

Use of game tools in martial arts for endurance development

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Abstract

Background and Study Aim The purpose of research is to test experimentally the effectiveness of the influence of game means on the dynamics of endurance development in 10-year-old boys who attend the sports section of Kyokushinkai karate.

Material and Methods Forty 10-year-old boys engaged in Kyokushinkai karate took part in the research. The children and their parents were informed about all peculiarities of the research and agreed to participate in the experiment. The following research methods were used to solve the tasks: analysis of scientific and methodological literature, pedagogical testing, and methods of mathematical statistics for processing research results.

Results Statistically significant changes in results occurred in the studied groups ($p < 0.001$). The improvement of the level of endurance development in 10-year-old boys' karate athletes in favor of EG is confirmed. The highest statistically significant changes in EG indicators ($p < 0.001$) occurred in tests "Bent arm hang" (14.6%), "Push-ups" (11.8%), "Burpee" (11.8%). The average performance in 300 m run (8.6%) and in kicks "Mawashi geri chudan" with the right (left) foot slightly increased by 9.8% and 8.1%, respectively. There was no significant difference in the results of the test "Sit-ups in 1 min from the supine position" between EG and CG groups (1.1%, $p > 0.05$). However, both groups showed a sufficiently confident increase in the level of local dynamic power endurance (EG – 11.6%, CG – 10.4% at $p < 0.001$).

Conclusions The level of boys' endurance at the initial stage of the pedagogical experiment corresponds to proper age norms. According to most results, 36% of boys are classified as of average level, 16.5% as above average, 17% as high. The rest of the indicators were distributed between below average and low levels, 12% and 18.5%, respectively. A significant lag was found in terms of general endurance (300 m run test). The dynamics of the obtained data testified to the effectiveness of the developed, tested, and implemented physical education methodology of endurance development in 10-year-old boys' karate athletes with outdoor games. Because of application of game load (5 games, 3 repetitions with rest intervals of 20 s) there was a statistically significant increase in endurance ($p < 0.001$).

Keywords: boys, endurance, outdoor games, game load, Kyokushinkai karate.

Introduction

The scientific and methodological literature contains many recommendations on the widespread use of game and competitive methods in various forms of physical exercises [1, 2, 3].

The authors note the importance of their application both in physical education [4, 5, 6] and at different stages of sports training [1, 7, 8].

Researchers emphasize the unique opportunity of play in the physical and moral education of children [9, 10]. Especially in the development of cognitive interests, in strengthening the will and character, and in forming the ability to navigate the environment and the team [11, 12, 13]. Outdoor games encourage logical thinking, taming emotions, and instantly reacting to the actions of the opponent and partner, even anticipating them. All of this

is especially important for personal development [14, 15, 16]. At the same time, the importance and necessity of game load management during the organization and conduct of outdoor games aimed at the development of motor abilities has been emphasized [4, 5, 17].

Outdoor games with elements of martial arts can be a mean to saturate new variable sections of the model curriculum "Physical Culture. Grades 5-6" for general secondary education institutions: combat horting, judo, hand-to-hand combat, sumo, sambo, wushu, fencing, military sports games, and others [18, 19]. Such an update can also contribute to the involvement of children in physical education and sports activities during extracurricular activities [14, 20, 21].

These sports activities require a sufficient level of endurance development. Scientists argue that the development of strength, speed, power, dynamic and static power endurance is of core importance

in martial arts training [22, 23]. The endurance development in this age period only within the methods of strictly regulated exercise, standard-repeated exercise, standard-continuous exercise, interval method, and others can lead to a decrease in performance, fatigue, negative emotions, and distraction. Therefore, there is a need to introduce game and competitive elements in the training process of Kyokushinkai karate for 10-year-old boys [8, 24, 25].

Unfortunately, there is little literature on the use of outdoor games and game exercises as a means of endurance development at the stage of initial training in Kyokushinkai karate. Most scientific works consider problems related to the sport of higher achievements. Therefore, the problem of searching and effective use of game means for endurance development in 10-year-old boys engaged in Kyokushinkai karate is actual.

