocols in order to increase their physiological and psychological capacities [17]. Accordingly, depending on the intensity and duration, different warm up protocols provide physiological, biochemical and psychological changes in the body [18, 19]. It is stated that in addition to physical warm-up, pre-exercise massage can be used [20] and muscle stiffness can be reduced by lengthening the massaged muscle [21]. Massage is a physical therapy intervention with psychological advantages by increasing flexibility, muscle temperature and blood flow, reducing muscle tension and pain, and preventing tissue adhesion by using hands or an accessory on the soft tissue of the body [22, 23]. It has been determined that self-massage does not reduce muscle strength or performance, and in addition increases flexibility [24], while massage application before stretching provides greater improvements in flexibility than stretching alone [24, 25]. Hemmings et al., [26] on the other hand, examined the effects of massage on repeated boxing performance using a boxing ergometer

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and stated that there was no difference in performance between the group that received a massage before the study and the group that did not.

The contribution of knowing the acute effect of different massage times on vertical jump, squat jump and flexibility performance in Muay Thai athletes to change the perspective of trainers and athletes is very important for the future of sports. In addition, the absence of a study in the literature that measured the acute effect of different massage durations on countermovement jump, squat jump and flexibility performance in muay thai athletes further increases the importance of the study. The aim of this study is to determine the effect of different massage durations on countermovement jump, squat jump and flexibility in muay thai athletes. For this purpose, as research hypotheses; (1) It is thought that flexibility performance will be positively affected in favor of 5MMSG.

Material and Methods

Participants

Twelve healthy male active muay thai athletes who exercise three times in a week voluntarily attended to this research (age, 19,83± 1,46 years; height, 175,33± 7,91 cm; body mass, 65,16 ±13,36 kg). Muay thai athletes trained for more than two years. To be included in the study, muay thai athletes should have had the following characteristics: (a) had at least 2 years of experience in the muay thai; (b) not have any functional limitation that could interfere in the tests performance; (c) not presented any medical condition that could influence the tests; (d) maintained their regular physical activity during the course of the study. Prior to participation, all subjects were briefed on the requirements and risks involved with the study. Parental consent was sought for subjects. The study started after the approval of the Research Ethics Committee of the institution (2021/2461). All tests and training practices were performed at the same time of the day (09.00-11.00).

Experimental Design of the Study

This study is available just one group in which was included twelve male muay thai athletes and there isn't any control group. Four different massage durations which have been applied with content for 48 hours. Twelve muay thai athletes into four different massage durations were randomly taken to exclude the cumulative effect. Throughout the familiarization session's muay thai athletes were familiarized with massage durations (NM, 5MMSG, 10MMSG, and 15MMSG). The entire massage durations carried at the same time of day (10.00 am, to avoid the effect of diurnal variations). Each massage durations started with 5 minutes of light-intensity aerobic jogging. Counter movement jump, squat jump, sit and reach flexibility were measured respectively after each massage durations (Figure 1). This study continued approximately 10 days. All protocols continued consecutive days. Sit and reach flexibility test was administered using a specially constructed box that had a slide ruler attached to the top. After one practice trial, the best score of three trials was recorded [27]. Three trials were performed for squat and counter movement jump test (Smart Jump; Fusion Sport, Australia). For each variable, the highest value of the three attempts was used for analysis.

Massage Protocols

Before starting the massage, the massage bed was wiped using disinfectant and covered with a clean disposable cover before each massage in order to ensure a hygienic environment. The temperature in the massage

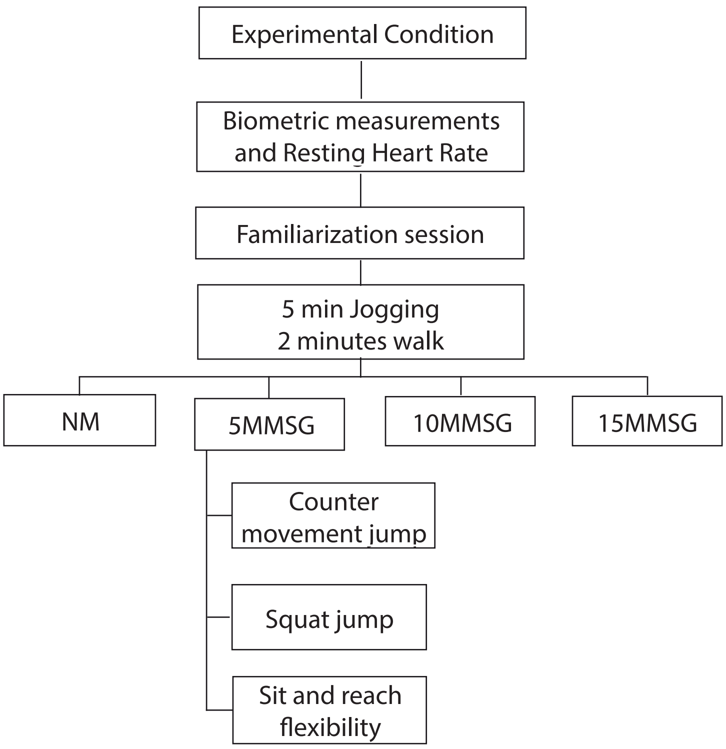

Figure 1. Experimental Design

room was adjusted to be 22-26 before each massage. All participants were massaged by the same masseur in order to ensure consistency between massage treatments applied to different athletes. After washing his hands, the expert masseur who will apply the massage poured about 3 ml of oil into his palms and started the massage by rubbing his hands to warm them. Aromatic oils, which affect the effect of the massage, were not used in the massage application. Approximately 30 ml of oil was used when massaging each participant, and the massage was done in the direction of the heart and muscle fibers. During the massage, Swedish massage was used, which can increase circulation [28] and flexibility [29], and eufluorage, friction, petrissage and pressing applications were made within Swedish massage [30, 31, 32, 33]. The original technique of Swedish massage also includes the tapotement technique, but the tapotement technique was not applied during the treatments as this process may increase muscle tension [34]. There are 4 different massage protocols and durations as no massage (NM), five minutes massage (5MMSG), ten minutes massage (10MMSG) and fifteen minutes massage (15MMSG). All massage protocols started after the participants were given detailed information about the test, before the test started, the participants' maximum heart rate was determined [35]. Then, warm-up rate of jogging each individual was calculated as 30-40% according to the heart rate [36]. Participants in the study were warmed up under the control of experts. In this way, both the warm-up intensity and the warm-up differences between the participants in the study were eliminated. Participants were asked to walk for 2 minutes until their heart rate was between 110-120 per minute. The massage protocols was performed for the following muscle groups (calf, quadriceps, adductor, hamstring and hip rotator) in all massage durations.

Statistical Analysis

The obtained data were analyzed in SPSS (25.0) package program. "Repeated Measures Anova" was used to determine the effect of different massage protocols on countermovement jump, squat jump and sit and reach flexibility. "Bonferroni" analysis, one of the multiple comparison tests, was used to determine which massage protocol favored the performance. Mauchly Test was used for homogeneity of variances and Greenhouse-Geisser correction factor was used to correct for variances. The significance level was chosen as $p<0.05$.

Results

Figure 2 shows a comparison between flexibility, squat jump and counter movement jump values for NMSG, 5MMSG, 10MMSG and 15MMSG. It was determined that there was an increase in flexibility, squat jump and counter movement jump performance values observed after 5MMSG (35,16±6,33; 36,05±4,68; 37,17±4,18) protocol. Also flexibility [F(1,693)= 10,872 p=.000, partial eta squared: ,497], squat jump [F(2.380)= 6.262 p=.002, partial eta squared: ,363] and countermovement jump [F(1.757))= 4.719 p=.008, partial eta squared: .300] values indicate a statistically significant difference between all protocols (p<.05). Performance improvement in squat jump parameters was determined as 5MMSG (36,05±4,68)>15MMSG (32,68±3,88)>10MMSG (31,96±5,11)> NMSG (31,91±4,96), from best to worst. When squat jump performances of the protocols were compared with each other, there was no statistically significant difference in any of them (p> .05). Pairwise comparison, the best flexibility performance after the 5MMSG (35,16±6,33) protocol was determined as 10MMSG (33,81±6,08), 15MMSG (31,90±5,87), NMSG (28,70±5,63), respectively. When the protocols were analyzed within themselves, a statistically significant difference was found between NMMSG -5MMSG, NMSG-10MMSG, NMSG-15MMSG (p< .05). There is a significant difference only between 5MMSG and 15MMSG in counter movement jump performances (p< .05).

