The influence of recreational exercises with tennis components on functional state and physical fitness of mature men, aged 40-49, residing in the Republic of Sakha

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

Elena V. Cherkashina [1ABCE], **Ilia A. Cherkashin** [1,2,3ABC], **Artur Kruszewski** [4ABCD], **Sergiei I. Gavrilev** [2BDE]

[1] Institute of Physical Culture and Sports, North-Eastern Federal University, Yakutsk, Russia
[2] Yakut State Agricultural Academy, Yakutsk, Russia
[3] Moscow State Academy of Physical Culture, Moscow Region, Malakhovka, Russia
[4] Department of Individual and Team Sports, Jozef Pilsudski Uniwersity of Physical Education in Warsaw, Warsaw, Poland

Received: 15 June 2019; **Accepted:** 22 September 2019; **Published online:** 20 December 2019

AoBID: 13669

Abstract

Background & Study Aim: Regular game of tennis positively affects cardiorespiratory and musculoskeletal systems, brain, helps to normalize body weight, develops dexterity, speed and endurance. Objective of the study was knowledge about the influence of recreational exercises with tennis components on functional state and physical fitness of mature men, aged 40-49.

Material & Methods: The sample consisted of 60 men: the experimental group (30 people aged 45 ±2.98 years); the control group (30 people aged 45 ±2.90 years). Two pedagogical tests were conducted before and after the experiment for men in the experimental and control groups. The functional state of the group under study was assessed seven times based on the analysis of heart rate variability (HRV) indicators.

Results: A cycle of recreational exercises with tennis components has been developed for men, aged 40-49, residing in the Republic of Sakha (Yakutia). The analysis of intergroup differences in HRV indicators after the experiment showed positive changes in the cardiovascular system in the experimental group members. All 16 studied indicators of HRV changed after one year of the experiment, which indicates a statistically significant improvement in the indicators of the physiological state ($p<0.05$). There was a significant decrease of the following indicators in comparison with the control group: stress index changed by 108.3%, LF/HF – by 101%, the indicator of activity of regulatory systems – by 231%, as well as an increase in HF (higher frequency of HRV) by 73% ($p<0.01$). In addition, throughout the experiment the experimental group showed positive dynamics of composite indices of heart rate regulation, myocardial and psychoemotional state, with a range of growth from 13% to 19%. There was an improvement in all tests of general and special physical fitness. The performance test figures for speed and dexterity significantly differ than those of the control group. The control group showed a proved improvement in the strength of the upper shoulder girdle muscles ($p<0.05$).

Conclusions: The positive influence of recreational exercises with tennis components on indicators of functional state, body weight, body mass index, as well as physical fitness of mature men, aged 40-49, residing in the Republic of Sakha (Yakutia) was revealed. They showed a decrease in the tension of regulatory systems, a decrease in humoral and metabolic effects on the heart rate regulation, and the economization of the cardiovascular system.

Keywords: cardiovascular system • climatic and geographic conditions • heart rate variability • physical fitness

Conflict of interest: Authors have declared that no competing interest exists

Ethical approval: The study was approved by the local Ethics Committee

Provenance & peer review: Not commissioned; externally peer reviewed

Source of support: Departmental sources

Author's address: Artur Kruszewski, Department of Individual and Team Sports, Józef Pilsudski University of Physical Education in Warsaw, Marymoncka St. 34, 00-809 Warsaw, Poland; e-mail: artur.kruszewski@awf.edu.pl

INTRODUCTION

More than 75 million people in the world regularly play tennis [1]. As Groppel and DiNubile [2] note, tennis is a sport with numerous health benefits for individuals of all ages. Regular participants experience a wide variety of health-related benefits. They have an improvement in the activity of the cardiovascular system [3, 4], metabolism [1], normalization of body weight [5], bone mineral density [6], brain activity [7], reduced mental stress [2], improved agility and speed [8]. And this is not the entire list of advantages of playing tennis for recreational purposes. Other authors note that tennis, like no other sport, has a positive effect on the body of participants [2].

Since tennis requires alertness and tactical thinking, regular games contribute to the formation of new neural connections in the human brain. Brain activity increases, which contributes to life expectancy [7].

A significant amount of calories can be burned by performing high-intensity interval physical activity alternating between low and moderate levels of intensity. And tennis is precisely related to an interval exercise. As noted by Pluim et al. [1] an hour of a single game can burn 580-870 calories.

In a study of tennis players over the age of 55, Howley et al. [9] found that older tennis players significantly improved their blood cholesterol profile. They increased their high-density lipoprotein (HDL), which is a good cholesterol, and also increased the ratio of HDL to total cholesterol in comparison with people of the same age who do not exercise.

Through playing tennis, the strength of various leg muscles is developed. Constantly performed during the game lunges, pushes or jumps contribute to the development of leg muscles, in contrast to many other activities [10]. With age, people experience weakening of the muscles of the lower extremities and impaired coordination of movements, which leads to a slowdown in movement. The risk of stumbling arises as a result of a decrease in the phases of movement of the limbs, as well as due to the low lifting of the legs. As well as the weakening of the strength of the leg muscles leads to a lack of control during tension of the limbs after the step [11, 12]. Tennis exercises contribute to the development of not only speed, but also coordination, which allows you to control your body at any age [13, 14]. Adaptation to physical exertion while playing tennis leads to positive changes in muscles, tendons, and ligaments [15].