The purpose of this research is to test experimentally the effectiveness of the influence of game means on the dynamics of endurance development in 10-year-old boys who attend a sports section of Kyokushinkai karate.

Materials and methods

Participants

The research involved forty 10-year-old boys engaged in Kyokushinkai karate. The children and their parents were informed about the features of the study and agreed to participate in the experiment.

Study Design

The following research methods were used to solve the following tasks: analysis of scientific and methodological literature, pedagogical testing, and methods of mathematical statistics for processing research results.

The testing program included well-known tests [26, 27, 28]. In addition, to assess endurance in martial arts athletes, tests were used that included special sports techniques and tests recommended by the authors when selecting children for the karate sports section [29, 30, 31].

1. Push-ups, times;
2. Sit-ups in 1 min from the supine position, times;
3. Bent arm hang, s;
4. Test on a bicycle ergometer for 15 s, number of rotations;
5. 300 m run, s;
6. Burpee test in 1 min (cycles);
7. Kicks "Mawashi geri chudan" at makiwara with the right foot for 30 s, times;
8. Kicks "Mawashi geri chudan" at makiwara with the left foot for 30 s, times.

1, 2, 3, 5 tests are well-known and are often used in the practice of physical education and sports. Therefore, the methodology of their implementation does not need to be described. We used the simplified

Burpee test without push-ups and vertical jump.

Test on a bicycle ergometer to control the development of alactate endurance.

Equipment: EcoFit 507SP bicycle ergometer and XL-5853 electronic stopwatch.

Test description. During the test, the pupil must pedal at maximum speed for 15 s.

General instructions and remarks:

1. The pedaling resistance was 0.5 kg.
2. Calibration and adjustment of the seat height, handlebar angle, and distance between the saddle and handlebars of the bicycle ergometer were performed in accordance with the testing conditions and height of the participants. The seat was adjusted such that the leg was almost straightened in the knee joint at the lower pedal position.
3. Before the test, pupils were warmed up for 1 min with a resistance of 0 kg and a pedal speed of 50-60.
4. It is not allowed to stand on the pedals during the test.
5. After completing the test, it is necessary to pedal the ergometer at a calm pace for some time until it comes to a complete stop.
6. It is suggested to perform one test attempt.

Test result:

1. The number of full pedals rotations in 15 s is recorded.
2. The number of full pedal rotations in the first and last 5 s of cycling ergometric work was also compared. The test is evaluated according to the following criterion (C_{relat}): the closer the ratio is to one, the higher is the alactic capacity.

Test "Kicks "Mawashi geri chudan" at makiwara with the right (left) foot". Test for detection of special speed and power endurance.

Equipment. Makiwara (a pillow for practicing kicks), electronic stopwatch XL-5853.

Test description. On the command "Kamae te" (means "beginning" or "introduction" and is traditionally used to start a fight in karate), the pupils take the starting position "Kumite dachi" [21]. On the command "Hajime" pupils begin to perform a kick as fast as possible a circle kick at the middle level "Mawashi geri chudan" [32] at makiwara for 30 s. On the command "Yame", pupil finishes the test. The assistant holding a makiwara keeps a total count of the number of kicks in 30 s. The assistant with the stopwatch counts the number of kicks for the first 5 s and the last 5 s.

General instructions and comments. Perform the exercise technically correctly and maintain the maximum kicks speed until the last second.

Test result. Total number of correctly performed kicks during 30 s. The number of kicks in the first 5 s and the last 5 s. The transition to the exercise with the other leg should occur after full recovery of the participant.

During classes in the experimental group, we used the game material and loads proposed by Khudolii and Marchenko [33], Jagiełło et al. [1]. Games for endurance development were conducted mainly at the end of the lesson. Sports games with simplified rules, collective games, relay races, and games in pairs with a focus on the education of different types of endurance were used (Table 1). Game load in a training session was 5 games, number of repetitions – 3, rest intervals – 20 s [34].

In the control group, training sessions were conducted according to the standard kyokushinkai karate program “Curriculum for children’s and youth sports schools” [35].