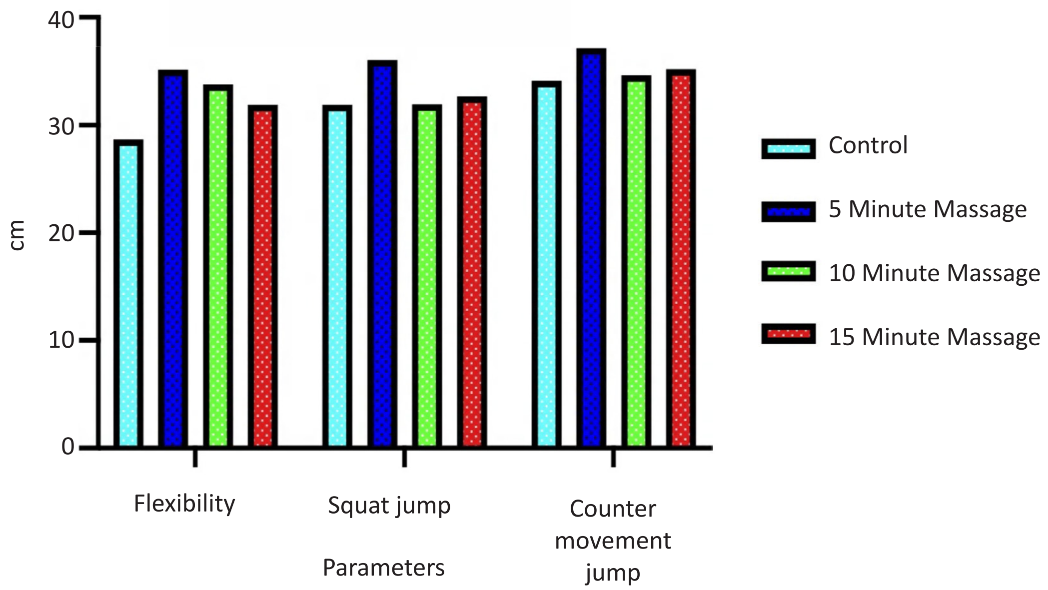

Figure 2. Flexibility, squat jump and counter movement jump performance of different massage durations

Discussion

Coaches and sports scientists work to provide warm-up and performance improvement before exercise or competition. It is thought that especially massage protocols applied before exercise or competition improve the physiological, biomechanical and psychological performance of the athletes by increasing their body temperature and range of motion. However, the optimal massage duration has not yet been determined in order to improve performance in applied massage protocols. It is important to determine the most appropriate massage duration, especially in short-term sports such as muay thai. Studies examining the effects of massage studies that provide performance improvement before exercise or competition may add originality to the literature for muay thai athletes. The aim of the study is to evaluate the effects of the most effective massage duration on flexibility, squat jump and counter movement jump performance among the different massage durations applied to muay thai athletes. It was determined that different massage durations could produce positive results on flexibility, squat jump and counter performance.

As a result of the study, it was determined that the most effective massage duration was 5MMSG. It was observed that 5MMSG had a significant increase in squat jump performance compared to the control group. When 10MMSG and 15MMSG were compared with the control group, it was observed that there was an increase in flexibility, squat jump and counter movement jump performance, while there were no significant differences between the averages of 10MMSG and 15MMSG values.

The results of the research are similar to the studies examining the effect of massage before exercise or competition. Studies have reported that massage stimulates the nervous system in the muscle tissue, increasing muscle elasticity and thus performance [37, 38]. Sykaras et al., [39] examined the effect of 2-minute massage (e.g. effusion, petrissage, friction, tapotement, pinching and squeezing) on knee extensor peak torque after concentric/eccentric contractions in Taekwondo athletes. As a result, it was observed that the massaged limbs performed better after intense exercise. Brooks et al., [40] reported that five minutes of manual forearm massage (including effusion and friction massage) showed significantly greater strength improvement in grip performance after 3 minutes of maximum exercise. The result of this study is similar to the results of some parameters measured in our study. Farr et al., [41] investigated the effects of massage including effusion and petrissage on muscle strength after 40 minutes of downhill walking on a treadmill in eight male participants and found that 40 minutes of downhill walking followed by 30 minutes of massage was associated with a significant benefit in strength gain.

Kargarfard et al., [42] found that 30 minutes of massage (including euphleurage, petrissage, and vibration) had positive effects on vertical jump performance in their study involving 30 male bodybuilders. Huang et al., [43] examined the effect of massage on the ROM of the hamstring muscle-tendinous junction and randomized ten active female participants to either 30-second massage, 10-second friction massage, or passive rest. As a result of the study, it was reported that there were significant increases in hip flexion ROM with 30 seconds of massage at the musculotendinous junction of the distal part of the hamstrings. However, they stated that there was no difference in passive leg tension or EMG findings. Arabaci [44] found that 10 minutes of back and 5 minutes of anterior lower extremity Swedish massage had a positive effect on sit and lie test results. This study is similar to our study in terms of reporting the positive effect of massage on flexibility performance.

It has been determined that there are studies stating that massage does not have a positive effect on strength and flexibility. For example, Hemmings et al. [45] found that massage had no positive effect on boxing power performance. Dawson et al., [46] examined the effect of repeated massage on strength gain after a half marathon and reported that massage had no effect on the rate of return to initial strength. Similarly, Dawson et al. [47] found in their study on runners that there was no significant difference between the groups in the strength indices of the athletes after the massage. Zainuddin et al., [48] stated that after eccentric elbow flexor exercise, 10-minute massage including effusion, petrissage and friction massage did not significantly improve muscle strength. In addition, studies have shown that massage does not have a positive effect on jumping performance [49, 50].

Conclusions

According to the results of this study, 5MMSG, 10MMSG and 15MMSG massage protocols provide positive effects on flexibility, squat jump and counter movement jump performances. It is thought that determining the most effective massage durations will save the athletes' time before the competition. As a limitation, this study did not include measurement tools that could directly identify the neurophysiological mechanisms implicated in enhancing physical performance of different massage durations, and only male muay thai athletes participated in this study. Studies that will determine the effects of different types of sports on different sports performance parameters in different massage types and massage durations to be made in the future will make significant contributions to sport performance.

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Conflict of interest

The authors report no conflict of interest.

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ORIGINAL ARTICLE

Thyroid hormone responses to acute aerobic exercise

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

Abstract

Background and Study Aim Thyroid hormone responses to acute maximal aerobic exercise is still unclear, so the aim of the study is to investigate the effect of acute maximal aerobic exercise resulting in fatigue on blood thyroid levels in men and women.

Material and Methods The study included 8 male and 7 female subjects who did not actively exercise. Both group participants were students in the Kastamonu University in the period of study. The heights, weights, resting hearth rates and 5 cc. venous blood samples of subjects were taken before the exercise. The subjects warmed up for ten minutes before they had 20 m shuttle run. The purpose of this test was to tire the subjects to the exhaustion. The heart rate were measured at the end of the test in order to determine the exhaustion levels of the participants. The 5 cc. venous blood samples were taken again just after the exhaustion exercise. Statistical analysis was carried out using Statistical Package for the Social Sciences (SPSS) 23 program (SPSS Inc. Chicago. II. USA). P value was set at p<0.05.

Results When results were compared between both sexes, no significant difference was found among variables (p>0.05). There was significant change in TSH values in all group. They increased following the exercise compared to pre-exercise values. Moreover, total T3 decreased in all group. No other significant difference was found in free T3 and free T4 variables.

Conclusions In conclusion, thyroid responses to exercise emerge in a very complex way, which makes it difficult to reach a clear conclusion about its effects. The reason why the results are so contradictory is that the duration and intensity of the exercise, age, not being able to control the diet, and the timing of collection of blood samples after exercise.

Keywords: aerobic exercise, fatigue, thyroid stimulating hormone

Introduction

It is a well-known fact that exercise affects many glands and the hormones they secrete. One of these affected hormones is thyroid [1]. Thyroid stimulating hormone (TSH) secreted from the pituitary gland is responsible for keeping the basal thyroid levels in the circulation constant by increasing or decreasing the release levels [2]. Thyrotropin releasing hormone (TRH) release from the hypothalamus stimulates the release of TSH from the anterior pituitary gland, which affects the release of triiodothyronine (T3) and thyroxine (T4) [3]. The major thyroid hormones T4 and T3 are critical for normal physiological functions throughout life. This is especially true for T3, the biologically active form of thyroid hormones [4]. These hormones have important effects on growth and development, temperature regulation, oxygen consumption [5], energy metabolism, carbohydrate metabolism and cardiac functions [2].

Some hormonal adjustments are required to balance the physical stress caused by exercise and its effects. Although there are studies in the literature that vigorous exercise causes an increase in T3 and T4 levels [6], the results are controversial and it is thought to be variable according to the duration and intensity of the exercise [7], ambient temperature and training status [8]. It is also known that thyroid hormones increase basal metabolic rate, protein synthesis and the effect of catecholamines. However, responses of thyroid hormones to different types of exercise are not clear. There are studies showing that aerobic exercise increases T3 and T4 depending on the intensity [9] However, studies showing that thyroid hormones do not increase acutely during exercise are also presented in the literature. It has been revealed that thyroid hormones exhibit inconsistent changes during long-term exercise periods [10]. The role of thyroid hormones during resistance training is unclear, but there are studies on their interactions with other hormones. Studies on moderately trained individuals and highly trained rowers have reported that T4 hormone, fT4 (free thyroxin in plasma) [11] and fT3 (free triiodothyronine in plasma) and TSH [12] levels significantly decreased in resting state.

In the light of abovementioned information, the aim of the study is to investigate the effect of acute maximal aerobic exercise resulting in fatigue on blood thyroid levels in men and women.

Materials and Methods

Participants

The study included 8 male and 7 female subjects who did not actively exercise. Both group participants were students in the Kastamonu University in the period of study. The mean age of the subjects was 21.16 ± 1.49 years, average antropometric measurements are as follows

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(Table 1) height of 173.62 ± 3.87 cm, weight of 69.97 ± 7.32 kg. All subjects were informed about the purpose and procedures of the study. For the standardize dietary, subjects were asked to obey dietitians advisement before exercise 3 days ago.

Research Design

The heights, weights, resting hearth rates and 5 cc. venous blood samples of subjects were taken before the exercise. The subjects warmed up for ten minutes before they had 20 m shuttle run. The purpose of this test was to tire the subjects to the exhaustion. The criterion to end the exercise was that subjects classified rate of perceived exertion at least 18 according to Borg scale [13]. The heart rate were measured at the end of the test in order to determine the exhaustion levels of the participants. The 5 cc. venous blood samples were taken again just after the exhaustion exercise.

