ORIGINAL ARTICLE

Influence of taijiquan martial art on the indicators of external respiration function and psychophysiological state of basketball players

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Abstract

Background and Study Aim: *Taijiquan* is a Chinese martial art and a complete system of rehabilitation and psychophysiological training. Aim of this study is influence of *taijiquan* classes during one year on the indicators of external respiration and psychophysiological condition of basketball players.

Material and Methods: The sample consisted of 36 male students: experimental group (18 people aged 20.0 ±1.58 years); control group (18 people aged 20 ±1.42 years). A pedagogical experiment was conducted during which athletes of the experimental group performed a set of *taijiquan* exercises in the final part of each training session. Two pedagogical and psychophysiological tests were performed, as well as an examination of the external respiratory function using spirography before and after the pedagogical experiment.

Results: The analysis of intergroup differences in spirography indicators allowed us to state that in the athletes of the experimental group of 14 studied absolute indicators of external respiration function 11 significantly changed ($p<0.05$, $p< 0.01$): one indicator – the breathing frequency by 18.26%, the rest has increased, the growth rates were in the range from 10% to 20%. Eight of the nine indicators of the external respiratory system, expressed as a percentage of the calculated due to value after the pedagogical experiment, have significantly changed ($p<0.05$, $p<0.01$). The volume indicators have increased – vital capacity of lungs on inspiration and expiration, inspiratory and expiratory reserve volume, forced expiratory volume after 1 second, peak expiratory flow ($p<0.05$). There was an increase in the level of implementation of the external respiratory system – index of maximum lung ventilation increased by 35% ($p<0.01$). Thirteen of the fifteen indicators of individual typological properties of higher nervous activity and sensorimotor functions of athletes in the experimental group significantly differed after the pedagogical experiment, which indicates a statistically significant improvement in psychophysiological indicators ($p<0.05$, $p<0.01$).

Conclusions: The positive influence of *taijiquan* classes on the indicators of respiratory function, psychophysiological state, and the effectiveness of basketball players who practiced *taijiquan* at the end of each training session six times a week for a year has been revealed. We are recomendet *taijiquan* exercises at the end of each training session at different stages of the annual training cycle, including the competition period.

Keywords: chronic • maximum lung ventilation • mobility of nervous processes • respiratory system • visual-motor response

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INTRODUCTION

Taijiquan (*taichi*) is a health-improving gymnastics, a part of Chinese martial arts and a means of cultural self-identification, as well as one of the auxiliary methods in training athletes in various sports [1, 2]. *Taijiquan* plays a positive role in stimulating the activity of the central nervous system, maintaining joint mobility, and improving the functioning of internal organs. It does not require a lot of space and time [3, 4].

There is evidence of a positive effect on the state of the respiratory system. This type of physical activity is of great benefit for chronic obstructive pulmonary disease (COPD). Experts have studied the possibility of improving the functional ability to exercise, physical performance and quality of life in people with this disease [5-8]. It was noted that yoga and *taichi* were more effective than conventional COPD treatments. They provide opportunities for COPD patients to improve their physical activity, quality of life, and lung function. Improvements were found in the "6-minute walk" test, the Forced Exhalation Volume in 1 s (FEV1), and the quality of life associated with health [9].

Taichi (*taijiquan*) was an effective and alternative method for the rehabilitation of patients with cystic fibrosis. Along with traditional medicinal treatments, performing *taijiquan* exercises affected sleep quality, reduced abdominal pain, and coughing in patients with cystic fibrosis [10].

Taijiquan also has a positive effect on stress perception and overall stress tolerance [11-13] and on mindfulness [14-, 15]. The possibility of safe and effective use of *taijiquan* for the treatment of depressive disorder has been also studied [16-18]. It was determined that Taijiquan classes affect the ability to coordinate movement control of different coordination complexity and the state of the psychomotor sphere and the target accuracy of space-time indicators of movement [19].