Statistical analysis

Data were collected and systematized using EXCEL (Microsoft Excel 2016, Microsoft Corp., Redmond, WA,

USA). Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp., USA. The following parameters were calculated: arithmetic mean ($\bar{X}$), standard deviation (S), standard error of the mean (m). Comparison of arithmetic means was performed using Student’s t-test for dependent samples and Student’s t-test for independent samples. The hypothesis of normality of the data distribution was determined using the Kolmogorov-Smirnov test.

Results

The Kolmogorov-Smirnov criterion made it possible to determine that the results of measurements at the determining stage of the study for all studied indicators characterizing the level of development of different types of endurance correspond to the law of normal distribution (Table

Table 1. Classification of games for endurance development based on organizational and methodological features

№	Name of the game	Organization of participation in the game		Predominant type of movement in the game				Predominant type of movement coordination				Physiological load					Place of the game in the lessons		
		Without division into teams	With division into teams	Run	Jumping	Throwing	Complex actions	Arms	Legs	Collaborative	Cross	Low	Average	Large	High	Maximum	Preparatory	Main	Final
1	March-throw		+						+					+			+	+	
2	Ball in front of the feet	+		+			+	+	+				+					+	
3	Partridge hunting		+	+		+		+	+					+			+	+	
4	Hockey without gates		+	+			+	+	+		+			+				+	
5	Mini football		+	+			+		+	+	+				+		+	+	
6	Mini basketball		+	+	+	+	+	+	+		+					+	+	+	
7	Mini handball		+	+	+	+	+	+	+		+				+		+	+	
8	Struggle for the ball		+	+	+	+	+	+	+	+						+	+	+	+
9	Hockey with hands		+	+	+		+	+	+	+	+				+			+	+
10	Small tennis		+	+			+	+	+		+			+			+	+	+
11	Pursuit racing		+	+			+		+	+	+			+			+	+	

Table 2. Statistical characteristics of endurance indicators of the studied groups at the beginning of the experiment

Indicators under study	EG (n = 20)			CG (n = 20)			p
	Mean	Standard deviation	Standard error of mean	Mean	Standard deviation	Standard error of mean	
1 Push-ups, times	26.35	7.604	1.700	26.55	7.674	1.716	.934
2 Sit-ups in 1 min from the supine position, times	29.85	3.924	.877	29.75	3.945	.882	.936
3 Bent arm hang, s	18.979	9.168	2.05	18.914	8.932	1.997	.982
4 Test on a bicycle ergometer for 15 s, number of rotations	26.80	6.178	1.381	27.10	5.964	1.334	.877
5 300 m run, s	79.85	6.580	1.471	79.95	6.353	1.421	.961
6 Burpee test in 1 min (cycles)	18.20	5.337	1.193	18.05	5.125	1.146	.928
7 Kicks «Mawashi geri chudan» at makiwara with the right foot for 30 s, times	31.20	7.898	1.766	31.10	7.398	1.654	.967
8 Kicks «Mawashi geri chudan» at makiwara with the left foot for 30 s, times	27.80	6.971	1.559	27.85	6.302	1.409	.981

2). There was no statistically significant difference between experimental and control groups ($p > 0.05$). This meets the requirements for conducting the experiment and indicates that the selected sample fully meets the requirements of representativeness. It reproduces the characteristics of the general population and ensures the objectivity of the conclusions of the pedagogical experiment.

The analysis of the obtained results of different types of endurance in 10-year-old boys at the beginning of the pedagogical experiment demonstrated not the same level of development. In general, boys' endurance levels correspond to age norms. A significant lag was found only in terms of general endurance in "300 m run". Most children showed low results (45%) and below average results (27,5%). Unfortunately, in the literature available to us, there are no normative tables that can be used to determine the level of development of special endurance abilities of schoolchildren engaged in Kyokushinkai karate at the sports and recreational or initial stages. Therefore, in tests "Kicks «Mawashi geri chudan» at makiwara with the right (left) foot" and "Test on a bicycle ergometer" only dynamics of changes in endurance indicators during the formative experiment were studied.

