Endurance development in Taekwondo according to the Tabata protocol

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Abstract:

The scientific literature presents a limited number of studies on Tabata training use for endurance, as the main physical quality for taekwondo athletes, development. *The purpose of the research:* to prove experimentally Tabata protocol training effectiveness to increase WTF taekwondo athletes' endurance. *Research material and methods.* The experiment was conducted at a sports school in Chelyabinsk (Russia). The study participants were 2 groups of athletes aged 16-18. All young men were engaged in taekwondo WTF at the stage of improving sports skills according to the program of the Russian federal standard of sports training in the sport «taekwondo ITF» (International Taekwondo Federation) (2019). In the main part of the training session, the experimental group conducted high-intensity interval training according to Tabata protocol (20-25 minutes) using a complex of strength, plyometric and coordination exercises with and without sports equipment. For a comparative analysis of the training process effectiveness in the control and experimental groups, the methods of anthropometry and physiometry, physical qualities and physical performance testing were used. *Results.* At the end of the experiment, all indicators improved in both observation groups. The increase in these indicators' values was higher in the boys of the experimental group: aerobic and anaerobic physical performance, absolute and relative hands muscles strength significantly increased. The indicators values of general, strength and speed endurance were higher than in the control group. *Conclusions.* High-intensity interval training according to Tabata protocol proved to be effective for general and special (strength and speed) endurance development in WTF taekwondo athletes at the stage of improving sports skills.

Key Words: Taekwondo, International Taekwondo Federation (WTF), Tabata training, general and special endurance

Introduction

In recent decades, young people's interest in the martial art of taekwondo has increased significantly in different countries of the world, especially after the inclusion of this sport in the program of the XXVII Olympic Games (Koshcheyev, Dolbysheva, 2021). Therefore, for the athletes' successful performance, coaches and specialists in the field of taekwondo face the task of finding new and improving existing means and methods for optimizing their training process (Glebov, Choi Sung Mo, 2002).

The existing «traditional» model of athletes', doing taekwondo, training process is based on physical, technical, tactical and psychological training. The training process is constantly being modernized, especially in the direction of general and special physical training (Hendarto et al., 2018; Simakov et al., 2018). There is an opinion that speed and strength endurance are the most significant motor qualities for improving athletic performance in taekwondo (Losik, 2018). In taekwondo training process practice, classical pedagogical techniques are used to develop significant motor qualities (Federal standard of sports training in the sport «taekwondo ITF», 2029) and experimental variants based on changes in the volume and intensity of physical activity at different stages of athletes' training (Bubka, Platonov, 2018; Koshcheyev, 2020; Guillermo et al., 2020). In 1996, at the Tokyo National Institute of Fitness and Sports, physiologist Izumi Tabata and colleagues developed a protocol for high-intensity interval training (HIIT), which lasts 4 minutes and consists of 8 repetitions of intense physical exercises each for 20 seconds and 10 seconds of rest between them (Tabata et al., 1996). Training according to the Tabata protocol leads to an increase in the maximum amount of oxygen consumption in the human body. An increase in VO_{2max} indicates an improvement in the activity of the cardiovascular and other functional systems and an increase in human physical performance (Saghiv et al., 2020).

Tabata training has an advantage over other types of physical activity: it develops aerobic and anaerobic capabilities of the human body, increases endurance and strength, does not require special outfit and equipment, is short in duration, more effective than regular training for an hour, and besides, it is available to people of different ages (Kuptsova, Chikeneva, 2018; Syamsudin et al., 2021). This makes Tabata training popular among various groups of the world's population (Thompson, 2018).

The positive effect of HIIT on a person's aerobic performance allowed Tabata protocol to be included in the training program of athletes in various sports. The literature presents materials of scientific observations on the use of HIIT in the training process of gymnasts (Zhuravskaya et al., 2019), judo wrestlers (Savinykh & Vikulov, 2020; Gryaznykh & Mustafin, 2020), Greco-Roman wrestling (Abramova, 2020), swimmers (Gussakov, 2021), badminton athletes (Nugroho et al., 2021).