Tennis players develop excellent hand-eye coordination, as they constantly have to feel the distance between them and the ball. Thanks to the game of tennis, bone tissue improves. Bones are rearranged in response to mechanical action. The bone that is subjected to stress becomes stronger. Tennis creates dynamic loads on the human body's skeletal system and has a positive effect on bone formation, as well as skeletal health and overall bone strength [16].

Tennis is considered a sport with a minimal risk of severe injury to participants [17-19]. The most common parts, subjected to injury while playing tennis, were the elbow (20%), shoulder (15%), knee (12%) and back (10%) [20].

Among people who play tennis for recreational purposes, 21% to 45% of injuries occurred in the upper limbs, 31% to 67% in the lower limbs, and 3% to 20% in the torso or head. The ankle, hip, shoulder, elbow and lower back are most frequently injured. Muscle strain accompanied by inflammation and sprain is the most common type of injury [21]. As a rule, injuries of the lower extremities are characterized by an acute course, and injuries of the upper

Tennis elbow – ***noun*** same as **lateral epicondylitis** [27].

Lateral epicondylitis – ***noun*** pain in the elbow joint caused by repeatedly moving the forearms, as in some racket sports, which strains the tendons at their point of attachment [27].

Forehand – ***noun*** (in racket games) a basic stroke played with the palm of the racket hand facing forwards ■ *adjective, adverb* (in racket games) played with the palm of the racket hand facing forwards, or relating to a stroke played in this way ■ *verb* (in racket games) to hit the ball with a forehand stroke [27].

Backhand – ***noun*** (in tennis and other racket games) a stroke made with the back of the hand turned towards the ball or shuttlecock as the arm moves outwards from a position across the body □ *verb* to hit the ball with a backhand [27].

Agility – ***noun*** a combination of physical speed, suppleness and skill [27].

Coordination – ***noun*** the ability to use two or more parts of the body at the same time to carry out a movement or task [27].

Coordination – the ability of a person to solve motor tasks most quickly, efficiently, accurately and economically [28].

extremities are more chronic [21, 22]. The level of injuries can be reduced to a minimum by rational arrangement of recreational activities with tennis components. When planning physical activity, it is necessary to take into account not only gender and age, health status, but also the level of physical fitness and functional state of the participants.

In the Republic of Sakha (Yakutia), tennis is played mostly for recreational purposes. It should be noted that 40% of the territory of Yakutia is located beyond the Arctic Circle. Yakutia has a remarkably extreme continental climate. Long periods of extremely low winter temperatures (−40 to −50°C) and short summers with temperatures rising to +35 and even +40°C. There are also illuminance peculiarities, which include long daylight hours in the summer months and a long winter polar night [23]. A distinctive feature is that in the Republic of Sakha for eight months, tennis fans are forced to play indoors due to climatic conditions.

Features of climatic and geographical living conditions should be considered when arranging recreational programs with tennis components for mature men.

Purpose of the study was knowledge about the influence of recreational exercises with tennis components on functional state and physical fitness of mature men, aged 40-49.

MATERIAL AND METHODS

Participants

The study involved 60 men of the second mature age. The age range of mature men was 40-49 years. They were divided into experimental and control groups, each consisting of 30 people. During the formation of groups, the calculated indicator of the homogeneity criterion for age, body weight, height and the calculated indicator of body mass index (BMI) was taken into account (Table 1). The coefficient of variation does not exceed 10% in any case, which indicates the homogeneity of the examined groups.

All men gave their written consent to participate in the surveys. The experiment was conducted in accordance with the ethical standards for human research proposed by the Helsinki Declaration.

Design of research

The study was conducted on the basis of Yakut State Agricultural Academy, Yakutsk. Prior to the experiment, a survey of the group under study, which included an assessment of the functional state, pedagogical testing of physical fitness. At the second stage, which lasted a year, a special developed cycle of recreational exercises with tennis components was introduced to the experimental group. Men had 90-minute exercises 3 times a week. The peculiarity of the exercises was that men simultaneously developed physical qualities, increasing aerobic capabilities and technical skills in tennis. Various tennis components were utilized (simulation, individual exercises, wall exercises, singles and doubles). They combined them with other physical exercises (aerobic and anaerobic, aimed at the development of strength, agility, speed, coordination, and overall endurance). At the end of each month, a functional state was examined based on the use of cardiointervalometry [24]. Heart rate variability (HRV) was used to evaluate the autonomic

Table 1. Characteristics of men of the second mature age participating in experimental studies.

Statistical indicator	Age (years)	Height (m)	Body weight (kg)	BMI
Experimental group (n=30)				
Average mean	45	1.74	86	28.4
Standard deviation	2.98	0.03	6.79	1.78
Variation coefficient	6.64	1.99	7.90	6.26
Control group (n=30)				
Average mean	45	1.74	86	28.3
Standard deviation	2.90	0.04	6.35	1.93
Variation coefficient	6.46	2.05	7.41	6.83

balance of heart rate regulation, psychoemotional and myocardial state, and heart rate features. This information made it possible to individually adjust the exercises taking into account the peculiarities of the functional state of the cardiovascular system.

The control group was engaged in a different program, focusing more on the development of such physical qualities as strength. Their exercises were held at the fitness center (Yakutsk). The duration and the frequency per week was identical to the experimental group. The program included aerobic exercises: running on the treadmill, exercises on training devices to develop the strength of various muscle groups. General developmental exercises, exercises to increase joint mobility, increase muscle elasticity were also included. At the end of the one-year experiment, a repeated survey of the experimental and control groups was carried out.