One of the limiting factors, of effective competitive activity of basketball players, is the functioning of the respiratory system. Therefore, the higher the indicators of external respiration, the higher the level of the functional condition of athletes, which affects the endurance and performance of an athlete who is able to effectively perform physical activity for a long time in a state of acytosis as a result of an increase in the content of lactic acid in the blood. Experts note that indicators of vital capacity of the lungs and exercises aimed at improving the shot performance are closely interrelated, in particular, at the precompetition stage of the annual training cycle, the correlation coefficients (r) between these indicators exceed 0.800 [20]. Available studies of the respiratory system of basketball players are more related to obtaining indicators of respiratory function for comparison in athletes of other sports [21]. Experts determined how basketball affects lung function [22-24]. The effect of training intensity on the concentration of salivary immunoglobulin A and the symptoms of upper respiratory tract infection in young male basketball players was studied [25]. Under the influence of pranayama, basketball players showed improvement in such indicators as Peak Flow Rate, Vital Capacity, Cardiorespiratory Endurance, Heart Rate, and Respiration Rate [26].

Perception and processing of visual information for athletes is an important property of psychophysiological functions [27]. Success in game sports depends on the speed of sensorimotor response, which determines the functional state of the central nervous system. The sensory component of the psychophysiological state of basketball players was studied by the time indicators of simple and complex visual-motor reactions, taking into account gender, role [28], age and qualification [29, 30].

A large number of literary sources have been identified, which provide data on the positive impact of the martial art of *taijiquan* on

Martial arts – various types of martial arts and self-defense. Mostly of East Asian origin; developed primarily as a means of hand-to-hand combat, developed especially in Japan and Korea and now usually practiced as a sport [34].

Chronic – *adjective* **1.** used for describing a disease or condition that lasts for a long time. Compare **acute 2.** used for describing severe pain [34].

Macrocycle – *noun* a training cycle that typically lasts for a year [34].

Training session – *noun* a period of time during which an athlete trains, either alone, with a trainer or with their team [34].

Taijiquan (Taichi) – (Trad. Chinese 太極拳, Simpl. Chinese 太极拳, Pinyin: tàijíquán) — literally: "fist of the great limit"; Chinese internal martial art, one of the types of Wushu. Popular as recreational gymnastics, but the prefix "Quan" (fist) implies that Taijiquan is a martial art [35].

Chen style – according to the Chinese government and the Chen family, the founder of Taijiquan is Chen Wangting. He was a soldier of the Imperial guard, but soon after the Manchu Qing dynasty came to power in 1644, he left the army. Being a great master of Wushu, he decided to systematize the skills he received in the army. As a basis of a new style, Chen Wangting used forms of fisticuffs, known to him from the "Treatise on the art of fisticuffs" Qi Jiguang (1528-1587), which served as a training manual for the Imperial guard. He presented the new style as a moment of a juxtaposition of external and internal — fighting techniques and their philosophical understanding. Gradually, the Chen family-

the functional state and manifestation of coordination abilities of people of different ages. However, data describing the use of *taijiquan* to improve the function of external respiration was not found.

Aim of this study is influence of *taijiquan* classes during one year on the indicators of external respiration and psychophysiological condition of basketball players.

MATERIAL AND METHODS

Participants

The study involved 36 male students practicing basketball. The age range of the athletes was 18 to 22 years. They made up control and experimental group of 18 people each. During the formation of groups, the calculated indicator of the homogeneity criterion for age, sports experience, and anthropometric data was taken into account. The value of the coefficient of variation does not exceed 10%, which indicates the homogeneity of the groups of athletes examined (Table 1). Student-athletes at the time of the research, according to the medical examination, were practically healthy. Also, written consent was received from student-athletes to participate in the surveys.

The experiment was conducted in accordance with the ethical standards of human research proposed by the Helsinki Declaration.

Design of research

The research was conducted at the sports Rehabilitation Experiment Center laboratory of the Dalian University of Technology. At the beginning of the experiment, the athletes of the experimental and control groups were examined and included the determination of indicators of external respiration function, individual typological properties of higher nervous activity and sensorimotor functions, and the effectiveness of basketball players' shots. During one macrocycle (one year), athletes of the control and experimental groups trained in the same team, performing the same physical activities, participating in the same number of games. The difference was that the representatives of the experimental group performed the Chen style *taijiquan* complex at the end of each training. After a one-year cycle, the basketball players were re-examined.