Statistical Analysis

Mean values, standard deviation and 95% confidence intervals of the variables were calculated. Normality of the variables were validated using the Shapiro-Wilk test. Paired sample T-test was used to examine within-group changes while Independent Sample T-test was used to compare genders. Statistical analysis was carried out using Statistical Package for the Social Sciences (SPSS) 23 program (SPSS Inc. Chicago. II. USA). P value was set at $p<0.05$.

Results

Mean values, standard deviation and 95% confidence intervals of the variables are presented in Table 2. When results were compared between both sexes, no significant difference was found among variables ($p>0.05$). There was significant change in TSH values in all group. They increased following the exercise compared to pre-exercise values. Moreover, total T3 decreased in all group. No other significant difference was found in free T3 and free T4 variables.

Table 1. Some of physical and physiological parameters of the participants

Parameters	N	Mean (X)
Age (year)	15	21.16±1.49
Height (cm)	15	173.62±3.87
Body Weight (kg)	15	69.97±7.32
Resting Hearth Rate(beat/min.)	15	77.16±7.36
Max VO_2 (mL.kg/min)	15	35.42±4.26

Table 2. Changes in variables pre and post training

Variables	Mean±SD	t	p
1st TSH (uIU/ml)	**1.46±0.43**	-6.011	**0.000***
2nd TSH (uIU/ml)	**2.00±0.71**		
1st FREE T3 (pmol/l)	5.37±0.44	1.093	0.292
2nd FREE T3 (pmol/l)	5.28±0.40		
1st FREE T4 (ng/dl)	1.34±0.20	1.345	0.199
2nd FREE T4 (ng/dl)	1.31±0.21		
1st TOTAL T3 (nmol/l)	**114.11±21.69**	2.474	**0.026***
2nd TOTAL T3 (nmol/l)	**106.50±19.74**		
1st TOTAL T4 (ng/dl)	9.01±1.27	-1.812	0.090
2nd TOTAL T4 (ng/dl)	9.42±1.27		

Note: * - $p<0.05$; TSH - thyroid stimulating hormone; FREE T3 - free triiodothyronine in plasma; FREE T4 - free thyroxin in plasma; T3 - triiodothyronine; T4 – thyroxine.

Discussion

Thyroid hormones play an important role in meeting the metabolic needs that increase with exercise, and these hormonal changes can be observed immediately after exercise and in the following hours [7]. When the results of our study were examined, no significant difference was found between genders in the parameters tested (p> 0.05). In statistical analysis conducted regardless of gender difference, it was observed that the increase in TSH hormone and the decrease in the Total T3 parameter were significant (p<0.05), but the difference in other parameters was not statistically significant (Table 2),

Considering the studies conducted on the effects of exercise on thyroid parameters in the literature, it is seen that it is very difficult to collect the results into a single point which are thought to differ due to the variability of external factors, For this reason, there are studies that support the results in the literature as we have obtained, as well as studies in the opposite direction. In the study conducted by Sullo et al. it was found that strenuous swimming exercise caused an increase in serum TSH levels and significant decreases in Total T3 and Total T4 in rats [14]. In the study conducted by Galbo et al on 8 men, the thyroid responses to exercises with gradually increasing workloads (47%, 77%, and 100% of MaxVO2) and to exercise up to prolonged fatigue were examined. As a result, significant increases in TSH levels were observed (P <0.001), but no significant difference was found in T3 and T4 levels [15]. In the study by Kilic et al., in which they examined the effects of exhausting cycling exercise performed on 10 sedentary men on thyroid and testosterone hormones, they reported significant decreases in total T3, total T4 and free T3 levels after exercise (p <0.01). However, they did not detect a significant difference between TSH and free T4 [16]. In the study conducted by Bosco et al. on 16 men who are professionally engaged in sports, it was found that there was a significant increase of 20% for TSH, 28% for free T3 and 30% for free T4 after the exhausting Bosco test of 60 seconds (p <0.05) [17]. In the study conducted by Huang et al., 26 healthy men were subjected to Bruce protocol with treadmill and examined the thyroid responses that emerged immediately after and after maximal exercise. As a result, they stated that the change in T3 and T4 parameters was not statistically significant, but the increase in TSH level was significant (p <0.01) [18]. Ciloglu et al. investigated the effects of exercise intensity on thyroid hormones and found that high intensity acute aerobic exercise with 90% of the maximum number of heartbeats caused higher TSH responses compared to 45% of the maximum number of heartbeats. However, significant reductions were also detected in total and free T3 levels [1]. In another study by Beyleroglu, in which thyroid responses emerging after acute aerobic exercise were examined, it was found that TSH and fT3 levels were found to be significantly decreased, but no change was observed in the fT3 level [19]. Sowers et al. reported that exercise-induced glucocorticoid increases may be a factor that stimulates TSH increase and T3 decrease [20]. Moore et al. are known to suppress thyroid functions of glucocorticoids such as cortisol. As a matter of fact, in their research, they examined the relationship between cortisol and thyroid hormones in strenuous exercises; they found a significant increase in TSH and fT3 levels right after running with about 75% of Max VO2, which continued until fatigue was reached [21]. In another study by Hesse et al., the thyroid responses to three different running distances (75 km, 45 km, 42.2 km) were examined. They found an increase in T4 in 75 km. and 42.2 km. groups while they found a decrease in T4 level in 45 km. group. Likewise, while a decrease in T3 level in 45 km. group was observed, an increase was observed in the other groups [22].

As in the studies mentioned above, there are many studies in the literature that mention the positive effect of exercise on TSH [23, 24, 25, 26, 27]. However, there are studies indicating that there is a decrease in TSH level or that the change cannot be detected [16, 28, 29, 30, 31, 32]. As in the different results observed in the TSH parameter, there are studies that mentioned decrease in T3 level [16, 27, 32] and increase in reverse [10, 31].

Conclusions

In conclusion, thyroid responses to exercise emerge in a very complex way, which makes it difficult to reach a clear conclusion about its effects. The reason why the results are so contradictory is that the duration and intensity of the exercise, age, not being able to control the diet and the blood samples after exercise.

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Conflicts of Interest

The authors declare no conflict of interest.

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ORIGINAL ARTICLE

The influence of special physical fitness of athletes on the level of technique of playing beach volleyball

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

Abstract

Background and Study Aim Aim is to determine the influence of the components of special physical training on the effectiveness of certain elements of the game technique during the competitive activities of beach volleyball athletes.

Material and Methods The study involved athletes (n = 20, age - 17-21 years, experience - 8-9 years), who are engaged in beach volleyball (Kherson, Ukraine). Experts (n = 5, work experience - over 20 years) from among the leading volleyball specialists were involved. Training sessions were conducted according to the author's structure and content of special physical training (preparatory period of the annual cycle). The author's program was to increase the volume of athletic work by 10% (selective classes and integrated work) and 17% (complex classes). The classes used a developed special training device. The device is designed to practice practical game skills. The load at the first stage was 70-80% of the maximum. The load in the second stage was 80-90% of the maximum.

Results Significant ($p < 0.05$) development of explosive power, speed and agility was revealed. There is a significant ($p < 0,05$) increase: in the number of jump serve and spike; improving the quality/number of serve and attack; improving the quality of passing and the number of blocks.

Conclusions The proposed structure and content of special physical training and exercises on a special simulator have significantly increased the level of development of physical qualities. The athlete training program helped to improve the effectiveness of certain technical actions during competitive activities.

Keywords: competitive activity, physical qualities, jump serve, attack.

Introduction

The stage of preparation for higher achievements plays a crucial role in preparing athletes for the main competitions in the chosen sport. At this stage, it is expected to achieve maximum results in sports and competitions. The main tasks of the stage are the maximum use of tools that can cause a rapid adaptation processes [1, 2]. A fundamentally important point is to ensure an important condition: the period of maximum propensity of athletes to achieve the highest results coincides with the period of intense training loads [1, 3-5]. An integral part of the process of sports improvement of athletes is special physical training [3, 6, 7]. It is believed that the process of sports training in beach volleyball is similar to classic volleyball. However, the special conditions of the competition make increased demands on physical and psychological readiness to competitive struggle [8-11]. This indicates the need to improve the process of special physical training of beach volleyball athletes.

Many studies have noted the importance of special physical training of athletes [1, 12-14]. Kostukov et al. [6] emphasize the lag in the level of training of domestic beach volleyball athletes from world standards. The authors emphasize the need to pay attention to the planning of the training process and its filling with effective content at the level of macro-, meso- and microcycles of training. Balasas [15] notes that physical training and variability of technique determine the achievement of high results in competitive activities. In other studies [12, 16, 17] it is proposed to improve the modern system of sports training by increasing the amount of special training. Such approaches of the authors require a careful analysis of the results of the study.

The level of game readiness of athletes depends on the effectiveness of certain elements of the game technique in terms of responsible competitions. This determines the achievements in the international arena and their competitiveness. Analysis of the strengths and weaknesses of the training of athletes requires special attention to the technical components and physical shortcomings, which need to be addressed [16-20]. The directions of improving the training of athletes mentioned by the authors are focused on elite athletes.

Shankulov et al. [21] found that the load of athletic orientation in elite teams prevails by 10-15%. Other studies [22-24] have modernized the process of training beach volleyball athletes by developing the structure and content of the annual cycle. The authors propose to increase the amount of training and competitive work, diverse use of techniques. Kostukov [6, 18] substantiates the training programs used in the physical, technical, tactical and medical-biological aspects of training beach volleyball athletes. Other authors [25-27] investigated the changes in the game that occurred due to the change in the

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rules of the game. The game has become unpredictable, competitive, spectacular due to the overall increase in active actions of athletes. Drikos et al. [28] determined the effectiveness of the elements of the game technique. The authors derived the coefficients of efficiency of service and attack (the ratio of goals won to lost). Such recommendations of the authors make it possible to plan the load depending on the individual characteristics of each athlete.

