

## The effects of high-intensity interval training using “Tabata Protocol” on the physical fitness of teenage wrestlers

Elaheh Piralaiy\*, Saeid D. Nikoukheslat, Kawan Saeidy

Department of Exercise Physiology, Faculty of Physical Education and Sport Sciences, University of Tabriz, Tabriz, Iran.

(\*Corresponding author: ✉ [epiralaiy@tabrizu.ac.ir](mailto:epiralaiy@tabrizu.ac.ir),  <https://orcid.org/0000-0002-9201-7170>)

Article Info	Abstract
<p>Original Article</p> <p><b>Article history:</b> Received: 25 October 2022 Revised: 03 March 2023 Accepted: 29 March 2023 Published online: 01 July 2023</p> <p><b>Keywords:</b> physical fitness, Tabata training, teenage, wrestling.</p>	<p><b>Background:</b> The physical fitness is essential for wrestlers to perform successfully. The Tabata Protocol can be appropriate to develop these physical qualities.</p> <p><b>Aim:</b> This study aims to investigate the effects of high-intensity interval training using “Tabata protocol” on the physical fitness of teenage wrestlers.</p> <p><b>Material and Methods:</b> 16 participants were randomly assigned to two groups of Tabata training (n=8) and the control group (n=8). All mentioned variables were measured before and after 4 weeks of the intervention. Tabata training group performed Tabata protocol in 2- 3 sets of 8 exercises with 20 sec of training and 10 sec of rest. The control group kept up their normal training routine during the same time. Physical fitness components were measured. The collected data were statistically analyzed by an independent t-test at a significance level of <math>P&gt;0.05</math>.</p> <p><b>Results:</b> Wrestlers in both groups significantly increased physical fitness components except flexibility (<math>P&lt;0.05</math>). Tabata training was significantly more efficient in endurance of core muscle (<math>P= 0.019</math>, <math>ES= 0.490</math>) and upper body strength (<math>P= 0.001</math>, <math>ES= 0.490</math>) than control group (<math>P&lt;0.05</math>). Also, results showed that for leg explosive power, only Tabata training had a positive effect (<math>P= 0.026</math>, <math>ES=0.541</math>).</p> <p><b>Conclusions:</b> Our results suggest that wrestlers after Tabata protocol interventions can obtain better physical fitness, and event time benefits with more efficient performance and time-efficient manner compared with control group.</p>

**Cite this article:** Piralaiy E, Nikoukheslat SD, Saeidy K. “The effects of high-intensity interval training using “Tabata Protocol” on the physical fitness of teenage wrestlers”. *Sport Sciences and Health Research*. 2023, 15(2): 171-180. doi: <https://doi.org/10.22059/SSHR.2024.368648.1110>.

This is an open access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (CC BY NC), which permits distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.



EISSN: 2717-2422 | Web site: <https://sshr.ut.ac.ir/> | Email: [jsshr@ut.ac.ir](mailto:jsshr@ut.ac.ir)

© The Author(s). Publisher: University of Tehran, Faculty of Sport Sciences and Health

## 1. Introduction

Until today, sports scientists have conducted a lot of research on how athletic performance can be improved in the most effective way and within the shortest amount of time. Such research focuses on selecting the most suitable athlete to achieve the target performance or training the current athlete in the most effective way possible to reach the target performance level [1, 2, 3, 4, 5]. Wrestling, as a sport, is extremely dynamic in nature being characterized by sudden explosive attacks and counterattacks that are executed repeatedly at a high intensity and alternated with submaximal work for a duration of up to 6 min [6, 7]. It is one of martial arts sport consisting of pulling technique, pushing, lifting, locking, rolling, suplex, and a combination of pinching [8]. The ability of a wrestler to catch and protect the point defines the winner [9].

Anaerobic and aerobic capacity, upper and lower body strength, power, agility, and flexibility are important factors needed to achieve good results in wrestling competitions [7, 10, 11, 12, 13]. Therefore, one of the challenges facing wrestling coaches is to understand the physical and physiological factors effective in successful wrestling [7].