To assess the functional state of the external respiratory function, a diagnostic automated complex "Cardio+" was used, which includes a spirograph. The examination included four breath tests: "Calm breathing", "VC Determination", "Forced VC", "Maximum Lung Ventilation". Recorded indicators also included: VT – tidal volume, liters; VC – Vital Capacity, liters; VCin – Vital Capacity of Lungs on inspiration, liters; VCex – Vital Capacity of Lungs on expiration, liters; MLV – Maximum Lung Ventilation, liters·per min^{-1}; MV – Minute Volume, liters · per min^{-1}; FEV_1 – Forced Expiratory Volume after 1 second; FEV_1/FVC_1 – the Tiffeneau Index (TI) – the ratio of Forced Vital Capacity expiratory volume after 1 second (FEV_1) to the Forced Vital Capacity (FVC_1), %; PEF – Peak Expiratory Flow – maximum volume speed of forced expiration, l·min^{-1}; IRV – Inspiratory Reserve Volume, liters; ERV – Expiratory Reserve Volume, liters; FVC – Forced Vital Capacity expiratory, liters; FVC_1 – Forced Vital Capacity volume after 1 second, liters; BF – breathing frequency, quantity per min. Absolute and relative indicators were determined. Some style was rationalized, and its philosophical impact was strengthened. So many complexes were no longer required to discover the metaphysical depth of Wushu reality. To do this, a few dozen movements performed in full compliance with the principles of Taijiquan were enough. Over time, only the first Taijiquan complex and the paochui complex ("exploding strikes"), which are now considered the first and second complexes of the Chen style, have been preserved as it was originally created by Chen Wangting [36].

Table 1. Characteristics of basketball players participating in experimental studies.

Statistical indicator	Age (years)	Experience (years)	Body length (cm)	Body weight (kg)
Experimental group (n = 18)				
Average mean	20	5	195	79
Standard deviation	1.58	0.36	6.54	2.15
Variation coefficient	7.52	7.20	3.74	3.98
Control group (n = 18)				
Average mean	20	5	204	84
Standard deviation	1.42	0.48	5.27	2.36
Variation coefficient	6.81	8.20	3.03	4.37

of the obtained data were compared with normal values of the main spirographic indicators (in percent relative to the estimated proper value; according to Shik and Kanaev [31]).

To determine the indicators of individual typological properties of higher nervous activity and sensorimotor functions of basketball, a "Diagnost-1" computer system was used [27, 32]. Indicators of the time of latent periods of simple and complex visual-motor reaction, the level of mobility and strength of neural processes, the presence of errors in processing visual information were determined. The group of pedagogical tests to determine the effectiveness of shots consisted of 7 exercises, with 9 indicators recorded: 2-pointers shots from set points (the number of hits out of 10 shots), mid-range shots (the number of shots and hits per 40 s), free throw (the number of hits out of 10 shots), 3-pointers shots (the number of hits out of 10 shots), jump shots (the number of hits out of 10 shots), shots from set points (40 shots for 3.5 min test time, the number of hits), shots for 5 min. (the number of shots and hits).

Statistical analysis

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

RESULTS

Fourteen (Table 2) absolute and 9 (Table 3) relative indices of external respiration function were determined in athletes of experimental and control groups at the beginning and after the pedagogical experiment. These indicators in athletes of both groups did not differ significantly at the beginning of the pedagogical experiment ($p>0.05$).

At the end of the pedagogical experiment, 11 of the 14 studied indicators of external respiration significantly increased among the experimental group ($p<0.05$, $p<0.01$). Significant changes were

Table 2. Changes in indicators of external respiration function (variable) of basketball players in the process of pedagogical experiment (n = 36).