Indicators of the tests characterizing the level of dynamic and static endurance of the upper extremities correspond to average, above average, and high levels. The best results at the stating stage of the experiment were obtained in tests aimed at revealing the dynamic and static endurance of muscles of the upper shoulder girdle. In accordance with the standards proposed by Sergienko [26] for junior schoolchildren, 60% of boys engaged in karate

performed the task "Push-ups" at a high level. The results obtained in the test "Bent arm hang" were distributed as follows: high level – 25%, above average – 20%; and average – 20%. The strength endurance test by the Burpee test demonstrated an average – 22.5% and above average – 72.5% level of fitness. This means that boys of this age can perform complex coordination actions for a long time and control their body and balance. The majority of boys performed the test "Sit-ups in 1 min from the supine position" at the average – 50% and above average – 20% levels, the last 30% had the level below average.

The data in Table 3 confirm that after the formative experiment that studied the effectiveness of the use of outdoor games for the endurance development in 10-year-old boys engaged in karate, the changes in indicators occurred at different rates both in experimental (EG) and in control (CG) groups. There is a tendency to improve the growth of results toward the experimental group.

At the control stage, the highest statistically significant changes of EG indicators ($p < 0.001$) occurred in tests "Bent arm hang" (14.6%), "Push-ups" (11.8%), "Burpee" (11.8%), "Sit-ups in 1 min from the supine position" (11.6%) from the initial level. However, it should be noted that the greatest difference in percentage ratio between CG and EG at the end of the forming experiment was observed in indicators of local static power endurance in the test "Bent arm hang" (5.8%) and anaerobic endurance in "Test on a bicycle ergometer for 15 s" (5.1%). EG in the test "Push-ups", which determined the level of local dynamic power endurance, was ahead of CG by 3.1%.

Positive changes in the state of the pupils'

Table 3. Characteristics of influence of outdoor games on the endurance development in 10-year-old boys

Indicators under study		Groups	Paired differences					t	Value (two- sided)	%
			Mean	Standard deviation	Standard error of mean	95% confidence interval for the difference				
						Lower	Upper			
1	Push-ups, times	EG	3.10	1.971	.441	2.178	4.022	7.034	.000	11.8
		CG	2.30	1.559	.349	1.570	3.030	6.596	.000	8.7
2	Sit-ups in 1 min from the supine position, times	EG	3.450	3.069	.686	2.014	4.886	5.027	.000	11.6
		CG	3.100	1.334	.298	2.476	3.724	10.394	.000	10.4
3	Bent arm hang, s	EG	2.767	1.704	.381	1.969	3.565	7.261	.000	14.6
		CG	1.658	.717	.160	1.323	1.994	10.346	.000	8.8
4	Test on a bicycle ergometer for 15 s, number of rotations	EG	2.850	.988	.221	2.388	3.312	12.899	.000	10.6
		CG	1.50	.513	.115	1.260	1.740	13.077	.000	5.5
5	300 m run, s	EG	6.850	1.694	.379	6.057	7.643	18.079	.000	8.6
		CG	4.60	1.903	.426	3.709	5.491	10.811	.000	5.8
6	Burpee test in 1 min (cycles)	EG	2.150	.875	.196	1.740	2.560	10.987	.000	11.8
		CG	1.600	.681	.152	1.281	1.919	10.514	.000	8.9
7	Kicks “Mawashi geri chudan» at makiwara with the right foot for 30 s, times	EG	3.050	.945	.211	2.608	3.492	14.441	.000	9.8
		CG	1.900	.788	.176	1.531	2.269	10.782	.000	6.1
8	Kicks «Mawashi geri chudan» at makiwara with the left foot for 30 s, times	EG	2.250	.967	.216	1.798	2.702	10.411	.000	8.1
		CG	1.450	.759	.170	1.095	1.805	8.542	.000	5.2

total coordination endurance at the end of the experimental period were observed. EG pupils performed the “Burpee” test better than CG pupils by 2.9%. It is expedient to use this test when studying the influence of game method as it characterizes not only pupils’ condition in terms of revealing endurance level but also condition of coordination, balance, speed, and power capacities.