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 min and consists of 8 repetitions of intense physical exercises each for 20 sec and 10 sec of rest between them [14]. Training according to the Tabata protocol leads to an increase in the maximum amount of oxygen consumption in the human body. An increase in  $VO_2$  max indicates an improvement in the activity of the cardiovascular and other functional systems and an increase in human physical performance [15].

The current Tabata training has an advantage over other types of physical activity: Tabata training has a possessive effect on athletes' fitness level as aerobic and anaerobic preparation [16], balance and strength [17], explosive lower body strength [18], flexibility and body weight [19], core muscle [20], speed and agility [21], fat bursts and metabolism increase [22]. It does not require special outfit and equipment. It is short in duration, more effective than regular training for an hour, and besides, it is available to people of different ages [23, 24]. This makes Tabata training popular among various groups of the world's population [25].

The positive effect of HIIT on a person's aerobic performance allowed the 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 [26], judo wrestlers [27, 28], freestyle wrestlers [29], runners [30] Greco-Roman wrestling [29], swimmers [31], badminton athletes [32]. The use of high-intensity interval training improved some indicators of cognitive abilities in physically inactive adolescents [33].

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 wrestling athletes, using HIIT (Tabata), general, and special physical fitness. In our opinion, the study of this issue has pedagogical expediency and will increase the effectiveness of wrestling athletes' training based on increasing their general and special physical fitness. The aim of the research is investigate the effects of high-intensity interval training using “Tabata protocol” on the physical fitness of teenage wrestling

## 2. Materials and Methods

### 2.1. Research pattern

This research was designed as a semi-experimental, pre-test, and post-test with a control group. Before starting the research, a medical ethics license with code IR.TABRIZU.REC.1402.032 was obtained from Tabriz University to implement the project.

### 2.2. Participation

The statistical population of the current research is teenage wrestlers, who volunteered to cooperate in the research after the call was announced. Using G-Power software, 16 people from teenage wrestlers were selected as a sample (age:  $15.6 \pm 1.3$  years, weight:  $60.1 \pm 9.2$  kg). Inclusion criteria included: (i) having the age range of 14-18 years, (ii) at least one year of wrestling experience, (iii) had no pre-existing illnesses or musculoskeletal problems that might compromise their performance. Exclusion criteria were Injury and absence of more than two training sessions.

Subjects attended the coordination meeting and completed the consent and health form (by research ethics committees of university of Tabriz) and maturity Tanner questionnaire after the full explanation of the goals and measurement methods by the researcher (all subjects had maturity). In the time intervals of one week before the start of the training protocol, homogenization of the groups using individual characteristics such as age, weight, maturity and history of participation in wrestling training and some of the physical fitness factors (agility, upper body muscle strength, speed, flexibility, explosive power of legs and central muscle endurance) was done. Finally, 16 male participants were randomly allocated into two equal groups: an experimental group ( $n=8$ ) and a control group ( $n=8$ ).

### 2.2.1. Study design

Researchers conducted a randomized trial study on two groups: an experimental group and a control group using a pre-and post-test. This paper was divided into four phases: Phase 1 was a preparatory study that took place over the course of one week and was used to familiarize the subjects with the assessment methods, exercises, and Tabata routine. Additionally, during this phase, the reliability of the tests used in the study, equipment, and gadgets was verified. During the familiarization meetings, demographic information was gathered; Phase 2 included a week of pre-testing; Phase 3, which involved individuals completing four weeks of training; and Phase 4, which included a week of post-testing. The pre-test and post-test procedures were the same protocol.

### 2.3. Procedure

The training program was started on 20/05/2022. During the four weeks intervention, the groups completed 12 sessions, i.e., 3 sessions/ week, each lasting from 70 to 75 min. A minimum of 48 hours of inter-session recovery was allowed between running sessions. The subjects warmed up for 15 min with jogging, flexibility, and stretching exercises before each session. Then, HIIT using the Tabata protocol was carried out lasting from 10 to 20 min. Following that, subjects trained for 30 to 35 min in usual wrestling gym training, and the last 10 min of the session were spent cooling down [14]. The control group continued their usual gym training. The traditional wrestling group kept up their normal training routine during the same time.