The functional state of men in the experimental and control groups was monitored seven times. The first examination was before the experiment, the second after two months of attending recreational exercises, consecutive examinations after every two months. At the end of the one-year experiment, the physical fitness of both groups was retested.

To assess the functional state, a "Cardio+" diagnostic automated complex was used, which includes rhythmocardiography. To assess indicators of heart rate variability we used the following indices: RR – mean of RR intervals ECG (s); SDNN – standard deviation of RR – intervals ECG (s); pNN50 – percentage (share) of consecutive RR – intervals ECG , the difference between which exceeds 50 ms (%); RMSSD – the square root of the mean squared differences of successive RR – intervals ECG (ms); SI – stress index (relative units); ΔRR – mean of variation of RR – intervals ECG (ms); IVR – index of vegetative balance (relative units); Mo – mode of RR – intervals ECG (s); AMo – amplitude of the mode of RR – intervals ECG (%); LF – low frequency of HRV (ms^2; %); HF – higher frequency of HRV (ms^2; %); VLF – very low frequency of HRV (ms^2; %); TP – total power of the heart rhythm spectrum (ms^2), IARS – is an indicator of the activity of regulatory systems (points). These indicators are most often used to analyse heart rate regulation [24-26].

General physical fitness control tests included 7 exercises: 60 m run (in motion) (s), standing long jump (m), bending/unbending of arms in prone position for 30 s (number of times), raising straight legs to an angle of 90^0 from the original supine position (no time limit, number of times), hang pull-ups on a high bar (number of times), body inclination forward (the athlete stand on a gymnastic bench) (cm), catching a falling ruler (cm). Special physical fitness control tests: four forehands (s), four backhands (s), four two-handed throws of a 4-kg medicine ball to the right (s), four two-handed throws of a 4-kg medicine ball to the left (s), tennis wall forehands (number of strokes), tennis wall backhands (number of strokes), volleying the ball against the tennis wall to the right without ground bouncing (number of strokes), volleying the ball against the tennis wall to the left without ground bouncing (number of strokes).

Statistical analysis

The statistical analysis of data is performed by means of the licensed IBM SPSS Statistics 22.0, MS Excel. It was defined the indicators of descriptive statistics: arithmetic mean value ($\overline{x}$), standard deviation (σ or ±) and error of mean (m), variation coefficient (V). The significance of differences in groups was estimated by means of Student's test (t).

RESULTS

At each 20-minute session, the men of the experimental group developed their physical fitness. The exception was those days when they took part in competitions. In just a year, men of mature age trained for 215 hours. The ratio of hours devoted to general physical training and special physical training was 26% to 74% (Table 2).

Indicators of weight, height and body mass index at the beginning of the experiment did not differ significantly among the experimental and control groups ($p>0.05$) (Table 3).

After the experiment, the men in the experimental group had a statistically significant change in body weight and body mass index relative to the initial data. On average, the group's body mass index decreased by 6.04 kg ($p<0.05$). The change was 3%. The body mass index decreased by 1.99 kg/m², a difference was 7%. In the control group, the average body weight decreased

Table 2. The main means of recreational exercises with tennis components for mature men aged 40-49.

Means of recreational exercises [indicator]	Workout per year
Warm-up (running, general development exercises, exercises to increase joint mobility, muscle elasticity, special athletics running and jumping exercises) [hours]	48
Exercises for physical fitness development: 1) abdominal exercises (leg lifts from a supine position, lifting the torso from a supine position) 2) leg muscle exercises (lunges in place, lunges in motion with a low position of the common centre of body mass, lunges using a body bar, squats time trial with back against the wall, side lunges from leg to leg in motion) 3) arm and shoulder girdle muscle exercises (4 kg weight lifts on biceps, bending/unbending of arms pinned against knees, bending/unbending of arms pinned against bench or in supine position; hang pull-ups on a high bar 4) spinal muscle exercises (lifting the torso in prone position) 5) exercises that have a complex effect on various muscles (6 kg body bar exercises: clean and jerk, snatch; plank, plank with arms apart) [hours]	43
Special track and field running and jumping exercises (mincing run, leg-folding run, high hip-lifting run, multi-jumps, straight leg run, wind sprint) [km]	5.04
Exercises with a tennis ball and racket to develop coordination [hours]	3.3
Simulated forehand and backhand strikes [hours]	3.5
Training of right and left strikes from throw [hours]	3
Training and improvement of flat serve [hours]	9
Training and improvement of various spin serves [hours]	8
Forehand and backhand on the tennis wall from different distances [hours]	4
Forehand and backhand tossing from stand and motion [number of strikes]	1,230
Forehand and backhand from throw from the opposite baseline [number of strikes]	3,510
Throws of medicine balls (3kg) to the right simulating forehand, to the left simulating backhand [number of throws]	1,080
Forehand and backhand in pairs standing on the baseline [hours]	10
Half court game in pairs [hours]	17
Over the net volleying in pairs [hours]	10.2
Agility ladder workout [hours]	4.5
Score games (singles, doubles) [hours]	48
Participation in competitions [number of competitions]	5

by 0.47 kg, which was 0.57% and did not significantly differ from the initial indicators ($p>0.05$). The average body mass index in this group also decreased slightly, but did not differ significantly. The difference was 0.16 kg/m² and 0.57%, respectively ($p>0.05$). The analysis of intergroup differences between two values – body weight and body mass index of the experimental and control groups showed that significant changes affected the indicators of the experimental group members. On average, the group's body weight decreased by 7.86%, and body mass index

Table 3. Changes in anthropometric indicators of men of the second mature age (40-49 years old) in the process of a pedagogical experiment.