Variable (indicator)	Statistical indicator $\overline{x}$ ±			
	Experimental group (n = 18)		Control group (n = 18)	
	prior to an experiment	at the end of an experiment	prior to an experiment	at the end of an experiment
VT (l)	1.95 ±0.12	2.10 ±0.67	1.93 ±1.15	1.98 ±0.78
BF (quantity·min^{-1})	13.67 ±1.84	**11.17** ±1.65*	14.1±1.92	13.21 ±2.01
MV (l·min^{-1})	26.62 ±3.49	25.45 ±3.49	26.78 ±3.56	26.17 ±3.76
VCin (l)	5.42 ±0.50	**6.14** ±0.56*	5.46 ±0.48	5.51 ±0.56
VCex (l)	5.57 ±0.53	**6.08** ±0.34*	5.48 ±1.01	5.48 ±0.98
IRV (l)	2.38 ±0.97	**2.76** ±0.78*	2.32 ±1.17	2.37 ±1.79
ERV (l)	1.52 ±0.20	**1.74** ±0.32*	1.47 ±0.80	1.52 ±1.12
FVC (l)	4.99 ±0.19	**5.66** ±1.12*	5.08 ±0.44	5.10 ±0.56
FEV_1 (l)	3.96 ±0.54	**4.61** ±2.16*	3.86 ±0.87	4.04 ±0.55
TI (%)	78.00 ±12.10	84.00 ±24.53	76.87 ±22.17	78.33 ±5.74
PEF (l·min^{-1})	7.66 ±0.98	**10.54** ±1.23**	8.10 ±1.45	8.78 ±2.01
MLV (l·min^{-1})	147.00 ±19.10	**201.00** ±24.56**	145.00 ±21.1	**160.00** ±18.34*
VTmlv (l)	1.30 ±0.21	**1.65** ±0.41**	1.32 ±0.24	1.38 ±2.11
BFmlv (quantity·min^{-1})	113.33 ±8.18	**130.33** ±7.12*	112.50 ±8.18	116.50 ±9.12

* $p<0.05$, ** $p<0.01$.

observed in the PEF indicators on average for the group. The increase was 38% (p <0.01). In the MLV indicators, the increase is 37% (p<0.01). The average group VTmlv indicators increased by 27% (p<0.01). These data indicate an increase in the level of functioning of the external respiration function of athletes in the experimental group at the end of the one-year experiment. Only one indicator – MLV p<0.05) significantly increased in the control group of athletes; the rest changed slightly after the pedagogical experiment (Table 2).

Relative to the indicators of the external respiratory system, expressed as a percentage of the proper value, they also did not differ at the beginning of the experiment between both groups. After the experiment, there were considerable changes among the basketball players of the experimental group (Table 3). The first survey revealed that the average FEV_1 rate for the experimental group is within the range of contingent standards of normal values of basic spirographic indices. The rest of the studied values correspond to the standard. It was found that 27% of the surveyed VC inhalation and exhalation indicators correspond to a conventional norm, while mild abnormalities were revealed among 18% of the subject persons, and 55% correspond to the standard, but the index is below 100% of the required value. The average index of maximum lung ventilation for basketball players group was equal to 76% of the required value, the maximum value - 92% of the required value, which indicates a decrease in the function of external respiration in representatives of this group. Consequently, 88% of basketball players did not have obstructive disorders, the percentage of FEV_1 reduction from proper values was in the range from 1 to 19%. For 12%, this indicator corresponded to the relative standard (Table 3).

The second survey revealed that all indicators increased and significantly differ from the initial data obtained after the first screening (p<0.05, p<0.01). In addition, the figures that were previously in the range of the conditional standard began to correspond to these standards. Indicators totaling 110% or more in relation to the calculated proper values were recorded among: VCin indicators 44%, VCex 9%, IRV and EVC 33%, FVC 50%, FEV_1 28%, TI 17% of subject persons, respectively. The most pronounced changes are observed at MLV – among 89%, this indicator corresponded to 120% or higher (p<0.01) (Table 3).

The control group shows similar results after the first survey. Therefore, the average group FEV_1 index is within the conditional standard, and the other studied values corresponded to the standard. However, it should be noted that 22% of subject persons have VC inhalation

Table 3. Changes in indicators of the external respiration system of basketball players in the course of a pedagogical experiment (as a percentage of the calculated proper value, n = 36).