The Tabata group performed Tabata protocol stations, where each station consisted of eight movements, which lasted for 4 min. The Tabata protocol consisting of eight movements was applied in the form of

the 20 sec working and 10 sec active recovery interval method. They performed Tabata exercises for each training session in two sets during the 1st and 2nd weeks, and 3 sets during the 3rd and 4th weeks. The rest interval was 2 min between sets [14].

To control the intensity, a 20-point rating of perceived exertion (RPE) was used. The duration of routine training of the control group was equal to the duration of Tabata exercises.

### 2.3.1. Measurement of physical fitness factors

Before and at the end of the 4-weeks study period, we examined physical fitness factors. Three separate sessions with 48-hour intervals were used to assess the subjects. Before the assessments began, a 10 min warm-up with low-intensity workouts including jogging and stretching was carried out.

On the day of the test, after having the same breakfast, the subjects appeared at the gym at 8:00 am. On the first day, the long jump and the 9x4 test, on the second day, the plank and 20 m tests, and the push-up, sit and reach tests were measured on the third day in the following way.

To measure physical fitness factors, the subjects appeared at the gym on three consecutive days at 8 am. After explaining the correct way to perform each of the tests, and after 10 min warming up, the corresponding tests were taken, in this way: on the first day, the long jump and 4x9 tests, on the second day, the plank and 20 m tests, and the push-ups and sit and reach tests was measured in the following way on the third day.

- **The explosive power of the legs.** To measure the explosive strength of the legs, the long jump test was used with an accuracy of 0.1 cm and on the hard floor. Subjects stood with parallel legs shoulder-width apart and toes behind the zero (start) line. Then the subjects performed the jump with maximum

power, twice with a 3 min rest interval to the maximum possible length, provided that they landed on the pair of feet and stood. The distance from the zero point to the back of the foot was measured and the best record was recorded was measured by the long jump test [1].

- **The endurance of core muscle.** To measure the endurance of core muscle, the Planck test was used with an accuracy of 0.1 sec. The subject was standing in the plank position and the time was taken, and the time was stopped at the moment the body touched the ground [2].
- **The upper body muscle strength.** To measure the strength of the upper body muscles, a maximum repetition of push-ups test was used. The subject put his toes and palms on the ground and the number of correct push-ups was recorded [2].
- **The speed.** To measure speed, a 20 m test was used with an accuracy of 0.1 sec. The funnels were placed 20 m apart. The subject, standing behind the zero line, ran 20 m at full speed after hearing the sound of the whistle, and the time was recorded. This test was performed twice with a distance of 3 min from each other and a better record was recorded [2].
- **The agility.** To measure the agility, the 9x4 test was used with an accuracy of 0.1. The funnels were placed at a distance of 9 m from each other and the subject was placed behind the zero line. Upon hearing the sound of the whistle, the subject made two rounds at the highest speed, and the time was recorded [2].
- **The flexibility.** To measure flexibility, the wells or sit and reach test was used

with an accuracy of 0.1 cm. The subject performed this test sitting and with the help of a bench, so that the subject stretched his hands forward as much as possible without leaving his knees off the ground and stayed in this position for 1 sec and the record was recorded [2].

**2. 4. Statistic**

The normality of the distribution was tested using a Shapiro-Wilk test. Physical fitness factors between the two groups were compared before (baseline) and after

exercise, using independent samples t-test. Data are presented as mean ± standard deviation. A p-value of <0.05 was considered statistically significant. The effect size (ES) was assessed using partial eta-squared ( $\eta^2$ ) values, as a small from 0.20 to 0.49, moderate from 0.50 to 0.79, or large effect >0.80. The IBM SPSS Statistics version 26.0 program was used to analyse all of the data. The level of significance used in the statistical analyses was 0.05.

Data were analyzed with the 26th version of IBM SPSS statistical software.