High-intensity interval training Tabata proved to be an effective means for the prevention of severe non-communicable human diseases associated with the development of physical inactivity: atherosclerosis, diabetes mellitus, obesity, cancer (Syamsudin et al., 2021; Usina, 2020). Training according to Tabata protocol allowed normalizing the content of the fat component in the body and reducing the waist circumference in schoolchildren (Segovia, Gutiérrez, 2020), in men, even those who violate the diet (Pignato et al., 2019). The use of high-intensity interval training improved some indicators of cognitive abilities in physically inactive adolescents (Emilio J. Martinez-Lopez, 2018). Despite a significant amount of scientific information about the use of the method of high-intensity interval training in various sports, the literature presents a limited number of studies on the development of taekwondo athletes', using HIIT, general and special endurance. In our opinion, the study of this issue has pedagogical expediency and will increase the effectiveness of taekwondo athletes' training based on increasing their general and special endurance. **The aim of the research** is to experimentally prove the effectiveness of Tabata protocol training to increase WTF taekwondo athletes' endurance.

Material & methods

The study was conducted from September 2020 to May 2021 at the Olympic Reserve Sports School in Chelyabinsk (Russia). The pedagogical experiment involved 2 groups of athletes aged 16-18, control (CG, n = 10) and experimental (EG, n = 10) ones. All young men were engaged in taekwondo WTF at the stage of improving sports skills 3 times a week for 2 hours, according to the program of the Russian federal standard of sports training in the sport «taekwondo ITF» (2019).

In the main part of the training session in the experimental group, high-intensity interval training of anaerobic orientation according to the Tabata protocol (Tabata et al., 1996) was conducted for 20-25 minutes for general and special endurance development in young men. The athletes were offered a set of strength, plyometric and coordination exercises, which were performed according to the scheme 11223344 with sports equipment (fitball, dumbbells, gymnastic roller, Bosu Balance hemisphere) or without them on a step platform or crossbar. The set of exercises according to Tabata protocol changed every month with an increase in the volume and intensity of loads. Table 1 shows the structure and content of an experimental training session of taekwondo athletes.

Table 1. An example of a main part of a taekwondo training session content using Tabata protocol

<i>Training direction</i>	<i>Set of physical exercises</i>	<i>Conducting method</i>
<i>I period (20-25 min)</i>		
Anaerobic, according to Tabata protocol	1. Lunges forward and to the side 2. Burpee 3. Stretching with a gymnastic roller 4. Jumps with a fitball	4 cycles of exercises for general and special endurance development. One cycle = 8 sets according to the scheme: the work phase is 20 seconds; the rest phase is 10 seconds. Exercises in each cycle are performed for four minutes.
<i>II period (45 min)</i>		
Aerobic	Performing exercises according to the standard training taekwondo program	Learning and improving basic taekwondo exercises.

To control the number of completed cycles, Tabata Workout Timer for HIIT application (version 5.0.0 for Android) was used, where a timer for physical activity and rest was installed, the interface of which was displayed on the TV screen in the gym. Before and after the pedagogical experiment, standard measurements of the athletes' of both groups data were carried out. Anthropometry - length, cm; body weight, kg; chest circumference, see Physiometry - resting heart rate, beats/min; strength of the hands muscles, kg with the calculation of the strength index (International Standards for Anthropometric Assessment, 2001). The Rufier-Dixon index was calculated, characterizing the reserve capabilities of the cardiovascular system of young men after performing physical activity in the form of squats in 45 seconds. The Rufier-Dixon index was evaluated in conditional units (up to 5 - good heart performance; 5.1-10 - average result; 10.1-15 - satisfactory; >15 units - unsatisfactory heart performance). The athletes' physical performance was evaluated in conventional units according to the value of the Harvard Step Test Index (HSTI) for people engaged in acyclic sports. If HSTI is below 61 - the athlete's performance level is poor; 61-70 - below average; 71-80 - average; 81-90 - above

average; 91-100 - good; > 100 conditional units – excellent level. The overall endurance of athletes was assessed using motor tests: «running 1000 m», m /s and «Cooper's 12-minute running test», m. Strength endurance was tested using tests: «chest dips», the number of times and «complex test», the number of movements.

The athletes' special speed endurance was determined by the maximum number of limb movements in 1 minute using tests: direct blow; rear straight kick (tweed chagi) on the bag; side kick (dolio chagi); side blow; two hands blow (straight punches) + side kick (dolio chagi), the number of episodes (Simakov et al., 2018). The work was carried out in compliance with international ethical rules and norms, the consent of the young men's parents was obtained. Statistical analysis of the obtained results was carried out by generally accepted parametric methods based on the licensed version of the STATISTICA 10.0, MS Exsel 2010 programs.