Variable [indicator]	Statistical indicator $\overline{x} \pm \sigma$			
	Experimental group (n=30)		Control group (n=30)	
	Before the experiment	At the end of the experiment	Before the experiment	At the end of the experiment
Height [m]	1.74 ±0.03	1.74 ±0.03	1.74 ±0.04	1.74 ±0.03
Body weight [kg]	85.97 ±6.79	79.92 ±4.62*	85.73 ±6.35	86.20 ±5.60
Body mass index [kg/m²]	28.44 ±1.78	26.45 ±1.12*	28.25 ±1.93	28.41 ±1.73

*$p<0.05$

decreased by 7.41% (p<0.05). Before the pedagogical experiment both study groups were equally represented by overweight men whose BMI was in the range from 25.0 kg/m² to 29.9 kg/m² and obese Class I with BMI 30-34 kg/m². In both groups, 80% of overweight men and 20% of obese Class I men were present. After the pedagogical experiment, the percentage changed. In the experimental group, 7% of the participants now have a normal weight. The number of obese men decreased from 20% to 6%. Undoubtedly, the largest percentage of participants remained overweight-77%. There were no positive changes in the control group (Table 3).

Analysis of 16 indicators of heart rate variability of mature men (aged 40-49) of the experimental and control groups before the pedagogical experiment did not significantly differ (p>0.05) (Table 4). At the end of the experiment, significant differences were found in all HRV indices of men of the experimental group and five HRV indicators of the control group (p<0.05, p<0.01). However, these changes were of a different nature (Table 5).

Among the experimental group, after the pedagogical experiment, such statistical indicators as SI, IVB, IARS and spectral indicators: TR, LF, HF, VLF, LF/HF changed significantly. On average, the stress index significantly decreased by 111.3 relative units, which corresponds to 53.1% (p<0.01). This was facilitated by a decrease in the body weight of participants and, accordingly, BMI, as well as regular adequate physical activity, which contributed to an increase in the functional state of the cardiovascular system. The IVB statistically significantly decreased by 46.6%, which indicates a shift in the autonomic balance towards parasympathotony (p<0.01). After the experiment the IARS indicator decreased by 56.9% (p<0.01). It should be noted that all 30 people in this group IARS ranged from 0 to 2, which indicates the optimal tension of regulatory systems, according to R.M. Baevsky [24] is necessary for an active balance of organism with the environment. Indicators of spectral analysis of heart rate variability characterize the influence of the sympathetic and parasympathetic parts of the autonomic nervous system on the regulation of heart

Table 4. Changes in heart rate variability of mature men (aged 40-49) during the experiment.

HRV [indicator]	Statistical indicator $\bar{x} \pm \sigma$			
	Experimental group (n=30)		Control group (n=30)	
	Before the experiment	At the end of the experiment	Before the experiment	At the end of the experiment
HR [beats·min^{-1}]	67.7 ±6.9	**61.18 ±2.88***	67.56 ±5.69	67.12 ±4.36
SDNN [ms]	40.5 ±17.12	**52.6 ±4.58***	42.25 ±14.34	39.12 ±2.10
RMSS,[ms]	28 ±14.66	**38.00 ±8.68***	30 ±4.24	30.22 ±7.88
PNN5 [%]	49.95 ±6.13	**54.00 ±4.48***	49.55 ±6.27	48.68 ±9.13
Mo [s]	753.23 ±11.34	**814.22 ±10.26***	773.86 ±12.4	737.45 ±11.34
AMo [%]	37.9 ±9.21	**34.16 ±4.18***	38.19 ±6.49	39.14 ±9.21
SI [relative units]	209.3 ±52.42	**98.00 ±10.22****	206.63 ±45.42	204.18 ±13.22
IVB [relative units]	210.2 ±64.61	**112.20 ±24.61****	165.2 ±64.61	158 ±46.38
TP [ms^2]	1,658.6±1189.23	**2,391.2 ±1116.28****	637.6 ±1711.03	1566.8 ±468.22
LF [ms^2]	500.22±122.20	**989.02±106.00****	510.46 ±122.2	528.18 ±104.42
HF [ms^2]	277.27±71.45	**709.26 ±105.24****	268.27 ±71.45	**189.2 ±66.10***
VLF [ms^2]	845.37±101.09	**620.92 ±252.09***	844.48 ±101.09	828.16 ±101.09
%LF [%]	64.42±12.77	**58.24 ±10.12***	65.98 ±22.58	**73.58 ±13.18***
%HF [%]	35.58±12.77	**41.76 ±8.78***	35.12 ±16.44	**26.42 ±12.58***
LF/HF	1.81±1.06	**1.39 ±0.45***	1.9 ±1.06	**2.79 ±1.24****
IARS [score]	2.23±1.68	**0.96 ±0.76****	2.23 ±1.68	**3.18 ±1.46****

*p<0.05, **p<0.01

rate. After the pedagogical experiment, the TP indicator increased significantly, the increase was 44.1% (p<0.01). Its growth signals an increase in the share of the parasympathetic link in the heart rate regulation. There was also an increase in LF by 97.7 % and HF by 155.8% (p<0.01). The indicator describing the balance of sympathetic and parasympathetic influences of LF/HF decreased by 23.2% (p<0.05). This indicates the predominance of the sympathetic type of autonomic regulation among the experimental group members. But after the experiment, on average, the evident predominance at the group was replaced by the moderate.