**Table 1.** Details of Tabata protocol intervention

Weeks	1st and 2nd weeks		3rd and 4 <sup>th</sup> weeks		
<b>Movements</b>	1	Jumping jacks	Jog in place		
	2	Jump squat	Squat		
	3	Push up	Push up		
	4	Mountain climbers	Basic burpee		
	5	Plank	Twist russian		
	6	Jump lunge	Reverse lunge		
	7	Bicycle crunch	Leg raise		
	8	Close arm push up	Superman		
<b>4-Week Tabata protocol program</b>					
Week	Loading (sec)	Rest between repetitions (sec)	Rest between sets (min)	Number of sets	Number of movements
<b>1<sup>st</sup> &amp; 2<sup>nd</sup> week</b>	20	10	1	2	8
<b>3<sup>rd</sup> &amp; 4<sup>th</sup> week</b>	20	10	1	3	8

**3. Results**

The demographic characteristics of the study participants are shown in Table 2.

**3. 1. Baseline data**

There were no statistically significant baseline differences in the variables measured between both groups at the pre-test, where (t-test= 0.153 to 1.040,  $P= 0.312$  to 0.880 ( $P>0.05$ )). All participants

completed an eight-week training period with an average training attendance of 100%.

A significant difference in the explosive power of the legs ( $t= 0.48$ ,  $P= 0.04$ ) and the strength of the upper body muscles ( $t= 0.226$ ,  $P= 0.048$ ) measurements was observed in favour of the experimental group compared to the control group (Table 4).

**Table 2.** The demographic characteristics of the participants

Variable/Groups	Tabata group			Control group		
	N	Mean	Standard deviation	N	Mean	Standard deviation
Age (year)	8	15.5	1.5	8	15.8	1.24
Weigh (Kg)	8	55.9	8.2	8	60.6	10.33

**Table 3.** Changes in physical fitness factors in the two study groups before and after 12 weeks of exercise and intra group results

Variable	Mean (SD) Value		t	P-value	Effects size	Change (%)
	Baseline	4 weeks				
<b>The explosive power of the legs (cm)</b>						
Tabata group	193.00 ± 25.61	205.87 ± 21.76	2.821	0.026*	0.541	6.6
Control group	202.62 ± 27.61	195.87 ± 28.13	1.879	0.10	0.20	-2.73
<b>The endurance of core muscle (sec)</b>						
Tabata group	105.12 ± 50.58	132.75 ± 60.59	-3.022	0.019*	0.49	20.8
Control group	86.12 ± 45.35	102.75 ± 41.63	-2.42	0.046*	.0395	19.2
<b>The upper body muscle strength (rep)</b>						
Tabata group	23.38 ± 11.96	29.38 ± 12.36	-5.896	0.001**	0.49	25.6
Control group	22.75 ± 11.26	26.25 ± 11.72	-3.274	0.014*	0.299	15.3
<b>The speed (sec)</b>						
Tabata group	4.09 ± 0.43	3.89 ± 0.35	3.52	0.01*	0.613	5.22
Control group	4.36 ± 0.53	4.00 ± 0.4	3.19	0.015*	0.877	8.16
<b>The agility (sec)</b>						
Tabata group	10.42 ± 1.02	10.01 ± 0.72	2.572	0.037*	0.475	4
Control group	10.99 ± 0.96	10.48 ± 0.82	3.67	0.008**	0.564	4.63
<b>The flexibility (cm)</b>						
Tabata group	32.94 ± 11.5	34.00 ± 12.13	-1.471	0.185	-	-
Control group	34.25 ± 9.51	35.43 ± 8.69	-2.236	0.06	-	-

\*\* The  $P < 0.01$  was considered statistically significant.

\* The  $P < 0.05$  was considered statistically significant.

**Table 4.** Independent t test results of physical fitness factors in two groups

Variable		Explosive leg strength	Speed	Agility	Endurance core muscle	Upper body strength	Flexibility
Equality of variances test	t	0.480	-1.118	-0.434	0.918	0.226	-137
	df	14	14	14	14	14	14
	sig	0.04*	0.280	0.671	0.374	0.048*	0.893