Indicator (% of proper)	Statistical indicator $\bar{x} \pm$			
	Experimental group (n = 18)		Control group (n = 18)	
	prior to an experiment	at the end of an experiment	prior to an experiment	at the end of an experiment
VCin	92.17 ±4.63	**110.00** ±3.23*	92.17 ±4.32	94.00 ±3.72
VCex	94.56 ±13.58	**108.00** ±11.16*	93.78 ±12.67	94.00 ±10.11
IRV	85.00 ±31.09	**98.00** ±34.56*	85.15 ±28.12	88.00 ±28.12
ERV	88.33 ±14.09	**100.00** ±9.01*	88.21 ±14.24	90.00 ±13.03
FVC	88.67 ±1.28	**101.00** ±12.10*	88.00 ±8.67	90.00 ±7.88
FEV_1	82.33 ±11.28	**102.00** ±12.89*	83.00 ±2.37	87.00 ±12.37
TI	94.00 ±11.33	100.00 ±7.12	94.00 ±6.42	95.46 ±9.19
PEF	75.00 ±12.03	**98.33** ±13.32*	74.50 ±13.45	80.00 ±10.16
MLV	76.33 ±10.53	**126.00** ±10.53**	75.27 ±10.53	81.88 ±10.53

* p<0.05, ** p<0.01.

and exhalation indicators within the conventional standard, among 16% there are moderate deviations, 62% the index was normal, but below 100% of the required value. The average group MLV value was equal to 75% of the required value, the maximum value-94% of the required value, which also indicates a decrease in the function of external respiration in the control group of basketball players. The analysis of Forced Expiratory Volume for the first second of the FVC maneuver showed that 94% of basketball players had no obstructive disorders. The percentage of FEV_1 reduction from proper was in the range of 1% to 19%. Among 6% of the subject persons, this indicator corresponded to the relative standard. The second survey of athletes in the control group showed that there were slight increases in indicators, but the data obtained do not differ significantly from the initial ones (p>0.05). The analysis of intergroup differences in spirography indicators allowed us to state that the experimental

Table 4. Indicators of the external respiration system of basketball players (variable) after a pedagogical experiment (experimental and control groups).

Variable (indicator)-	Statistical indicator $\bar{x} \pm$		
	Experimental group (n = 18)	Control group (n = 18)	Size of distinctions
VT (l)	2.10 ±0.67	1.98 ±0.78	0.12
BF (quantity·min^{-1})	11.17 ±1.65	13.21 ±2.01	**−2.04***
MV (l·min^{-1})	25.45 ±3.49	26.17 ±3.76	−0.72
VCin (l)	6.14 ±0.56	5.51 ±0.56	0.63*
VCex (l)	6.08 ±0.34	5.48 ±0.98	0.60*
IRV (l)	2.76 ±0.78	2.37 ±1.79	0.39*
ERV (l)	1.74 ±0.32	1.52 ±1.12	0.22*
FVC (l)	5.66 ±1.12	5.10 ±0.56	0.56*
FEV_1 (l)	4.61 ±2.16	4.04 ±0.55	0.57*
TI (%)	84.00 ±24.53	78.33 ±5.74	5.67
PEF (l·min^{-1})	10.54 ±1.23	8.78 ±2.01	1.76*
MLV (l·min^{-1})	201.00 ±24.56	**160.00** ±18.34*	41.00**
VTmlv (l)	1.65 ±0.41	1.38 ±2.11	0.27*
BFmlv (quantity·min^{-1})	130.33 ±7.12	116.50 ±9.12	13.83*

* p<0.05, ** p<0.01.

Table 5. Indicators of the external respiration system of basketball players expressed as a percentage of the calculated proper value after the pedagogical experiment (experimental and control groups).

Indicator (% of proper)	Statistical indicator $\bar{x} \pm$		
	Experimental group (n = 18)	Control group (n = 18)	Size of distinctions
VCin	110.00 ±3.23	94.00 ±3.72	16.00*
VCex	108.00 ±11.16	94.00 ±10.11	14.00*
IRV	98.00 ±34.56	88.00 ±28.12	10.00*
ERV	100.00 ±9.01	90.00 ±13.03	10.00*
FVC	101.00 ±12.10	90.00 ±7.88	11.00*
FEV_1	102.00 ±12.89	87.00 ±12.37	15.00*
TI	100.00 ±7.12	95.46 ±9.19	4.54
PEF	98.33 ±13.32	80.00 ±10.16	18.33*
MLV	126.00 ±10.53	81.88 ±10.53	44.12**

* p<0.05, ** p<0.01.

group of 14 persons, the absolute indicators of external respiration function has significantly changed among 11 of them ($p<0.05$, $p<0.01$): the only indicator – the respiratory rate decreased by 18.26%, the rest of all shows increase, the growth rates are in the range of 10 to 21% (Table 4).