Among the control group members, on the contrary, who trained for a year under another fitness club program, the %LF indicator increased by 46.6%, LF/HF by 100%, IARS by 117%, and the %HF indicator accordingly decreased by 36.7% (p<0.05, p<0.01). The evidence of the prevalence of severe sympathotony.

The analysis of intergroup differences in HRV indicators after the experiment also showed positive changes among the experimental group. All 16 studied time, statistical and spectral indicators of HRV in the experimental group significantly changed after one year of the experiment (Table 5).

There is a significant difference in four indicators: SI, HF, LF/HF, and IARS. The difference was 108.3% for SI, 73.32% for HF, 100.7% for LF/HF, and 231.2% for IARS (p<0.01). The range of differences in other HRV indicators varies from 10 to 46.6% (p<0.05).

A composite index of heart rate regulation, expressed as a percentage, which characterizes the activity of the autonomic nervous system, the balance of the sympathetic or parasympathetic link in its regulation, the degree of tension of the body's regulatory systems and fatigue of the cardiovascular system, in the experimental group, on average, has positive dynamics (Figure 1). If the results of the second and third examinations do not significantly differ from the initial data, then after 6 months the level of the composite index of heart rate regulation increased statistically significantly, the increase was 12.3% (Figure 1).

Table 5. Heart rate variability indices of men of the second mature age (aged 40-49) after the experiment (experimental and control groups).

HRV indicator	Statistical indicator, $\bar{x} \pm \sigma$		
	Experimental group (n=30)	Control group (n=30)	Differences
HR [beats min^{-1}]	61.18 ±2.88	67.12 ±4.36	**–5.94***
SDNN [ms]	52.60 ±4.58	39.12 ±2.10	**13.48***
RMSSD [ms]	38.00 ±8.68	30.22 ±7.88	**7.78***
PNN50 [%]	54.00 ±4.48	48.68 ±9.13	**5.32***
Mo [s]	814.22 ±10.26	737.45 ±11.34	**76.77***
Amo [%]	34.16 ±4.18	39.14 ±9.21	**–4.98***
SI [relative units]	98.00 ±10.22	204.18 ±13.22	**–106.18***
IVB [relative units]	112.20 ±24.61	158 ±46.38	**–45.80****
TP [ms^2]	2,391.20 ±1116.28	1,566.8 ±468.22	**824.40****
LF [ms^2]	989.02 ±106.00	528.18 ±104.42	**460.84****
HF [ms^2]	709.26 ±105.24	189.2 ±66.10	**520.06***
VLF [ms^2]	620.92 ±252.09	828.16 ±101.09	**–207.24****
%LF [%]	58.24 ±10.12	73.58 ±13.18	**–15.34***
%HF [%]	41.76 ±8.78	26.42 ±12.58	**15.34****
LF/HF	1.39 ±0.45	2.79 ±1.24	**–1.40***
IARS [score]	0.96 ±0.76	3.18 ±1.46	**–2.22***

*p<0.05, **p<0.01

In the following months, this index continued to increase. After 8 months of regular recreational activities, the composite index of heart rate regulation increased by 13.8% from the initial data ($p<0.05$). And after 10 and 12 months, it increased by 15,4 and 18.5%, respectively ($p<0.05$). After the experiment, a group average of this index sustained a high level. The composite index of myocardial state after two months of training of the experimental group statistically significantly increased, the increase was 10.1% ($p<0.05$). After the pedagogical experiment, this indicator significantly increased by 13.0% from the initial data and sustained a high level ($p<0.05$). More pronounced changes affected the composite index of psychoemotional state, which positively changed after two months of training of this group. The second survey showed that the composite index of psychoemotional state increased by 13.2%, which significantly differs from the initial data ($p<0.05$). Later on, changes in this index have a wave-like pattern. However, the monitoring carried out after the experiment showed that the composite index of psychoemotional state is at a high level.

In the control group, on average, the composite index of heart rate regulation decreased statistically significantly after two months of the