Araújo et al. [29] investigated the efficiency coefficients of different types of blocks depending on the court zones. The authors state the constant processes of adaptation in the game in attack and defense to the manner of playing the game by the opponent. Silva et al. [30] stated the fact that analytical studies in classical volleyball were comparative and prognostic. Medeiros et al. [31] have studied the analytical materials of beach volleyball games and claim a gradual transition from descriptive to comparative and prognostic. Balasas et al. [32] claim that the accentuated effect of athletic orientation for 12 weeks increases the strength of the leg muscles and the effectiveness of the jump (by 11.6%) on hard surfaces. Lin [33] and Hunchenko [34] argue that the use of multidirectional and multifaceted serving significantly increases the effectiveness of action team. The ability to perform the following technical actions better than the previous ones leads to a significant reserve to improve the effectiveness of the game in general [35-40]. Other authors [41-43] emphasize the development of accuracy through strength exercises. Such approaches of the authors indicate the need to find new approaches in the training of elite volleyball players [44-46]. Tili et al. [47], Wnorowski et al. [48] investigated the anthropometric data of the winners of games under the aegis of the FIVB before and after changes in the rules of the game and depending on the specialization. Other studies [49, 50] have shown the effectiveness of setting the ball to qualified volleyball players in competitive conditions. Such approaches are focused on supporting coaches and players to develop game strategies, exercise planning.

These studies prove the importance of physical fitness of beach volleyball athletes. The variety of approaches to improving the components of physical fitness of athletes requires consideration of specific training conditions. The fact that there are no examples of the use of training devices in the training of athletes is noteworthy. Analysis of research to improve the structure and content of special physical training of beach volleyball athletes indicates the need for further research.

The purpose of the study is to determine the impact of the components of special physical training on the effectiveness of certain elements of the game technique during the competitive activities of beach volleyball athletes.

Material and methods

Participants. The study involved athletes (n = 20, age - 17-21 years, experience - 8-9 years), who are engaged in beach volleyball (Kherson, Ukraine). All participants gave written consent to participate in the experiment. Athletes were evaluated by 5 experts (coaches with more than 20 years of experience). According to the video of the game, they distributed technical actions according to the quality of execution (high, medium, low levels).

Organization of the study. The study was conducted on the basis of Kherson State University (Kherson, Ukraine), sports school № 6 (Kherson, Ukraine). The pedagogical experiment was conducted in two stages. At the first stage (December 2018 - April 2019) included the preparatory period of the annual cycle. It consisted of conducting the training process according to the program of the sports school [51]. The program of sports school on beach volleyball provides: theoretical (42 hours); physical (358 hours, including general - 100 hours and special physical - 258 hours); technical (398 hours); tactical (510 hours); psychological and competitive training (200 hours); testing (28 hours); pedagogical reserve (128 hours).

The second stage was held from December 2019 to March 2020. It consisted of conducting classes on the author's structure and content of special physical training of athletes (preparatory period of the annual cycle). The author's program was to increase the volume of athletic work by 10% (selective classes and integrated work) and 17% (complex classes). The increase was due to the use of pedagogical reserve time. The classes used a developed special training device. The device is designed to practice practical skills of the game [52]. 704 hours (32 hours per week) were allocated for the training process during the training period. The load at the first stage of the experiment was 70-80% of the maximum, at the second - 80-90% of the maximum.

At the end of each stage, the control of special physical fitness was carried out according to the control tests: 30 meter sprint test (s); running in place (10s; number of steps); 4x10 meter Shuttle run (s); "92 m running with changing direction" test (s) (fig. 1); running 400 m (min, s); long jump (cm); attack jump test, cm (maximum vertical jump with run up approach); overhead medicine ball (2kg) throw (cm); handgrip strength test - right and left hand (kg); Pull-Up Bars (quantity of times) [32].

The games of the Championship of Ukraine (U-21) and the open championship of Kherson State University in beach volleyball (Kherson, Ukraine) were videotaped. Recording was conducted only for athletes who participated in the experiment. The method of expert evaluation of athletes' actions on the basis of video recordings was used. Five experts (trainers with more than 20 years of experience) were involved. The analysis of performance of separate elements of beach volleyball techniques in competitive conditions (quantitative and qualitative indicators, with a gradation of quality of performance - high, average and low) was carried out.

Statistical analysis. We used the program Microsoft Excel 2007. Determined the arithmetic mean, standard deviation, reliability coefficients. The coefficients of efficiency of each technical action in competitive conditions and correlation coefficients of tests of special physical training and elements of game technique were

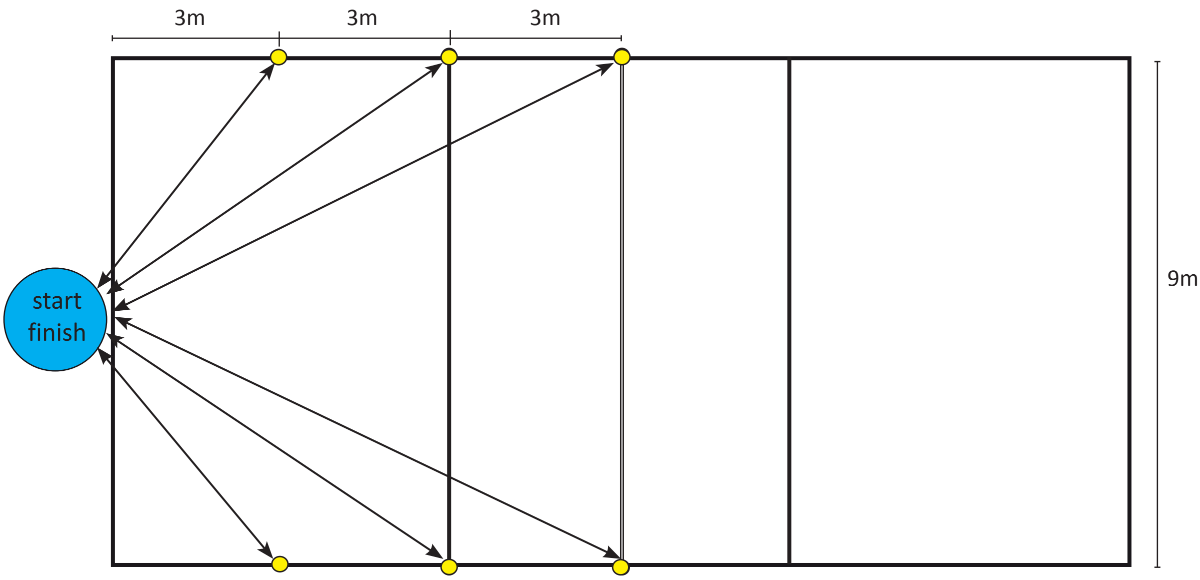

Figure 1. Test "92 m running with changing direction" (scheme)

also determined. Statistical significance was established at $p < 0.05$.

Results

The opinions of the experts on each of the technical actions were sufficiently consistent. The coefficients of variation range from 8.15% to 12.47%. Since $V \leq 15\%$, the opinions are consistent, the set is homogeneous and the results can be trusted.

Table 1 shows the average indicators of special physical training of athletes in the first and second stages of the experiment.

At the end of the pedagogical experiment, the average indicators of special physical fitness of athletes indicate the following: the rate of speed abilities corresponds to the level of assessment of "good"; speed of movement - a high level; dexterity - "excellent"; endurance - "satisfactory"; explosive force - "excellent"; explosive strength of the muscles of the torso and arms - "excellent"; arm flexor strength - "satisfactory"; handgrip strength test (dynamometry of the right and left arm) - the average level of physical development.

The analysis of indicators (Table 1) shows that the developed and implemented structure and content of special physical training of athletes contributed to a significant reliable ($p < 0.05$) development of the explosive force of the extensor muscles. The speed also experienced a significant ($p < 0.05$) increase. The strength of the flexor muscles of the upper extremities has significant ($p < 0.05$) differences at the lower limit of the representativeness error. The strength of the muscles of the torso and extensors of the arms outweigh the similar indicators of the first stage. The differences are statistically significant ($p < 0.05$). The proposed structure and content of special physical training of athletes fully contributed to the development of flexor muscles of athletes' limbs. Indicators of arm and leg flexor muscles do not have significant dynamics of improvement: the changes are significant ($p < 0.05$), but their result has changed from the level of evaluation "unsatisfactory" to the level of evaluation "satisfactory".

Table 2 shows the indicators of attacking actions of athletes in competitive conditions in the first and second stages of the experiment. Analysis of attack performance indicators (Table 2) indicates the presence of significant ($p < 0.05$) differences in technical performance indicators. The quantitative indicator of serving strategy (1. Serving high, placing the ball short; 2. Serving high, placing the ball deep; 3. Serving low, placing the ball short; 4. Serving low, placing the ball deep) performance has decreased. However, the indicator did not reach the appropriate level of reliability ($p > 0.05$).

Table 3 shows the indicators of action in defense. Analysis of performance indicators in defense in competitive conditions indicates the presence of significant differences (Table 3). Thus, the rate of quality of reception has increased significantly. This indicates a significant improvement in the efficiency of this technical action. Quantitative and qualitative indicators of the game in defense has increased slightly. However, the changes did not reach the appropriate level of reliability ($p > 0.05$).