Eight of the nine indicators of the external respiration system of basketball players, expressed as a percentage of the calculated proper value after the pedagogical experiment, significantly changed ($p<0.05$, $p<0.01$). At the end of the experiment, the MLV indicator changed significantly, with an increase of 35% ($p<0.01$). It increased slightly and did not significantly differ between the experimental and control groups of athletes ($p<0.05$).

The analysis of absolute and relative indicators of the external respiratory system indicates that the *taijiquan* complex of exercises introduced into the training process had a positive impact on the functional state of the external respiratory function. The volume indicators increased among VCin, VCLex, IRV, ERV, FEV_1 and PEF; rationalization of the respiratory system via reducing the frequency of breathing at rest, as well as increasing the level of implementation of the external respiratory system – the growth of the MLV indicator due to a significant increase in BFmlv and VTmlv.

The analysis of intergroup differences in the data of psychophysiological testing of basketball players from both groups showed that the studied indicators significantly improved in the experimental group (Table 6). It was found that 13 out of 15 indicators of individual typological properties of higher nervous activity and sensorimotor functions of athletes significantly differ after the pedagogical experiment ($p<0.05$, $p<0.01$).

The influence of *taijiquan* on the effectiveness of basketball players' shots in training conditions during competitive games was determined. Performance indicators of shots of representatives of the experimental and control groups did not differ significantly during the first test

Table 6. Results of psychophysiological testing of basketball players after a pedagogical experiment (experimental and control groups).

Test	Variable (indicator)	Result in psychophysiological testing $\bar{x} \pm$		
		Experimental group (n = 18)	Control group (n = 18)	Sizes of distinctions
SHER	Latency period (ms)	298.22 ±27.76	347.81 ±22.52	**–49.59***
	Quantity of Mistakes	0.23 ±0.08	**1.53** ±0.23*	**–1.3****
RC1-3	Time of the latency period (ms)	446.32 ±34.25	490.44 ±27.15	**–44.12***
	Quantity of Mistakes	0.29 ±0.10	**1.55** ±0.14*	**–1.26****
RC2-3	Time of the latency period (ms)	467.22 ±29.08	516 ±34.37	**–48.78***
	Quantity of Mistakes	1.82 ±0.13	2.41 ±0.21	**–0.59****
LFMNP	Time of the latency period (ms)	389.76 ±24.51	429 ±25.55	**–39.24***
	Quantity of Mistakes	17.76 ±1.62	21.77 ±1.99	–4.01
	Minimum signal exposure time (ms)	314.12 ±11.40	368.23 ±13.82	**–54.11***
	Total test run time (c)	88.94 ±11.36	110.58 ±11.08	**–21.64***
	Time to the minimum exposure (c)	52.35 ±8.02	65.47 ±11.35	–12.65
SNP	Time of the latency period (ms)	360.76 ±6.80	387.47 ±17.09	–26.71
	Quantity of Exposures	317.71 ±11.85	298.52 ±16.64	19.19
	Minimum signal exposure time (ms)	287.06 ±7.48	331.18 ±10.78	**–44.12***
	Time to the minimum exposure (c)	114.94 ±14.68	138.41 ±20.81	**–23.46***

SHER: simple hand-eye reaction, **RC1-3:** the reaction of choosing one signal from three, **RC2-3:** reaction of choosing two signals from three, **LFMNP:** level of functional mobility of nervous processes, **SNP:** strength of nervous processes, * $p<0.05$, ** $p<0.01$.

Table 7. Changes in indicators of pedagogical testing aimed at determining the effectiveness of basketball players' shots in the course of a pedagogical experiment (n = 36).