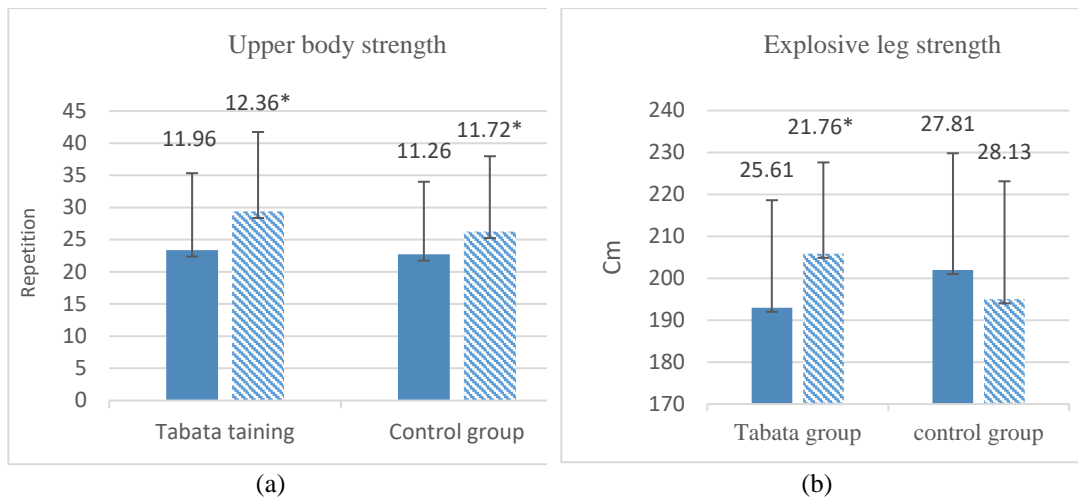
\* The  $P < 0.05$  was considered statistically significant.

Moreover, both groups have a significant effect on speed (respectively  $P= 0.01$ ,  $ES^1=0.613$  and  $P= 0.015$ ,  $ES= 0.877$ ), agility (respectively  $P= 0.03$ ,  $ES= 0.475$  and  $P= 0.008$ ,  $ES= 0.564$ ), endurance of core muscle (respectively  $P= 0.019$ ,  $ES= 0.490$  and  $P= 0.04$ ,  $ES= 0.395$ ), and upper-body muscle strength (respectively  $P= 0.001$ ,  $ES= 0.490$  and  $P= 0.01$ ,  $ES= 0.299$ ). In addition, results showed that for leg explosive power, only Tabata training had a positive effect ( $P= 0.026$ ,  $ES=0.541$ ). But none of the groups have not had a positive effect on flexibility ( $P>0.05$ ; Figures 1-3).

#### 4. Discussion

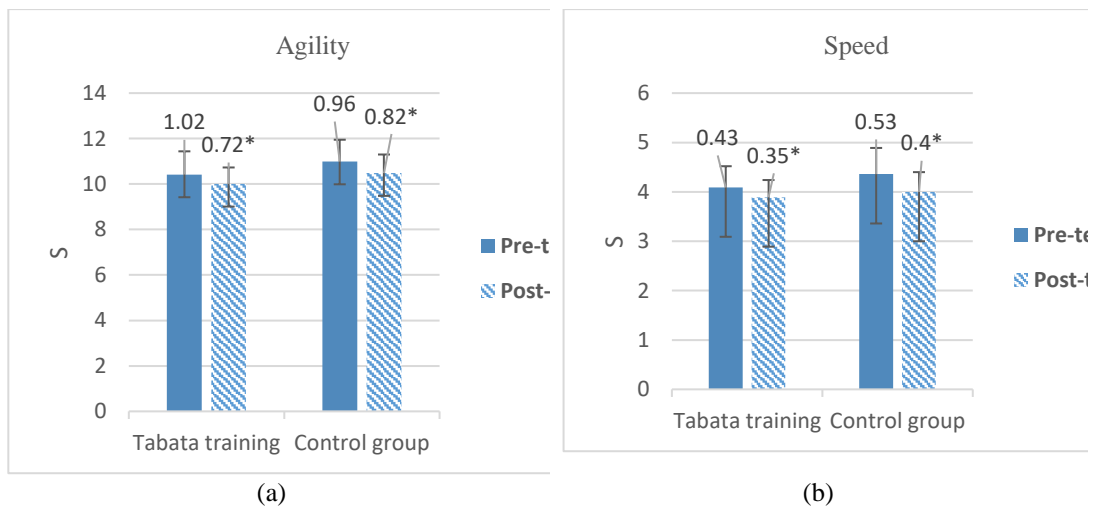
A significant difference in the explosive power of the legs and the strength of the upper body muscles measurements was observed in favour of the experimental group compared to the control group. Moreover, both groups have a significant effect on speed, agility, endurance of core muscle, and upper-body muscle strength. Also, results showed that for leg explosive power, only Tabata training had a positive effect. But, none of the groups have not had a positive effect on flexibility.