Table 4 shows the coefficients of effectiveness of action in the attack of athletes in competitive conditions in the first and second stages of the experiment. This ratio was calculated by the ratio of successful actions (high level of performance) to all actions from a particular element of the game technique. Analysis of the effectiveness of game actions in the attack (Table 4) shows that most indicators of technical action have increased significantly. It is established that most of the indicators of efficiency of the performed technical actions at the second stage of the experiment improved in relation to the first. The jump serve efficiency indicator improved by 0.03 units. It should also be noted the significant increase in goals scored due to this technical action. At the same time, the efficiency of tactical delivery has an increase. Passing efficiency increased by 0.1 units.

Table 1. Average indicators of special physical training of athletes in the first and second stages of the experiment (n = 20)

Tests	Statistical indicators					
	First stage of the experiment (n=20)		Second stage of the experiment (n=20)			
	X̅	S	X̅	S	t	p
30 meter sprint test (s)	4.51	0.19	4.0	0.08	**-10.59**	<0.05
Running in place (10s.; number of steps)	67.05	5.37	72.3	4.64	**3.23**	<0.05
4x10 meter Shuttle run (s)	6.74	0.22	6.51	0.07	**-4.29**	<0.05
"92 m running with changing direction" test (s)	24.37	0.86	23.39	0.79	**-3.66**	<0.05
Running 400 m (min, s)	1.1	0.11	1.0	0.52	-1.96	>0.05
Long jump (cm)	264	0.16	296	0.06	**8.19**	<0.05
Attack jump test (cm)	66.75	5.32	84.7	2.74	**13.8**	<0.05
Overhead medicine ball (2kg) throw (cm)	821	0.45	864	0.32	**3.42**	<0.05
Handgrip strength test, right hand (kg)	43.85	13.61	50.2	11.69	1.54	>0.05
Handgrip strength test, left hand (kg)	38.45	15.08	47.3	12.5	1.97	>0.05
Pull-Up Bars (number)	10.4	3.83	13.0	3.38	**2.27**	<0.05

Table 2. Indicators of attacking actions of athletes in the first and second stages of the experiment (n = 20)

№	Technical actions	First stage of the experiment		Second stage of the experiment		Δx	t	p
		X̅	S	X̅	S			
1	Number of jump serve	1.05	1.05	4.5	2.48	2.09	**5.58**	<0.05
	High level of jump serves	0.4	0.68	1.85	1.13	2.09	**4.77**	<0.05
2	Number of tactical serves	21.6	3.6	19.2	3.65	2.09	-1.78	>0.05
	High level of serve	6.0	7.36	8.4	2.5	2.09	1.34	>0.05
3	Number of settings	19.05	9.6	19.35	8.85	2.09	0.1	>0.05
	High level of settings	13.5	9.58	16.15	8.82	2.09	0.89	>0.05
4	Number of tactical attacks	15.4	7.98	12.6	5.69	2.09	-1.25	>0.05
	High level of tactical attacks	4.35	3.34	6.75	2.36	2.09	**2.56**	<0.05
5	Number of attacks	6.9	4.76	13.5	2.95	2.09	**5.14**	<0.05
	High level of attack	3.95	3.69	8.1	1.33	2.09	**4.61**	<0.05

Table 3. Indicators of protective actions of athletes in the first and second stages of the experiment (n = 20)

№	Technical actions	First stage of the experiment		Second stage of the experiment		Δx	t	p
		X̅	S	X̅	S			
1	Number of passing (the forearm pass, overhead passing)	22.55	9.25	23.35	7.47	2.09	0.66	>0.05
	High level of passing (the forearm pass, overhead passing)	14.9	9.07	19.55	6.58	2.09	**2.10**	<0.05
2	Number of technical actions in defense	15.9	10.26	16.85	9.21	2.09	0.30	>0.05
	High level of technical actions in defense	8.15	5.07	11.25	5.44	2.09	1.82	>0.05
3	Number of technical actions blocks	12.75	18.32	18.35	16.86	2.09	0.98	>0.05
	High level of technical actions blocks	2.35	2.92	7.05	5.53	2.09	**3.27**	<0.05

Table 4. Coefficients of effectiveness of action in the attack in the first and second stages of the experiment (n = 20)

Stage of the experiment	Attack Actions				
	Jump serve	**Tactical serve**	**Setting**	**Attack**	**Tactical attack**
First	0.38	0.31	0.71	0.57	0.28
Second	0.41	0.49	0.84	0.6	0.54

Table 5. Coefficients of effectiveness of actions in defense at the first and second stages of experiment (n = 20)

Stage of the experiment	Defense Actions		
	Passing	**Game in defense**	**Blocking**
First	0.66	0.51	0.18
Second	0.84	0.67	0.38

Table 6. Correlation coefficients between indicators of special physical fitness and indicators of action in the attack of athletes before and after the second stage of the experiment (n = 20)

Tests/indicators of game technics	Stages of the experiment	Number of jump serve	High level of jump serves	Middle level of jump serves	Number of tactical serves	High level of tactical serves	Middle level of tactical serves	Number of setting	High level of setting	Number of attacks	High level of attack	Middle level of attack	Number of tactical attacks
Tests		**Correlation coefficients between indicators**											
30 meter sprint test (s)	before	0.10	**0.37**	-0.10	-0.10	0.13	0.12	-0.07	0.04	**0.41**	0.29	0.23	0.03
	after	**0.37**	**0.32**	0.20	0.06	-0.13	0.29	0.19	0.27	**0.43**	**0.36**	**0.41**	-0,23
Running in place (10s.; number of steps)	before	-0.10	**-0.35**	0.20	**0.34**	**0.3**	-0.17	0.19	0.27	-0.01	0.22	**-0.43**	0.06
	after	0.14	0.05	**0.31**	0.29	0.29	0.15	**0.32**	**0.36**	-0.23	-0.11	-0.22	0.05
4x10 meter Shuttle run (s)	before	**-0.48**	**-0.34**	**-0.58**	-0.05	0.22	**-0.35**	**0.32**	0.22	0.13	0.15	0.25	-0.10
	after	**-0.46**	-0.25	**-0.54**	-0.24	-0.15	-0.19	0.25	-0.04	0.26	0.20	0.11	-0.21
"92 m running with changing direction" test (s)	before	**-0.31**	0.01	**-0.61**	-0.29	0.26	**-0.42**	**0.3**	0.09	0.26	0.27	0.21	**-0.41**
	after	**-0.39**	-0.21	**-0.60**	-0.13	0.03	**-0.34**	0.17	-0.09	0.27	0.25	0.29	**-0.3**
Long jump (cm)	before	0.58	**0.39**	**0.61**	**-0.31**	**-0.30**	-0.23	0.23	**0.43**	**0.41**	**0.42**	-0.01	**-0.44**
	after	**0.60**	**0.57**	**0.50**	-0.27	**-0.35**	0.18	**0.53**	**0.52**	**0.4**	**0.37**	-0.22	**-0.48**
Attack jump test (cm)	before	**0.54**	0.18	**0.55**	-0.05	-0.16	0.16	-0.27	-0.18	**0.31**	**0.44**	0.1	**-0.31**
	after	**0.49**	0.27	**0.50**	-0.1	0.03	-0.03	-0.26	-0.24	**0.51**	**0.48**	0.28	-0.27
Overhead medicine ball (2kg) throw (cm)	before	0.11	0.12	0.08	-0.03	0.06	-0.15	**0.38**	**0.30**	0.11	0.21	-0.12	-0.17
	after	0.26	0.23	0.22	-0.29	-0.17	-0.13	**0.52**	**0.43**	0.14	0.21	-0.28	-0.32
Pull-Up Bars (number)	before	**0.36**	-0.07	**0.35**	**0.31**	0.24	0.16	0.17	**0.40**	**0.36**	**0.48**	-0.23	0.22
	after	**0.38**	0.22	**0.55**	0.21	0.29	0.25	0.18	**0.33**	**0.30**	**0.38**	**-0.34**	-0.03

Table 5 shows the coefficients of effectiveness of actions in defense in competitive conditions in the first and second stages of the experiment. The analysis of indicators indicates that the effectiveness of actions in the second stage of the experiment exceeds the performance indicators of the first stage. In particular, the efficiency of passing and blocking prevails by 0.2 units, and in defense - by 0.16 units. Blocking is the most difficult and effective means of defense. This indicates a significant increase in the overall effectiveness of gaming in competitive conditions.

Table 6 shows the correlation coefficients between the indicators of special physical fitness and action in the attack of athletes (competitive conditions in the first and second stages of the experiment). In most cases, we note a slight increase in the coefficients after the second stage of the experiment (Table 6).

Table 7 shows the correlation coefficients between indicators of special physical fitness and quantitative and qualitative indicators of actions in the protection of athletes in competitive conditions. The data of the relationship between the studied components of protection in the test "30 meter sprint test (s)" had a positive effect on the performance of blocks. There is a negative relationship with the indicators of reception and play in defense. The "Running in place (10s.; number of steps)" test confirms a positive relationship with blocking (direct correlation) and a negative relationship with defensive performance.

The proposed experimental structure and content of special physical training of athletes contributed to a significant increase in the strength of the muscles of the extensors of the arms, thighs and legs. On this basis, they contributed to the development of explosive power. This had a real impact on the performance of competitive activities in technical actions with the manifestation of explosive force: jump serve, attack, blocking.

The obtained reliable data ($p < 0.05$) changes in the indicators of explosive force, dexterity and strength of extensor muscles contributed to more drastic changes in the indicators of action in defense in competitive conditions. This trend was observed by us in previous studies [34-36].