Results

At the beginning of the pedagogical experiment, there were no significant differences between the morpho-functional indicators of the young men's of the control and experimental groups physical development ($p > 0.05$). At the end of the pedagogical experiment, a significant difference was found only in the values of young men's of both groups hands dynamometry ($p < 0.05$). Compared with CG boys, EG boys had an increase in the muscles strength of the left hand by 2.2 times, and the right hand by 2.1 times. At the end of the experiment, the strength index of the right hand was 18.8% higher in the EG boys and 16.0% higher in the left than in the CG boys. The level of physical performance and characteristics of the state of the cardiovascular system of young men at the beginning and at the end of the pedagogical experiment are given in Table 2.

Table 2. Harvard Step test index and the Ruffier-Dixon index values in athletes at the beginning and at the end of the experiment ($M \pm m$)

Indices	CG (n=10)		EG (n=10)	
	At the beginning of the experiment	At the end of the experiment	At the beginning of the experiment	At the end of the experiment
Physical capability				
Harvard Step test index (HSTI), conditional units	63,0±4,76	62,0±4,34	72,0±5,28	84,0±5,71*
Cardiovascular system capability				
Ruffier-Dixon index (RDI), conditional units	9,0±2,43	10,0±2,84	8,0±2,26	4,0±2,37*

Note. * - significant difference in the test indicators' values at the end of the pedagogical experiment ($p < 0,05$)

At the beginning of the pedagogical experiment, there were no significant differences between the values of HSTI and RDI indicators (Table 2) in CG and EG boys, which fact indicates approximately the same initial level of their physical performance and reserve capabilities of the cardiovascular system ($p > 0.05$). At the beginning of the experiment, HSTI in the boys of both groups was below average, RDI had an average result. At the end of the pedagogical experiment, only EG boys showed a significant increase in the values of HSTI and RDI indicators (by 16.7% and 50%, respectively), $p < 0.05$. General and special (strength and speed) endurance of taekwondo athletes are the leading and necessary motor qualities that should be developed during the training process. Table 3 shows the values of endurance testing indicators for taekwondo athletes of the control and experimental groups.

Table 3. Indicators values of the boundary (high-stakes) endurance testing of young men from CG и EG ($M \pm m$)

Tests	CG (n=10)		EG (n=10)	
	At the beginning of the experiment	At the end of the experiment	At the beginning of the experiment	At the end of the experiment
General endurance				
1. Running 1000 m, m /s	4,27±0,52	3,98±0,22	4,42±0,57	3,12±0,61*
2. Cooper's 12-minute running test», m	2634,64±9,32	2873,22±9,41*	2627,24±12,74	3089,56±9,65*
Special endurance				
Strength endurance				
3. Chest dips, the number of times	16,0±2,64	18,0±3,34	15,0±2,13	21,0±3,49*
4. Complex test, the number of movements	137,0±5,54	144,0±6,91	134,0±5,23	156,0±7,13*
Speed endurance				
Maximum number per 1 minute	5. Direct blow	176,0±9,34	190,0±10,56	180,0±9,94
	6. Rear straight kick (tweed chagi) on the bag	52,0±4,42	64,0±4,53*	48,0±3,63
	7. Side kick (dolio chagi)	58,0±4,51	73,0±5,34*	60,0±4,92
	8. Side blow	114,0±9,52	136,0±9,66*	110,0±9,22
	9. Two hands blow (straight punches) + side kick (dolio chagi)	32,0±2,54	42,0±3,35*	29,0±2,34

Note. * - significant difference in the test indicators' values at the end of the pedagogical experiment ($p < 0,05$)

At the beginning of the experiment (Table 3), there were no statistically significant differences between the results of testing the young men's of CG and EG endurance, $p > 0.05$. At the end of the pedagogical experiment, athletes of the experimental group had a significant increase in the value of endurance indicators in all tests, $p < 0.05$. In the boys of the control group, a significant increase in the indicators values was found in 4 out of 9 tests. In this group, there is no significant increase in the values of the indicator in two tests for strength endurance, in one test for general and speed endurance (Table 3). During the experiment, both groups experienced an increase in the values of general and special endurance testing indicators (Figure). The greatest increase in all tests was registered in EG boys who trained according to Tabata protocol.