Test	Statistical indicator $\bar{x} \pm$			
	Experimental group (n = 18)		Control group (n = 18)	
	prior to an experiment	at the end of an experiment	prior to an experiment	at the end of an experiment
2-point shots from set points, number of hits out of 10	5.33 ±1.19	**7.72** ±1.13*	5.33 ±1.46	5.78 ±1.48
Mid-range shots, number of shots per 40s.	9.39 ±0.78	**11.33** ±0.97*	9.33 ±1.24	9.56 ±1.38
Mid-range shots, number of hits per 40 s.	5.17 ±1.72	**7.22** ±1.35*	5.00 ±1.46	5.39 ±1.42
Free throw, number of hits out of 10	5.78 ±1.40	**7.78** ±1.35*	5.72 ±1.23	6.11 ±1.08
3-point c, number of hits out of 10	3.94 ±1.06	**6.06** ±0.94*	3.94 ±0.73	4.28 ±0.75
Jump shots, number of hits out of 10	4.11 ±1.32	**5.78** ±1.17*	4.17 ±1.29	4.50 ±1.42
Shots from set points (40 shots in 3.5 minutes of the test time, the number of effective shots	19.72 ±3.95	**23.83** ±2.73*	19.78 ±4.08	21.11 ±3.48
Shots within 5 min., the number of shots	43.50 ±4.87	48.83 ±3.50*	43.56 ±5.04	43.83 ±5.65
Shots within 5 min., the number of effective shots	21.17 ±1.98	24.89 ±1.37*	21.11 ±2.25	22.22 ±3.48

* $p<0.05$, ** $p<0.01$.

(p>0.05), which indicated the homogeneity of the examined groups of athletes (Table 7). The basketball players' test shows that after the pedagogical experiment, all nine studied indicators significantly increased among the experimental group (p<0.05). Significant changes were observed in such indicators as 2-point shots from set points (the number of hits out of 10), where the average result for the group increased by 44.8%. The test scores for mid-range shots (the number of hits in 40 seconds) and free throw (the number of hits out of 10) increased by 39.8% and 34.6%, respectively. The most considerable increases in the indicator are at 3-point shots (the number of hits out of 10), where the average group indicator increased by 53.5%. Also, the jump shots index (the number of hits out of 10) increased by 40.5%, which also indicates a significant increase in the effectiveness of shots as a result of the use of a set of *taijiquan* exercises in the training process of basketball players (Table 7).

In the control group, after the experimental macrocycle, the results in pedagogical testing on average for the group increased slightly and did not significantly differ from the initial indicators (p>0.05). The values of differences before and after the experiment vary within 1%-8% (p>0.05).

In the experimental group, the result significantly increased when performing 2-point shots from set points (number of hits out of 10), mid-range shots (number of hits in 40 seconds) the increase in both cases was 25.18% (p<0.05), as well as there was 21.43% increase in free throw indicators (number of hits out of 10), 22.12% – the jump shots indicators (number of hits out of 10) (p<0.05). Significant changes have been observed in the effectiveness of 3-point shots (the number of hits out of 10) showing an increase of 29.36% (p<0.01). The performance indicators of mid-range shots (the number of throws per 40 s) also increased by 15.69% (p<0.05). The effectiveness of shots in the final two tests also shows some increase, ranging from 10.21% to 10.71% (p<0.05) (Table 8).

The analysis of intergroup differences showed that the effectiveness of shots in all nine tests (Table 8) used has significantly increased in the experimental group of basketball players (p<0.05, p<0.01).

Table 8. Indicators of pedagogical testing aimed at determining the effectiveness of basketball players' shots after a pedagogical experiment (experimental and control groups).

Test	Statistical indicator $\bar{x} \pm$		
	Experimental group (n = 18)	Control group (n = 18)	Size of distinctions
2-point shots from set points, number of hits out of 10	7.72 ±1.13	5.78 ±1.48	1.94*
Mid-range shots, number of shots per 40 s.	11.33 ±0.97	9.56 ±1.38	1.78*
Mid-range shots, number of hits per 40 s.	7.22 ±1.35	5.39 ±1.42	1.83*
Free throw, number of hits out of 10	7.78 ±1.35	6.11 ±1.08	1.67*
3-point c, number of hits out of 10	6.06 ±0.94	4.28 ±0.75	1.78**
Jump shots, number of hits out of 10	5.78 ±1.17	4.50 ±1.42	1.28*
Shots from set points (40 shots in 3.5 minutes of the test time, the number of effective shots	23.83 ±2.73	21.11 ±3.48	2.72*
Shots within 5 min., the number of shots	48.83 ±3.50	43.83 ±5.65	5.00*
Shots within 5 min., the number of effective shots	24.89 ±1.37	22.22 ±3.48	2.67*

* $p<0.05$, ** $p<0.01$.