The general trend of the relationship between the leading physical qualities and the level of performance of certain techniques of the game technique indicates the quality of performance of the elements of the game technique in the attack. The quality of performance of the elements of the technique of play in defense depends

Table 7. Correlation coefficients between indicators of special physical fitness and indicators of action in the defense of athletes before and after the second stage of the experiment (n = 20)

Tests/indicators of game technique	**Stages of the experiment**	**Number of passing**	**High level of passing**	**Middle level of passing**	**Number of games in defense**	**High level of games in defense**	**Middle level of games in defense**	**Number of blocks**	**High level of blocks**	**Middle level of blocks**	**Low level of blocks**
Tests		**Correlation coefficients between indicators**									
30 meter sprint test (s)	before	**0.31**	0.24	0.19	0.49	**0.47**	0.12	-0.22	**-0.39**	-0.06	**-0.3**
	after	0.41	0.37	0.48	0.49	**0.48**	0.16	**-0.31**	**-0.34**	-0.12	**-0.37**
Running in place (10s.; number of steps)	before	0.17	0.24	-0.01	-0.36	-0.32	-0.13	0.39	0.3	0.35	0.43
	after	0.18	0.20	0.26	-0.35	**-0.31**	0.02	**0.37**	**0.41**	0.26	**0.43**
4x10 meter Shuttle run (s)	before	0.24	0.06	**0.39**	-0.07	-0.07	**-0.32**	0.14	0.1	0.2	0.08
	after	0.15	0.05	**0.48**	0.06	-0.09	**-0.31**	0.03	-0.05	0.1	0.06
"92 m running with changing direction" test (s)	before	**0.31**	0.05	**0.49**	-0.01	-0.02	**-0.4**	0.19	-0.04	0.29	0.17
	after	**0.34**	0.23	**0.49**	0.13	0.01	**-0.43**	0.11	-0.05	0.12	-0.02
Long jump (cm)	before	-0.03	0.15	-0.13	**-0.55**	**-0.61**	**-0.33**	0.3	0.33	0.22	**0.33**
	after	0.22	**-0.38**	**-0.32**	**-0.61**	**-0.64**	**-0.33**	**0.59**	**0.66**	**0.48**	**0.59**
Attack jump test (cm)	before	-0.25	-0.01	**-0.57**	-0.25	-0.18	**-0.47**	0.22	0.26	0.13	0.29
	after	**-0.56**	**-0.41**	**-0.36**	-0.13	-0.16	**-0.31**	0.25	0.24	0.12	0.27
Overhead medicine ball (2kg) throw (cm)	before	**-0.42**	**-0.42**	-0.15	**-0.41**	**-0.42**	0.1	0.23	**0.42**	0.17	0.29
	after	**-0.36**	**-0.31**	-0.11	**-0.58**	**-0.61**	-0.1	**0.46**	**0.54**	**0.32**	**0.41**
Pull-Up Bars (number)	before	0.23	0.27	-0.03	**0.34**	**0.41**	0.13	0.06	-0.01	0.09	0.05
	after	0.2	0.21	0.11	**0.31**	0.27	0.17	0.21	0.19	0.18	0.2

on the level of development of the strength of the flexor muscles of the upper and lower extremities.

Discussion

Beach volleyball is currently developing rapidly in the world. Scientists note that recently the game has undergone significant changes in connection with the objective process of game development, as well as significant changes in the rules of the competition [18, 25-27]. In recent years, issues related to the construction of the training process in classical and beach volleyball have been studied in detail [19, 23, 24]. Today, there are not enough studies that reveal the structure and content of special physical training of beach volleyball athletes. The aim of the study was to determine the impact of the components of special physical training on the effectiveness of certain elements of the game technique during the competitive activities of beach volleyball athletes.

The level of manifestation of leading physical qualities in the chosen sport plays one of the leading roles in the realization of individual potential of athletes in competitive conditions. In comparison with the data of the first and second stages of the experiment, we observe a significant (p <0.05) improvement in the level of explosive force. It is manifested in the shortest possible time in competitive activities (strikes of force and tactical nature in the attack and blocking). This is evidenced by the indicators of the tests "Long jump, cm" and " Attack jump test, cm"). The indicators obtained by us complement and confirm the opinion of scientists [25, 32, 33, 37]. The authors note that the special physical training of athletes in the training process fully promotes the development of extensor muscles in the knee joint and ankle joint. This affects the explosive force when performing jumps for tactical strikes and blocks. Training on sandy areas ~~loose soil~~ requires more effort than indoors.

The use of integrated exercises in conditions of time deficit significantly (p <0.05) had an impact on improving dexterity in the tests "4x10 meter Shuttle run, s" and ""92 m running with changing direction" test). At the end of the second stage of the experiment, we observe a significant (p <0.05) improvement in speed and movement rate of athletes. Test results "30 meter sprint test, s" and " Running in place (10s.; number of steps)" indicate this. Analysis and comparison of the obtained data with the results of other studies allows us to state that special physical training and variability of technique cause positive changes in the results of competitive activities. This conclusion confirms the data available in the literature of other authors [6, 15, 16. 21].

The use of a well-founded author's program of special physical training of athletes contributed to a significant (p <0.05) improvement of competitive activity indicators: quantity and quality of serving floaters and jump serves; quality of serving (the forearm pass, overhead passing); quantity and quality of blocking. This is due to the fact that most serving (serving floaters and jump serves) complicate the defensive actions of their opponents. Confirmation of our positions are the results of other studies [9, 21, 30, 34]. The authors note that in such cases this leads to a winning win.

The coefficients of effectiveness of game actions in attack and defense at the end of the experiment significantly (p <0,05) increased. It should be noted the increase in the efficiency of jump serves by 0.03 and setting - by 0.13 units. We also note an increase in the number of goals scored and spike by 0.03 units, soft spike - by 0.26, passing - by 0.18 and the number of blocks - by 0.2 units. Drikos et al. [28], Araújo et al. [29] suggest that there is a significant relationship between attack effectiveness and set outcome. Teams that win a set make fewer mistakes and are more effective in attacking. There is an increase in the effectiveness of technical actions in attack and defense, depending on the level of preparedness of the team.

The high level of speed qualities of athletes positively (p <0.05) contributed to the improvement of tactical and power strikes and blocking. It should be noted that the agility of athletes significantly (p <0.05) affected the performance of jump serves, soft spike (half-speed shot, off-speed shot, change of pace) and passing. Also, we note that explosive force positively increased technical actions of force and tactical character, passing and blocking. This means that attacking and defensive skills are related to the agility, strength and speed abilities of athletes. Silva et al. [30], Tili et al. [47] show that athletes in the game make mistakes in attack and defense. Athletes' mistakes determine the effectiveness of the match (win / lose). In this context, improving the effectiveness of game activities should be a priority in the training process at the level of improving the development of leading physical qualities. It is necessary to use in the preparation of attackers and blockers the most common in practice game situations and effective solutions to game problems [30, 47].

Our research is a confirmation that the author's program of special physical training of athletes contributed to the development of physical qualities and variability of the game technique. The structure and content provided for the redistribution of hours of pedagogical reserve for selective and comprehensive classes. The training sessions used a developed training device to practice practical ball skills. Indicators of special physical fitness of beach volleyball athletes have a positive effect on the effectiveness of the elements of the technique of the game in competitive conditions. Our data complements and expands the available information on the content of the training period for team sports athletes.

Conclusions

The positive influence of the components of special physical training on the effectiveness of certain elements of the game technique during the competitive activity of athletes is determined. The experiment was based on: a sound structure and content of special physical training of athletes; author's simulator. It is recommended to take into account that strength abilities, speed qualities and dexterity significantly improve the game actions in attack (both jump and tactical serves and attacks, passing) and defense (digs and blocks). The obtained data complement and confirm new approaches to improving the level of special physical fitness of athletes, which affects the results of their competitive activities.

The revealed regularities and features of influence of physical qualities on efficiency of competitive activity testify to expediency of their account: in system of sports selection; in the control of sports fitness; in the prevention of adverse changes; in the optimization of the training process.

Conflicts of Interest

The authors declare no conflict of interest.

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ORIGINAL ARTICLE

Discriminant analysis: peculiarities of impact of sports specialization on 3rd-year female students' functional and motor fitness

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Abstract

Background and Study Aim The objective of the study was to determine the peculiarities of impact of sports specialization on 3rd-year female students' functional and motor fitness.

Material and Methods The study involved 3rd-year female students of the Donbas State Engineering Academy in Kramatorsk, who practiced badminton (n = 43), aerobics (n = 43), and callanetics (n = 43). To solve the tasks set, the following research methods were used: analysis of scientific literature, pedagogical observation, pedagogical testing; index method and medical-biological methods. Pedagogical methods were used to study the peculiarities of students' functional state of the body and motor abilities; for data processing discriminant analysis was used. Sectional classes were held in groups according to the schedule – twice a week.

Results The study revealed the peculiarities of impact of attending badminton, aerobics, and callanetics sports sections on the level of 3rd-year female students' functional and motor fitness. The female students who play badminton show better results in the 100-meter dash and the Standing long jump. In the exercise "Push-ups", better results are shown by the female students who do aerobics.

Conclusions The results of classification of students by the level of motor and functional fitness and the analysis of multidimensional averages (centroids) point to the peculiarities of dynamics of female students' state depending on sports specialization. The results of the following tests are most important for differentiated assessment of the state of motor and functional fitness at the first level: Romberg test (r = 0.662), 100-meter dash (r = 0.491), Push-ups (r = 0.491). At the second level – Stange test (r = 0.417), Standing long jump (r = 0.412).