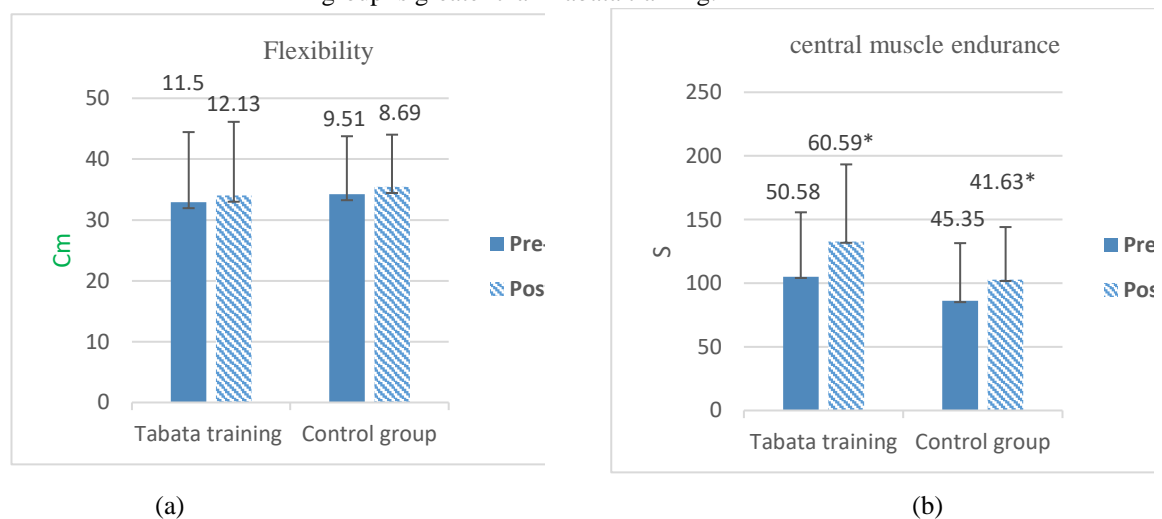
\* The  $P < 0.05$  was considered statistically significant.

**Figure 1.** Pre and post-Test of (a) upper body strength and (b) explosive leg strength: the effect size of Tabata training is greater than control group.



\* The  $P < 0.05$  was considered statistically significant.

**Figure 2.** Pre and post-test of (a) agility and (b) speed: In both parameters, the effect size of control group is greater than Tabata training.



\* The  $P < 0.05$  was considered statistically significant.

**Figure 3.** Pre and post-test of (a) flexibility and (b) central muscle endurance: In both parameters, the effect size of Tabata training group is greater than control group.

In increasing the wrestling training process effectiveness, a significant role is assigned to the development of general and special physical fitness factors [34, 35]. 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 the author's research related to improving the wrestling training process effectiveness using various means and techniques [36, 37]. At the same time, the issues of using the high-intensity interval training protocol in wrestling athletes' preparation are not sufficiently reflected.

Some researchers have proved that an important condition for using Tabata training is consistently increasing physical activity, which increases the aerobic and anaerobic capabilities of the human body and develops general physical fitness, which is the basic component for special physical fitness formation [23].

Wrestling is a two-person confrontation sport that requires extremely high explosive power of the human body. Strength can play a big role in wrestling, strength is the foundation of all techniques, and the power of wrestling is mainly explosive during the game [38]. HIIT (also Tabata) workouts provide physical capacity and conditioning as well as improved glucose metabolism and also in improving muscle and bone mass. Jump squat and push-up (that use in the Tabata protocol) by increasing the capacity of the involved muscles, have strengthened and increased the record of the wrestlers more than control group.