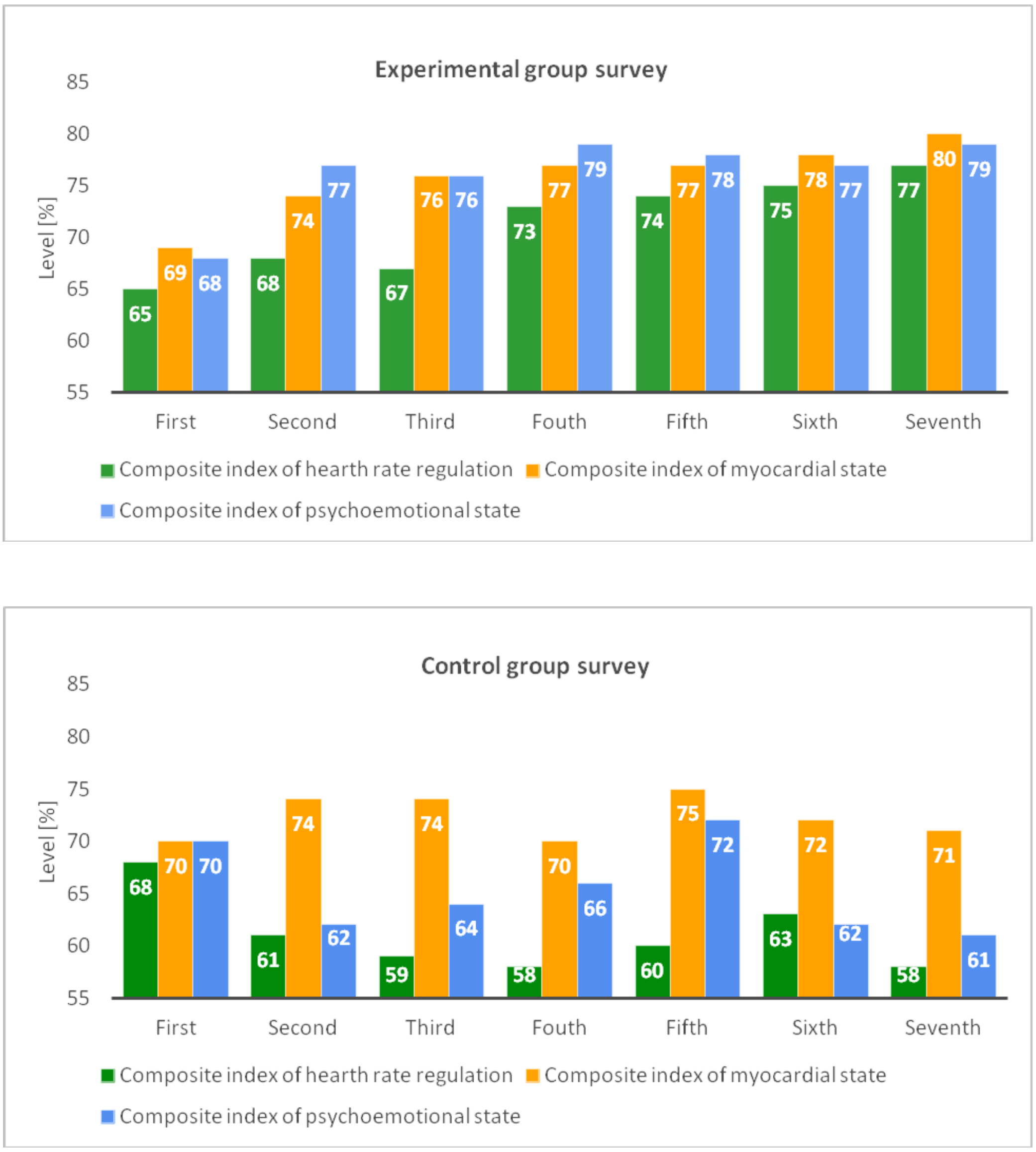

Figure 1. Dynamics of functional state components of the experimental and control groups during the experiment (group average).

experiment, by 10.3 %. And also continued to decrease significantly relative to the initial data ($p<0.05$). After the experiment, it was equal to 58% and corresponded to the average level, the decrease in the index was 14.7% ($p<0.05$). The composite index of myocardial state during the experiments and afterwards did not change significantly, the decrease in the index was 1.4 % ($p<0.05$). Before and after the experiment, the composite index of myocardial state corresponded to the above-average level. The composite index of psychoemotional state has significantly changed. It corresponded to a high level before the experiment, and at its completion it corresponded to an average level. The second survey showed a decrease in this index by 11.4 %, which significantly differs from the initial data ($p<0.05$). After the experiment, the composite index of psychoemotional state decreased by 12.9 % from the initial level ($p<0.05$). It was also determined that among the members of the control group after the pedagogical experiment, five had a general, seven had a significant and four had a pronounced mental tension, and eight people had a negative index of emotional state.

It should be noted that prior to the experiment, both subject groups did not show any heart rate disorders. But after the experiment, a control group monitoring made it possible to diagnose minor heart rate disorders: extrasystole, tachycardia, which was the result of overstrain and overwork of participants, the accumulation of emotional stress and other abnormalities. No such disorders were found in the experimental group. Dynamics of the composite index of the functional state of mature aged men in the experimental and control groups changed differently during the experiment.

Before the experiment, the functional state in both groups corresponded to the average level and did not differ significantly ($p> 0.05$). In the experimental group, this index grew throughout the experiment and at the end of the year of the experiment corresponded to 79%, an increase was 23.4% ($p<0.05$). On average, among the control group, the composite index of functional state decreased by 6.0% ($p>0.05$). The difference in the average functional state indices between the experimental and control groups was 21.5% ($p<0.05$), which indicates significant differences in the studied indicator after the experiment.

The indicators of general physical fitness at the beginning of the pedagogical experiment among the experimental and control groups did not differ significantly ($p>0.05$) (Table 6). An intra-group analysis of the results of pedagogical testing showed significant changes in both groups after the experiment. All seven indicators of general physical fitness ($p<0.05$, $p<0.01$) and all indicators of special physical fitness ($p<0.05$) were statistically significantly increased in the experimental group. In the 60-meter run at the end of the experiment, the average for the group decreased by 1.24 s, which was 10.7% ($p<0.05$). In the long jump, improvement amounted 19 cm ($p<0.05$), and in the ruler catching quickness test the result decreased by 6 cm ($p<0.01$). The group average change in indicators under study was 8.6% and 29.5%, respectively. The test result of raising straight legs to an angle of 90 from the original supine position increased by 9.9%, where the average indicator after the experiment increased by 2 times. Also, on average, the indicator of bending/unbending of arms in prone position increased by 4 times, which corresponds to 15.8 % ($p<0.05$). Pronounced changes in the overall physical fitness indicators affected the flexibility test, the indicator increased by 57.1% and the hang pull-ups on a high bar increased by 52.0% ($p<0.01$). Positive dynamics after the experiment can also be observed in the indicators of special physical fitness of men. The average increase in the results of eight special tests for the group was 9-15%. Four-stroke forehand and backhand time trial decreased by 1.76 s and 1.71 s, which was 9.7% and 9.4%, respectively ($p<0.05$). The indicator of two-handed throws of a 4-kg medicine ball to the right (4 throws, s) decreased by 2.63 s (13.9%). And the indicator of two-handed throws of a 4-kg medicine ball to the left (4 throws, s) decreased by 1.98 s (10.7%), also significantly differs from the initial data ($p<0.05$). The group average indicator of forehand and backhand, performed on the tennis wall for 15 seconds, increased by 9.2% and 10.8% ($p<0.05$). In the final two tests aimed at determining the indicators of special physical fitness, the most significant changes were noted. The indicator of the number of ball volleys against the tennis wall to the right (in the next test – to the left) without ground bouncing for 10 seconds has increased by 18.7% and 15.1%, respectively ($p<0.05$).