Keywords: students, badminton, aerobics, callanetics, discriminant analysis.

Introduction

Recently, there has been a noticeable deterioration in the state of health and a decline in motor fitness of students throughout the country, which causes concern among physical education specialists [1-3].

Decreased physical activity and motivation to exercise among adults, as well as children and young people is a global phenomenon [4-6]. Sigmundová et al. [4] point out that 69% of female students and 74% of male students of Czech universities meet the 10,000 steps daily criterion on four or more days per week; Cachón-Zagalaz et al. [5] focus on using the method for identifying professionally important qualities as components of a student's competency levels and their physical activity levels; Doroshenko et al. [6] indicate that taking into account female students' motor age during recreational aerobics classes ensures optimal motor activity and increases the level of physical fitness.

A number of studies are aimed at studying the dynamics of motor fitness [7-9], the influence of predominant orientation means on students' motor and functional fitness [10-12], methods of fundamental movement screening [13-15].

Much less research focuses on studying the functional peculiarities of the cardiovascular and respiratory systems, motor fitness of student youth under the influence of sports [1, 16, 17].

Multidimensional methods of mathematical statistics, such as factor and discriminant analysis are effective methods of studying the peculiarities of functional and motor fitness [18, 19, 20]. Discriminant analysis is used to assess both the results of sports training [21-23] and recreational classes [24-26].

The objective of the study was to determine the peculiarities of impact of sports specialization on 3rd-year female students' functional and motor fitness.

Materials and methods

Study participants

The study involved 3rd-year female students of the Donbas State Engineering Academy in Kramatorsk, who practiced badminton (n = 43), aerobics (n = 43), and callanetics (n = 43). The study started after the approval of the Research Ethics Committee of the Academy.

Study organization

To solve the tasks set, the following research methods

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were used: analysis of scientific literature, pedagogical observation, pedagogical testing; index method and medical-biological methods. Pedagogical methods were used to study the peculiarities of students' functional state of the body and motor abilities; for data processing discriminant analysis was used. Sectional classes were held in groups according to the schedule – twice a week.

Testing procedure

The testing program included well-known tests proposed by Serhiyenko [27]: Standing long jump (cm), 100-meter dash (s), Push-ups (times), Romberg test.

The Ruffier index, the Stange test, the Genchi test were used to assess the functional state [28, 29].

Ruffier-Dickson index. The test was used to assess cardiovascular performance during exercise.

Equipment: Stopwatch, tonometer, a device for measuring blood pressure.

Testing procedure. After 5 minutes of sitting calmly, the number of pulses was counted for 15 seconds (P1). Then 30 squats were performed for 45 seconds, using a metronome. Immediately after squatting, the pulse was measured for the first 15 seconds (P2) and the last 15 seconds (P3) of the first minute after the end of exercise.

Testing evaluation. The results are evaluated by an index determined by the formula: Ruffier index = (P3 + P2 – P1 – 70)/10. Ruffier index: 0–5 - good cardiovascular performance; 5.1–10 - average result; 10.1–15 - satisfactory (moderate heart insufficiency); 15.1–20 - bad (significant heart insufficiency).

Stange test. The test was used to assess the functional state of the respiratory system.

Equipment: Stopwatch.

Testing procedure. In a sitting position, the subject inhales deeply and exhales, then inhales again (approximately 80% of the maximum), closes the mouth and simultaneously pinches the nose with fingers, holds breath (timing begins when inhale finishes and stops when exhale starts).

Testing evaluation. Breathhold: up to 35 s - fatigue; for 40-55 s - healthy untrained; for 60-90 s - healthy trained.

Genci test. The test was used to assess the functional state of the respiratory system.

Equipment: Stopwatch.

Testing procedure. The Genci test involves breath-holding after exhalation. It was conducted not earlier than 5-7 minutes after the Stange test.

Testing evaluation. Breathhold: up to 20 s - fatigue; for 25–30 s - healthy untrained; for 40–60 s - healthy trained.

Romberg test. The test is used to assess static balance.

Equipment: Stopwatch.

Testing procedure. The participant stands with the feet on one line, one in front of the other, eyes closed, arms forward. Timing begins at the moment when a steady position is assumed, the test stops when the steady position is lost.

Result. The time of holding a steady position in seconds is recorded.

Testing evaluation. Normally, balance should not be lost for 30 seconds.

Statistical analysis

The study results were processed by the method of mathematical statistics. The following parameters were calculated: arithmetic mean (x), error in calculating the arithmetic mean (s); significance of difference between means (t). The significance of difference between statistical indicators (t) was evaluated using the Student's t-test. Discriminant analysis created a prognostic model for group membership. This model builds a discriminant function (or, for more than two groups, a set of discriminant functions) in the form of a linear combination of predictor variables, which provides the best discrimination between the groups. These functions are developed from a sample of cases for which their group membership is known. These functions can be further used for new cases with known values of predictor variables and unknown group membership. For each variable, the following values are calculated: means, standard deviations, one-way ANOVA (Box's M test, within-group correlation matrix, within-group covariance matrix, covariance matrices for separate groups, total covariance matrix). For each canonical discriminant function: eigenvalue, percentage of variance, canonical correlation, Wilks' Lambda, Chi-square. For each step: prior probabilities, Fisher's function coefficients, unstandardized function coefficients, Wilks' Lambda for each canonical function.

Results

Tables 1-2 show the results of analysis of the motor and functional fitness of 3rd-year female students attending badminton, aerobics, and callanetics sports sections. It was found that by the level of fitness the female students of the three groups differ statistically significantly both at the beginning of attending the section and after a year of training. According to the Ruffier index, the female students have a satisfactory level of heart performance. According to the indicators of the Stange test, they are assessed as healthy untrained. According to the Genchi test – as healthy trained. According to the Romberg test indicators, the female students show below normal results.

The female students who play badminton show better results in the 100-meter dash and the Standing long jump. In the exercise "Push-ups", better results are shown by the female students who do aerobics.

Discriminant analysis was conducted to identify the peculiarities of the female students' motor and functional fitness. The first canonical function explains 53.5% of the variation of results, the second function – 34.1%, which indicates their high informativeness (r_1 = 0.619; r_2 = 0.532) (see Table 3). The materials of analysis of the canonical functions show a statistical significance of the first, second, and third canonical functions (λ_1 = 0.384; p_1 = 0.001; λ_2 = 0.623; p_2 = 0.001; λ_3 = 0.870; p_2 = 0.002). The first, second, and third functions have a high discriminative ability and value in interpretation of the general population (Table 4).

Tables 5 and 6 show the standardized and structure canonical discriminant function coefficients. The results of the following tests are most important for differentiated

Table 1. Group Statistics

Indicators	Badminton				Aerobics				Callanetics			
	pre-test		post-test		pre-test		post-test		pre-test		post-test	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Ruffier index	14.7	5.1	14.3	4.2	14.3	4.2	12.0	3.4	12.9	3.1	12.6	2.9
Stange test, s	55.1	17.2	64.0	31.8	44.8	9.8	49.8	11.7	38.6	12.1	44.1	12.9
Genchi test, s	43.5	10.7	41.4	15.0	31.0	7.6	35.3	8.1	32.5	10.1	40.1	12.4
Romberg test, s	7.0	4.2	5.7	2.7	10.9	7.4	13.3	6.1	4.7	3.4	6.6	5.2
100-meter dash, s	16.2	1.7	15.8	1.7	17.7	1.2	17.2	1.0	17.6	1.2	17.3	1.1
Standing long jump, cm	198.3	31.1	208.8	32.5	179.1	14.2	184.8	14.0	179.3	15.6	180.4	30.3
Push-ups, times	15.7	6.8	16.9	7.3	18.8	5.3	22.3	4.1	16.6	6.7	17.1	6.3

Table 2. Tests of Equality of Group Means

Indicators	Wilks' Lambda	F	df1	df2	Sig.
Ruffier index	.937	3.387	5	252	.006
Stange test, s	.816	11.381	5	252	.000
Genchi test, s	.844	9.290	5	252	.000
Romberg test, s	.734	18.218	5	252	.000
100-meter dash, s	.784	13.925	5	252	.000
Standing long jump (cm)	.822	10.919	5	252	.000
Push-ups, times	.890	6.240	5	252	.000

Table 3. Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.621[a]	53.5	53.5	.619
2	.396[a]	34.1	87.6	.532
3	.087[a]	7.5	95.1	.283
4	.054[a]	4.6	99.7	.226
5	.003[a]	.3	100.0	.058

Table 4. Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 5	.384	239.511	35	.000
2 through 5	.623	118.447	24	.000
3 through 5	.870	34.967	15	.002
4 through 5	.946	14.016	8	.081
5	.997	.845	3	.839

assessment of the state of motor and functional fitness at the first level: 100-meter dash (r = 0.586), Standing long jump (r = -0.493). At the second level – Romberg test (r = 0.614), at the third level – Genci test (r = -0.803).

The analysis of multidimensional averages (centroids) shows different levels of motor and functional fitness of the female students according to pre-test and post-test results. There are peculiarities of dynamics of the female students' state depending on sports specialization (Table 7, Fig. 1).

Discriminant analysis of the three groups. Post-test

To clarify the impact of specialization on the 3rd-year female students' functional and motor fitness, the study conducted a discriminant analysis of post-test results in groups practicing badminton, aerobics, and callanetics. The first canonical function explains 66.4% of the variation of results, the second function – 33.6%, which indicates their high informativeness (r_1 = 0.689; r_2 = 0.560) (Table 8). The materials of analysis of the canonical functions show a statistical significance of the first and second canonical functions (λ_1 = 0.360; p_1 = 0.001; λ_2 = 0.686; p_2 = 0.001). The first and second functions have a high discriminative ability and value in interpretation of the general population (Table 9).