Our pedagogical experiment results of using high-intensity interval training according to Tabata protocol in the wrestling athletes' training process showed a positive effect in physical fitness development. This fact is confirmed by a higher significant 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 [26], judo wrestlers [27], in hand-to-hand combat [39], swimmers [31], badminton athletes [32].

Megahed et al. (2023) suggest that runners after Tabata protocol interventions can obtain better pulmonary function, endurance, and event time benefits with more efficient performance and time-efficient manner compared with traditional training [30].

Kolimechkov et al. (2023) investigate the Tabata protocol-based high-intensity interval training in freestyle wrestlers, and suggest that when the Tabata protocol used 5 times per week for eight weeks as part of the wrestlers' training, can improve their endurance [40].

By increasing the amount of physical activity during training, Tabata leads to an increase in aerobic endurance of the body, and an increase in exercise intensity leads to anaerobic endurance development. The physical performance and the body's tolerance to physical activity increase, the reserve capabilities of the cardiorespiratory system increase. The inclusion of Tabata training in the wrestling classes program for students allowed them to form a higher level of not only general endurance, but also significantly develop special ones [23, 41]. Also, due to the compatibility of the nature of Tabata training with wrestling (due to high intensity, low volume, and short time) using this training protocol seems useful for mesocycles close to the match.

One of the limitations of the current research is the lack of complete matching of exercise intensity between the two groups, which we used a RPE scale to control the intensity between the two groups.

## 5. Conclusions

The positive results of testing high-intensity interval training of wrestling 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 wrestling athletes for their participation in major international competitions and the Olympic Games. Conflicts of interest.

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Conflict of interest

The authors declared no conflicts of interest.

### Authors' contributions

All authors contributed to the original idea, study design.

### Ethical considerations

The author has completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc.