DISCUSSION

The *taijiquan* complex introduced into the training process had a positive impact on technical readiness, which was manifested in an increase in effective shots. This was due to increased proprioceptive sensitivity and intermuscular coordination. Athletes who performed the *taijuan* complex for one year managed to increase the number of different types of shots in comparison with the basketball players of the control group. Also, an increase in the majority of indicators of external respiration function of basketball players in the experimental group had a positive impact on the performance and endurance of basketball players. There was a statistically significant increase in diverse shots – free shots, 2-pointers, three-pointers, shots from the set points under the time limit, the limited number of shots, and shots performed in the condition of accumulated fatigue. The team, which included basketball players of the experimental group, won six victories. Two wins and two losses before the pedagogical experiment and four wins after the pedagogical experiment. This team was distinguished by a significant preponderance over the rival team, which included the control group members. As a result of three control games, the indicators of competitive activity of athletes in the experimental group significantly improved in relation to the control group. Indicators in 2-point shots increased by 16.9%, 3-point shots-by 47.6% and penalties 14.0%; in the number of points scored per match, 23.8% ($p<0.05$).

Taijiquan is widely used as an alternative means of increasing the functional capabilities of the body. The authors of existing studies emphasize that *taijiquan*, along with medication, helps in the fight against diseases of the respiratory system [5-9]. In our study, it was found that the use of the Chen complex for a year six times a week leads to an increase in the functional state of the external respiratory function in young healthy people. We have confirmed data [9] that *taijiquan* contributes to an increase in the FEV_1 index. This indicator, according to [31], is the main criterion for diagnosing the presence of obstructive airway disorders. Yoga breathing exercises served to improve three indicators of external respiration function of basketball players [26]. Our research shows an improvement in 11 absolute and 8 relative indicators of respiratory function in *taijiquan* practitioners.

We also confirmed data [11-13] that *taijiquan* has a positive effect on overall stress tolerance and stress perception. This was reflected

in the competitive activity and the reduction in the number of mistakes made when processing visual information during psychophysiological testing. The research shows the relationship between the psychophysiological state and the performance of games in basketball [28-30, 33]. But we are not talking about correcting these data. We have proved that *taijiquan* has a positive effect on the sensory component of the psychophysiological state. Under the influence of *taijiquan* classes, the time of simple and complex visual-motor reactions, the minimum time of signal exposure, and the time to reach the minimum exposure during psychophysiological testing decreases. It also increases the mobility and strength of the nervous processes. Consequently, there are no research papers devoted to improving the functioning of the external respiratory function, indicators of psychophysiological state and the effectiveness of shots under the influence of regular use of *taijiquan* exercises by young people engaged in basketball.

Our research data allow us to recommend basketball coaches to use *taijiquan* as an alternative tool to improve the functionality of the respiratory system, a sensory component of the psychophysiological state, which does not require additional equipment and special conditions. Having studied a set of *taijiquan* exercises, it can be applied independently at the end of each training session at different stages of the annual training cycle, including the competition period.

CONCLUSIONS

The study showed a positive effect of *taijiquan* on the indicators of respiratory function, psychophysiological state, and the effectiveness of basketball players' shots. Athletes in the experimental group practiced *taijiquan* at the end of each training session six times a week for a year. These athletes demonstrated a significant improvement in almost all indicators of individual typological properties of higher nervous activity and sensorimotor functions, absolute and relative indicators of the function of external respiration. Basketball players have reduced the time of simple and complex visual-motor reactions, the number of errors in processing information, increased lung volumes and capacities, and a considerable increase in the MLV index. The performance of the control group's basketball players was significantly worse. Analysis of the performance of basketball players' shots during testing and competitive games confirmed the high success of the experimental group.

We are recomendet *taijiquan* exercises at the end of each training session at different stages of the annual training cycle, including the competition period.

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