Note: test numbers (1, 2 – general endurance; 3, 4 – strength endurance; 5 – 9 – speed endurance)

Fig. The increase in the endurance indicators values in athletes of CG and EG at the end of the experiment (%)

After the experiment, the speed endurance of EG athletes improved the most (tests 6-9). They increased the number of direct blows (punches) 2.5 times (test 5), rear direct kick on the bag 2.3 times (test 6), side kick 2.4 times (test 7), side blow 2.7 times (test 8) and a series of direct blows (punches) and side kick 2.9 times (test 9), compared with the results of testing athletes of CG. Overall endurance increased significantly: 4.3 times in the 1000 m run (Test 1) and 1.9 times in the 12-minute Cooper running test (Test 2), compared to CG. Strength endurance increased the least (test 4). Analysis of our research results showed that Tabata protocol training for taekwondo athletes' general and special endurance development was more effective than conducting a training session according to the traditional program.

Dicussion

In increasing the taekwondo training process effectiveness, a significant role is assigned to the development of general and special (strength and speed) endurance (Simakov, 2010; Losik, 2018). Therefore, the development and improvement of educational and training programs for these motor qualities education is an urgent scientific topic. In the scientific literature, there are materials of author's research related to improving the taekwondo training process effectiveness using various means and techniques (Bubka, Platonov, 2018; Koshcheyev, 2020; Guillermo et al., 2020). At the same time, the issues of using the high-intensity interval training method in taekwondo athletes' preparation are not sufficiently reflected. Some researchers have proved that an important condition for using Tabata training is consistent increasing physical activity, which increases the aerobic and anaerobic capabilities of the human body and develops general endurance, which is the basic component for special endurance formation (Kuptsova, Chikeneva, 2018).

By increasing the amount of physical activity during training, Tabata leads to an increase in aerobic endurance of the body, and an increase in the exercise intensity leads to anaerobic endurance development. The physical performance and the body tolerance to physical activity increases, the reserve capabilities of the cardio-respiratory system increase. The inclusion of Tabata training in the PE classes program for students allowed them to form a higher level of not only general endurance, but also significantly develop special one (Timokhina, Shavyrina, 2017; Kuptsova, Chikeneva, 2018).

According to Kong et al. (2016); Saghiv et al. (2020), HIIT practitioners experience an increase in the level of maximum oxygen consumption and, consequently, physical performance of the body. Our research results are consistent with these authors' data. The taekwondo athletes examined by us, who train according to Tabata protocol, showed a significant decrease in the Ruffier-Dixon index and an increase in the Harvard step test

index, which indicates an increase in the experimental group athletes' cardiovascular system and physical performance efficiency.

Our pedagogical experiment results of using high-intensity interval training according to Tabata protocol in the taekwondo athletes' training process showed a positive effect in endurance development. This fact is confirmed by a higher reliable increase in the values of the general, speed and strength endurance indicators in the boys of the experimental group, compared with the results obtained in the control one, where the training process was carried out according to the traditional curriculum. Our data are consistent with the results of studies by other authors who have received a positive effect from the use of Tabata training in the training of gymnasts (Zhumanova et al., 2019), judo wrestlers (Savinykh, Vikulov, 2020), in hand-to-hand combat (Tyupa, & Vorozheikin, 2021), swimmers (Gussakov, 2021), badminton athletes (Nugroho et al., 2021).

At the end of our experiment, there was a significant increase in the athletes' strength abilities values. It was found that in the experimental group, the increase in the right hand strength was 15.1% higher, the left hand by 12.5%, the right hand strength index by 18.8%, the left hand by 16.0% than in the boys of the control group. The increase in the strength tests values was 3.2 times greater in the athletes of the experimental group, compared with the results of the boys of the control one. We believe that further study of Tabata protocol training use is promising and will improve athletes' performance.

Conclusions

1. A method of using high-intensity interval training Tabata (HIIT) to increase WTF taekwondo athletes' general and special (strength and speed) endurance at the stage of improving sports skills has been developed and tested.

2. It is proved that the use of a set of aerobic and anaerobic exercises in Tabata protocol training in the experimental group significantly increased the increase in the values of indicators of general, strength and speed endurance, absolute and relative strength of the both arms hands muscles, physical performance and the athletes' cardiac system work. This increase was significantly greater than that of the athletes from the control group. The highest increase in the values of the indicators was registered when testing speed endurance (93.1%), which is the main physical quality of taekwondo athletes.

3. The positive results of testing high-intensity interval training of taekwondo athletes according to Tabata protocol allow us to recommend the proposed technique for use in sports schools and sections.

In our opinion, the use of the HIIT method is a promising direction in general and special endurance development and in improving the training programs of taekwondo athletes for their participation in major international competitions and the Olympic Games.

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