There was no significant difference between and CG groups in the results of the test “Sit-ups

in 1 min from the supine position” (1.1%), as both groups showed rather confident growth of the level of indicators of local dynamic power endurance (EG - 11.6%, CG - 10.4% at $p < 0.001$).

In our opinion, the local endurance development of a group of muscles of a press is insufficient using only mobile games. There is a necessity to supplement the content of training with special exercises or to develop additional game exercises aimed at the target development of these muscles.

The average results of EG's general endurance in 300 m run increased sufficiently (8.6%, $p < 0.001$). In addition, children are not always able and willing to make maximum efforts every time they perform monotonous work for a long time. The trainer has to keep the children's attention all the time, avoiding large loads. During the tests in EG, this problem was solved using game and competitive methods.

The control exercise "Mawashi geri chudan", which used the karate kicking technique, demonstrated significant changes in the results of special high-speed and power endurance in favor of EG. The average indicators of kicks "Mawashi geri chudan" with the right (left) foot increased by 9.8% and 8.1% respectively ($p < 0.001$). The difference in the test results between EG and CG was 3.7% with the right foot and 2.9% with the left foot. Research has shown that the game method is effective for the development of this type of endurance. Its sufficient level allows an athlete to perform highly active technical actions of power character for a long period.

The ratio of the number of performed movements for the first 5 s and the last 5 s in tests on a bicycle ergometer (C_{relat} : EG – 1.2; CG – 1.3) showed that the alactate anaerobic capacity of younger children is at a low level. The control of development of high-speed and power endurance in kicks "Mawashi geri chudan" defined the best level in EG on both feet (C_{relat} of the right foot: EG – 1.1; CG – 1.2; C_{relat} of the left foot: EG – 1.1; CG – 1.3).

Discussion

The study assumed that the use of specially selected outdoor games can contribute to the endurance development in 10-year-old boys engaged in Kyokushinkai karate at the initial training stage. In experimental group, the comparison of indicators showed a larger relative increase than in control group for all indicators. The dynamics of the results of all exercises were statistically reliable ($p < 0.001$).

To assess the motor abilities of martial arts athletes, previous studies have used various methods, from additional exercises to complexes that include special sports techniques [36, 37, 38]. These tests differ in their ability to describe different physiological attributes or performance characteristics with varying levels of accuracy, informativeness, and economic feasibility [29, 38].

We have supplemented the battery of tests, including technical actions, with the exercise "Kicks "Mawashi geri chudan" to identify the level of special speed and power endurance development.

The obtained results coincide with the conclusions of Marchenko [34], Jagiełło et al. [1] that the dynamics of endurance indicators are statistically significantly influenced by specially selected games, considering organizational and methodological features and modes of game work. We confirm the opinion of Balushko et al. [24] that the development of dynamic and static power endurance is of profile importance during training in single combat. Our results emphasize the importance of using game and competitive exercise methods in physical education and sports training.

Conclusions

1. Outdoor games are an important part of the training process in Kyokushinkai karate. They promote the effective complex development of different muscle groups. The competitive character of the game stimulates all participants to a greater manifestation of their possibilities.
2. The level of boys' endurance at the initial stage of the pedagogical experiment corresponds to appropriate age norms. According to most results, 36% of boys are classified as having an average level, 16.5% as above average, 17% as high. The rest of the indicators were distributed between below average and low levels, 12% and 18.5%, respectively. A significant lag was found in terms of general endurance (300 m run test).
3. The dynamics of the obtained data testified to the efficiency of the developed, tested, and implemented in the process of physical education methodology of the endurance development in 10-year-old boys-karate athletes with outdoor games. Because of application of a game load (5 games, 3 repetitions with rest intervals of 20 s) there was a statistically significant increase in endurance ($p < 0.001$).
4. Special tests for controlling the level of endurance of karate athletes of different age categories and qualifications require further development, study, and evaluation.

Conflict of interest

The authors declare that there are no conflicts of interest.

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