Tables 10 and 11 show the standardized and structure canonical discriminant function coefficients. The results of the following tests are most important for differentiated assessment of the state of motor and functional fitness at

Table 5. Standardized Canonical Discriminant Function Coefficients

Indicators	Function				
	1	2	3	4	5
Ruffier index	-.345	.401	.311	.696	.000
Stange test	-.236	.537	.321	-.200	.835
Genchi test	-.372	-.254	-.889	.276	.108
Romberg test	.526	.668	-.219	.440	-.171
100-meter dash	.435	-.062	.308	.089	.534
Standing long jump	-.073	.478	.438	-.169	-.377
Push-ups	.236	.257	-.126	-.570	-.033

Table 6. Structure Matrix

Indicators	Function				
	1	2	3	4	5
100-meter dash	.586*	-.373	.183	.266	.520
Standing long jump	-.493*	.386	.053	-.329	-.443
Romberg test	.558	.614*	-.410	.286	-.080
Genchi test	-.446	.100	-.803*	.054	.204
Ruffier index	-.205	.109	.378	.665*	.007
Push-ups	.347	.295	-.202	-.456*	.040
Stange test	-.412	.537	-.081	-.285	.624*

Table 7. Functions at Group Centroids

1, 3, 5 – pre-test; 2, 4, 6 – post-test	Function				
	1	2	3	4	5
1.00	-.863	.151	-.205	.302	-.070
2.00	-1.113	.545	.220	-.239	.042
3.00	.788	.280	.346	.308	.043
4.00	1.000	.698	-.263	-.217	-.036
5.00	.193	-.963	.287	-.161	-.060
6.00	-.005	-.710	-.386	.007	.080

Table 8. Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.905	66.4	66.4	.689
2	.458	33.6	100.0	.560

Table 9. Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 2	.360	125.654	14	.000
2	.686	46.381	6	.000

the first level: Romberg test (r = 0.662), 100-meter dash (r = 0.491), Push-ups (r = 0.491). At the second level – Stange test (r = 0.417), Standing long jump (r = 0.412).

The analysis of multidimensional averages (centroids) shows different levels of motor and functional fitness of the female students according to post-test results. There are peculiarities of dynamics of the female students' state depending on sports specialization (Table 12, Fig. 2). The results of classification of the female students by the level of motor and functional fitness show that 71.3% of the students were classified correctly (Table 13).

Discussion

The study assumed that on the basis of discriminant analysis it is possible to determine the peculiarities of the functional and motor fitness of female students attending badminton, aerobics, and callanetics sports sections. The testing of discriminant functions revealed that they have a high discriminative ability and value in interpretation of the general population.

The data presented add up to the results of the study by Ivashchenko [18, 30], Chernenko et al. [19] on the effectiveness of discriminant analysis in assessing

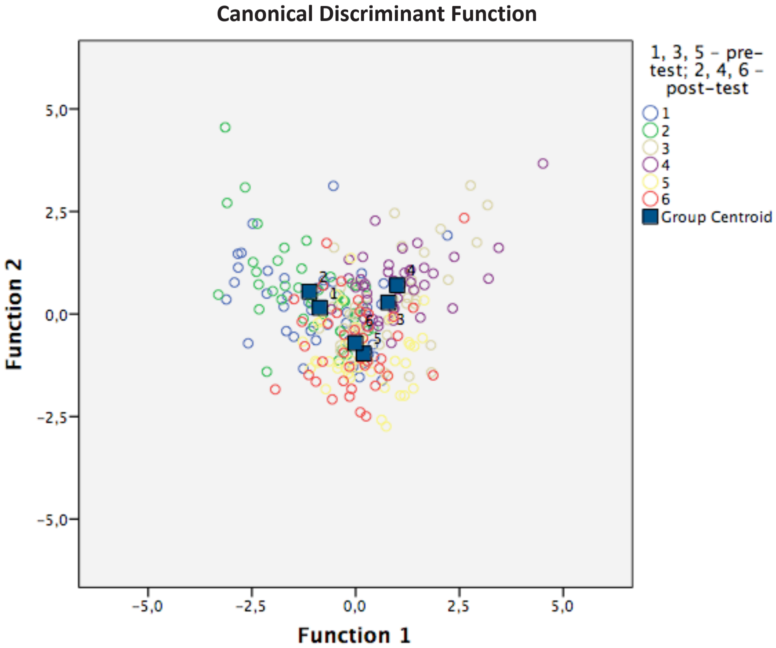

Fig. 1. Indicators of female students' fitness depending on sports specialization: 1, 2 – badminton; 3, 4 – aerobics; 5, 6 – callanetics

Table 10. Standardized Canonical Discriminant Function Coefficients

Indicators	Function	
	1	2
Ruffier index	-.502	.462
Stange test	-.276	.507
Genchi test	-.164	-.481
Romberg test	.577	.542
100-meter dash	.476	-.119
Standing long jump	-.044	.675
Push-ups	.286	.388

Table 11. Structure Matrix

Indicators	Function	
	1	2
Romberg test	.662*	.453
100-meter dash	.491*	-.396
Push-ups	.377*	.309
Ruffier index	-.281*	.094
Genchi test	-.214*	-.114
Stange test	-.302	.417*
Standing long jump	-.396	.412*

Table 12. Functions at Group Centroids

1 – badminton; 2 – aerobics; 3 – callanetics	Function	
	1	2
1.00	-1.171	.448
2.00	1.131	.498
3.00	.040	-.945

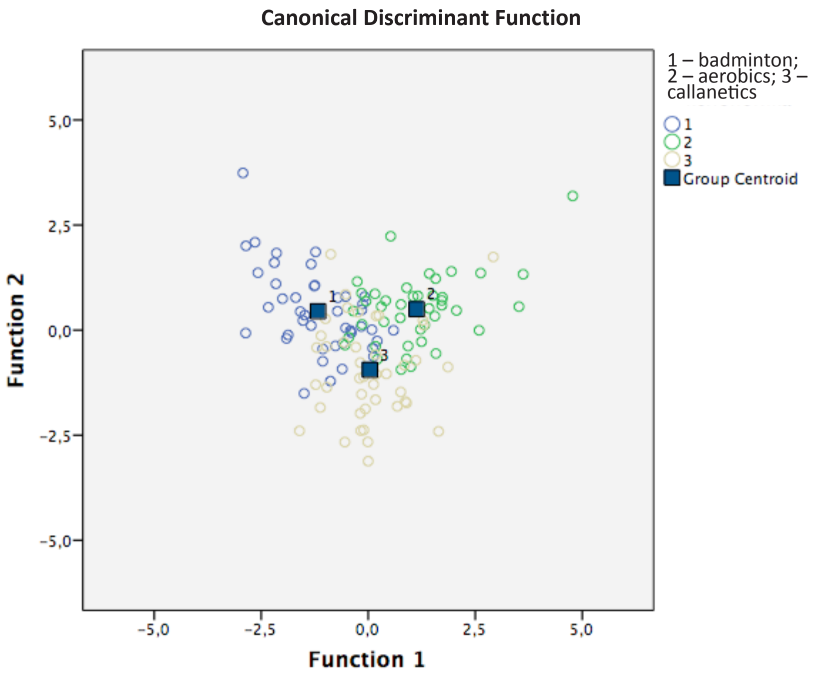

Fig. 2. Indicators of female students' fitness depending on sports specialization: 1 – badminton; 2 – aerobics; 3 – callanetics

Table 13. Classification Results

		1 – badminton; 2 – aerobics; 3 – callanetics	Predicted Group Membership 1.00	2.00	3.00	Total
Original	Count	1.00	32	1	10	43
		2.00	5	31	7	43
		3.00	8	6	29	43
	%	1.00	74.4	2.3	23.3	100.0
		2.00	11.6	72.1	16.3	100.0
		3.00	18.6	14.0	67.4	100.0

a.71.3% of original grouped cases correctly classified

students' functional and motor fitness.

The findings show that the 3rd-year girls most significantly differ in the results of coordination fitness testing. According to the Romberg test, the female students show below normal results. The data confirm that the third year is a problematic period in physical education of students [19]. The findings complement the information on the need for additional introduction of more intensive forms of classes into the system of physical education of students [2, 11, 31], on the importance of motor activity in the educational process of students [32-34].

An important conclusion is that the results of the following tests are most significant for differentiated assessment of the state of motor and functional fitness at the first level: Romberg test (r = 0.662), 100-meter dash (r = 0.491), Push-ups (p = 0.491). At the second level – Stange test (r = 0.417), Standing long jump (r = 0.412). The results complement the data on pedagogical control in physical education of students [6, 35].

Thus, to assess functional and motor fitness, the first discriminant function and the function value in group centroids can be used, as the results of classification of the female students by the level of motor and functional fitness show that 71.3% of the students were classified correctly.

Conclusions

The results of classification of students by the level of motor and functional fitness and the analysis of multidimensional averages (centroids) point to the peculiarities of dynamics of female students' state depending on sports specialization. Female students who play badminton show better results in the 100-meter dash and the Standing long jump. In the exercise "Push-ups", better results are shown by female students who do aerobics.

The results of the following tests are most important for differentiated assessment of the state of motor and functional fitness at the first level: Romberg test (r = 0.662), 100-meter dash (r = 0.491), Push-ups (r = 0.491). At the second level – Stange test (r = 0.417), Standing long jump (r = 0.412).

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