In the control group, at the end of the experiment, four out of seven indicators of overall physical fitness were statistically significantly changed in relation to the initial data. The average indicator of body inclination forward (the athlete stand on a gymnastic bench) increased by 24.6 % (p<0.05). Three indicators that characterize power abilities significantly changed. The average group indicators of raising straight legs to an angle of 90 from the original supine position, as well as bending/unbending of arms in prone position for 30 seconds increased by 14.5% and 17.7%, respectively (p<0.05). There was a marked change in the quantity of pull-ups, which increased from four to seven times in group average, which was 75 % (p<0.01) (Table 6).

The analysis of intergroup differences in test results revealed that two out of seven indicators of physical fitness of the experimental group members significantly differ after the experiment (Table 7). However, one indicator – the number of hang pull-ups on a high bar, is significantly higher among the control group members (p<0.01). Men in the experimental group had significantly different indicators in 60-meter dash and catching a falling ruler by 10.6% and 29.1%, respectively (p<0.05). In two tests – standing long jump and body inclination forward (the athlete stand on a gymnastic bench), the indicators increased slightly, but they do not differ significantly (p<0.05). The obtained data from the analysis of intergroup differences indicates that the strength indicators are significantly higher in the control group, but the speed indicators are significantly higher in the experimental group. The

Table 6. Change in physical fitness indicators of mature men (aged 40-49) during the experiment

Test [indicators]	Statistical indicator, $\bar{x} \pm \sigma$			
	Experimental group (n = 30)		Control group (n = 30)	
	Before the experiment	At the end of the experiment	Before the experiment	At the end of the experiment
60 m run (in motion) [s]	11.47 ±1.71	**10.23 ±1.52***	11.50 ±1.43	11.32 ±1.21
Standing long jump [m]	2.19 ±0.11	**2.38 ±0.24***	2.20 ±0.19	2.22 ±0.11
Catching a falling ruler [cm]	20.00 ±2.50	**14.13 ±2.68****	19.64 ±2.45	18.24 ±2.50
Body inclination forward (the athlete stand on a gymnastic bench) [cm]	3.50 ±0.27	**5.50 ±0.37****	4.11 ±0.67	**5.12 ±0.47****
Raising straight legs to an angle of 90 from the original supine position [number of times]	23.83 ±2.52	**26.20 ±2.64***	24.00 ±3.24	**27.48 ±5.52***
Bending/unbending of arms in prone position for 30 s [number of times]	23.87 ±2.46	**27.65 ±2.50***	23.62 ±2.78	**27.80 ±6.47***
Hang pull-ups on a high bar [number of times]	4.13 ±0.98	**6.28 ±1.12****	4.00 ±1.12	**7.00 ±2.22****
Forehand 4 strikes [s]	17.98±3.38	**16.2 2±4.39***	–	–
Beckhand (4 strikes [s]	18.05±2.68	**16.3 4±4.42***	–	–
Two-handed throws of a 4-kg medicine ball to the right 4 throws [s]	18.81±2.18	**16.18 ±2.30***	–	–
Two-handed throws of a 4-kg medicine ball to the left 4 throws [s]	18.54±3.84	**16.56 ±3.56***	–	–
Tennis wall forehands in 15s [number of strokes]	11.90±2.42	**13.00 ±1.44***	–	–
Tennis wall backhands in 15 s [number of strokes]	10.83±2.41	**12.00 ±1.98***	–	–
Volleying the ball against the tennis wall to the right without ground bouncing in 10 s [number of strokes]	12.63 ±2.95	**15.00 ±2.50***	–	–
Volleying the ball against the tennis wall to the left without ground bouncing in 10 s [number of strokes]	10.63±2.46	**12.24 ±3.20***	–	–

*p<0.05, **p<0.01

average indicators of flexibility and speed-power abilities are higher in the experimental group, but they do not differ significantly from the data of the control group ($p<0.05$) (Table 7).

DISCUSSION

The developed cycle of recreational exercises with tennis components for mature aged men positively affected the complex demonstration of speed, as well as quickness of response, dexterity, indicators of the functional state of men aged 40-49. The programs were developed taking into account the peculiarities of people residing in the Republic of Sakha. Men were engaged for one calendar year. After a year of training, they had a shift in the autonomic balance towards parasympathotonia, which is characterized by increased economization of the functioning of the cardiovascular system. At the same time, they still have a predominance of sympathetic influences in the heart rate regulation. The average for the group revealed a moderate prevalence of sympathotonics type of heart rate regulation. A decrease after a year of training in the VLF index (heart rate fluctuations in a very low frequency range 0.04-0.003 Hz) from 845.37 ms^2 to 620.92 ms^2 indicates a decrease in humoral and metabolic effects in the heart rate regulation. Also, as a result of recreational activities with tennis components, men showed a marked decrease in the tension index of regulatory systems. The activity index of regulatory systems also significantly decreased ($p<0.01$). Men in the control group after the experiment revealed marked sympathotony. Among men of this group, 63.3% differ in humoral and metabolic effects in the heart rate regulation. And high IARS values signal moderate and pronounced stress of regulatory systems. At the end of the experimental cycle, 12 people were identified, which made up 40 % of the sample, with a state of moderate tension of the regulatory systems. In this state, when adapting to environmental conditions, the body needs to spend functional reserves. Among 7 people (23%), a state of pronounced tension of the regulatory systems was revealed, which is associated with the mobilization of protective mechanisms, increased activity of the sympathetic-adrenal system and the pituitary-adrenal system. Among these men, the IARS index was equal to 6 and 63 % of the surveyed control group showed tension of the regulatory systems, in contrast to the members of the experimental group, who were diagnosed with optimal tension of the regulatory systems of the body.

Tennis is known for its positive effect on the functioning of various organs and systems of the body, develops various muscle groups, contributes to the normalization of body weight. In studies by Pluim et al. [1] it is shown that a single game of tennis allowed the player to be in the range of 70% to 90% of the maximum heart rate. This indicates a significant influence of tennis on the development of the cardiorespiratory system. Playing just 3 hours a week will reduce the risk of heart disease by 56%.

Table 7. Indicators of general physical fitness of mature men (aged 40 - 49) after a pedagogical experiment (control and experimental groups).

Test [indicators]	Test result, $\overline{x} \pm \sigma$		
	Experimental group (n = 30)	Control group (n = 30)	Differences
60 m run (in motion) [s	10.23 ±1.52	11.32 ±1.21	**–1.09***
Standing long jump [m]	2.38 ±0.24	2.22 ±0.11	0.16
Catching a falling ruler [cm]	14.13 ±2.68	18.24 ±2.50	**–4.11***
Body inclination forward (the athlete stand on a gymnastic bench) [cm]	5.50 ±0.37	5.12 ±0.47	0.38
Raising straight legs to an angle of 90 from the original supine position [number of times]	26.20 ±2.64	27.48 ±5.52	–1.28
Bending/unbending of arms in prone position for 30 s [number of times]	27.65 ±2.50	27.80 ±6.47	–0.15
Hang pull-ups on a high bar [number of times]	6.28 ±1.12	7.00 ±2.22	**–0.72***

*p <0.05

Our study shows that recreational exercises with tennis components three times a week for one year contributed to an increase in the functional state of men aged 40-49. We have confirmed data [5] that tennis contributes to weight loss. And we also confirmed the conclusions [2] that recreational exercises with tennis components reduce the psychoemotional stress of men aged 40-49. The positive effect on the cardiovascular system of people who regularly play tennis is reflected in the works of various authors [5, 14, 18]. In our studies, mature men were engaged in indoor activities for one year and they also showed an increase in the level of functional state of the cardiovascular system.

Among men who regularly attend recreational exercises with tennis components, all indicators of general and special physical fitness ($p<0.05$, $p<0.01$) significantly changed after the experiment. The analysis of inter-group differences showed that among the participants of our program in contrast to those engaged in the fitness center program the indicators of speed and dexterity statistically significantly increased at the end of the experiment. Those who were engaged in the fitness center program have positive significant changes in strength and flexibility ($p<0.05$, $p<0.01$).

Our research confirms the available data [10] that playing tennis develops various leg muscles. We had also confirmed the data [13, 14] that recreational exercises with tennis components affect the development of speed, dexterity and coordination abilities. During the entire year of the experiment, no injuries from the proposed physical activity were recorded among the members of the experimental group. The parallel development of physical qualities and functional state with the use of tennis moves in exercises (simulations, individual exercises, wall exercises, singles and doubles) helped to increase the functional capabilities of the body.

Data from experimental studies suggest that the developed cycle of recreational exercises with tennis components can be recommended for men of mature age in order to improve the functioning of the cardiovascular system, physical fitness.

CONCLUSIONS

The study showed that the cycle of recreational exercises with tennis components introduced into the training process contributed to an increase in the level of general and special physical fitness and functional state of mature men residing in the Republic of Sakha. Men aged 40-49 trained three times a week for one year. They showed significant improvement in almost all indicators of physical fitness and heart rate variability. They showed a decrease in the tension of regulatory systems, a decrease in humoral and metabolic effects on the heart rate regulation, and an economization of the cardiovascular system. They also showed positive changes in indicators of autonomic regulation of heart rate, myocardial and psychoemotional state, and composite index of functional state. Men in the control group showed a significant increase only in the strength of the shoulder girdle muscles. Also, at the end of the experiment, they showed psychoemotional stress, high values of stress index and activity index of the body's regulatory systems, and a pronounced predominance of the sympathetic type of autonomic regulation of heart rate.

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Cite this article as: Cherkashina EV, Cherkashin IA, Kruszewski A et al. The influence of recreational exercises with tennis components on functional state and physical fitness of mature men, aged 40-49, residing in the Republic of Sakha. Arch Budo Sci Martial Art Extreme Sport 2019; 15: 129-141