### References

- [1] Rajabi H, Garzi A. *Exersice Science (Body and Exercise Design for Coaches and Athletes)*. Tehran, Iran: Academic Jihad Publications. 2019. [in Persian]
- [2] Ölmez C. (2017). *Müzikli ritim çalışmalarını ile yapılan taekwondo eğitiminin çocukların teknik ve motorik gelişimlerine etkisi*. Karadeniz Teknik Üniversitesi. [in Turkish]
- [3] Pion J, Fransen J, Lenoir M, Segers V. "The value of non-sport-specific characteristics for talent orientation in young male judo, karate and taekwondo athletes". *Archives of Budo*. 2014; 10(1): 147-152. icid: 1109842.
- [4] Reid M, Schneiker K. "Strength and conditioning in tennis: Current research and practice". *Journal of Science and Medicine in Sport*. 2008; 11(3): 248-56. doi: 10.1016/j.jsams.2007.05.002.
- [5] Thomas E, Petrigna L, Tabacchi G, Teixeira E, Pajaujiene S, Sturm DJ, et al. "Percentile values of the standing broad jump in children and adolescents aged 6-18 years old". *Eur J Transl Myol*. 2020; 17, 30(2): 9050. doi: 10.4081/ejtm.2019.9050.
- [6] Hübner-Woźniak E, Kosmol A, Lutoslawska C, Bem EZ. "Anaerobic performance of arms and legs in male and female free style wrestlers". *J Sci Med Sport*. 2004; 7(4): 473-80. doi: 10.1016/s1440-2440(04)80266-4.
- [7] Mirzaei B, Curby DG, Rahmani-Nia F, Moghadasi M. "Physiological profile of elite Iranian junior freestyle wrestlers". *J Strength Cond Res*. 2009; 23(8): 2339-44. doi: 10.1519/JSC.0b013e3181bb7350.
- [8] Curby DG. "Gathering for competition and celebration in rio—A time of cautious optimism for wrestling". *International Journal of Wrestling Science*. 2016; 6(1): 1-2. doi.org/10.1080/21615667.2016.1207965.
- [9] Rajabi H, Goderzi A. *Science of Training*. 2020. Press Organization Jahade Daneshgahi.
- [10] Bloomfield J, Ackland TR, Elliot BC. *Applied Anatomy and Biomechanics in Sport*. 1994. Blackwell Scientific Publications.
- [11] Horswell CA. "Applied physiology of amateur wrestling". *Sports Medicine*. 1992; 14(2): 114-43. doi: 10.2165/00007256-199214020-00004. [in French]
- [12] Horswill A C, Scott JR, Galea P. "Comparison of maximum aerobic power, maximum anaerobic power, and skinfold thickness of elite and nonelite junior wrestlers". *Int J Sports Med*. 1989; 10(3): 165-8. doi: 10.1055/s-2007-1024894.
- [13] Yoon J. "Physiological profiles of elite senior wrestlers". *Sports Medicine*. 2002; 32(4): 225-33. doi: 10.2165/00007256-200232040-00002.
- [14] Tabata I, Nishimura K, Kouzaki M, Hirai Y, Ogita F, Miyachi M, et al. "Effects of moderate-intensity endurance and high-intensity intermittent training on anaerobic capacity and VO<sub>2</sub>max". *Med Sci Sports Exerc*. 1996; 28(10): 1327-30. doi: 10.1097/00005768-199610000-00018.
- [15] Segovia Y, Gutiérrez D. "Effect of a game-based high intensity interval training program on body composition in primary education: Comparison of the sport education model and traditional methodology". *Journal of Physical Education and Sport*. 2020; 20(2): 791-799. doi: 10.7752/jpes.2020.02113.
- [16] Wilmore JH, Costill DL, Kenney WL. *Physiology of Sport and Exercise*. 2012. 5th ed. Medicine & Science in Sports & Exercise.
- [17] Buchheit M, Laursen PB. "High-intensity interval training, solutions to the programming puzzle: Part I:M Cardiopulmonary emphasis". *Sports Medicine*. 2013; 43(5): 313-38. doi: 10.1007/s40279-013-0029-x.
- [18] Fox EL. *Sport Physiology*. 1979. Saunders, Philadelphia.
- [19] Cinar G, Tamer K. "Lactate profiles of wrestlers who participated in 32nd European Free-Style Wrestling Championship in 1989". *Journal of Sports Medicine and Physical Fitness*. 1994; 34(2): 156-60.
- [20] Fox EL, Bartels RL, Billings CE, O'Brien R, Bason R, Mathews DK. "Frequency and duration of interval training programs and changes in aerobic power". *J Appl Physiol*. 1975; 38(3): 481-4. doi: 10.1152/jappl.1975.38.3.481.
- [21] Gibala MJ, Little JP, Macdonald MJ, Hawley JA. "Physiological adaptations to low-volume, high-intensity interval training in health and disease". *Journal of Physiology*. 2012; 590(5): 1077-1084. doi: 10.1113/jphysiol.2011.224725.
- [22] Rich. "Benefits of Tabata training". 2013. [www.tabatatraining.com/benefits-of-tabata-training/](http://www.tabatatraining.com/benefits-of-tabata-training/) (Accessed on 15 February 2018).

- [23] Kuptsova VG, Chikeneva IV. “General endurance upbringing by the ‘Tabata’ method in physical culture lessons for students”. *Problems of Modern Teacher Education*. 2018; 61(1), 123-127. [in Russian]
- [24] Syamsudin F, Wungu CDK, Qurnianingsih E, Herawati L. “High-intensity interval training for improving maximum aerobic capacity in women with sedentary lifestyle: A systematic review and meta-analysis”. *Journal of Physical Education and Sport*. 2021; 21(4): 1788-1797. doi: 10.7752/jpes.2021.04226.
- [25] Thompson WR. “Worldwide survey of fitness trends for 2019”. *ACSMs Health Fit J*. 2018; 22(6): 10-17. doi: 10.1249/FIT.0000000000000438.
- [26] Zhumanova AS, Kharaliev AN, Avsievich VN. “Special physical training of young gymnasts using the Tabata interval training method”. *Young Scientist*. 2019; 18(4): 842-857. doi: doi.org/10.14198/jhse.2023.184.09.
- [27] Savinykh LE, Vikulov EA. “Study of the influence of interval training on physical fitness in judo”. *Collection of Materials of the XIX All-Russian Scientific and Practical Conference with International Participation*. 2020. pp. 759-764. [in Russian]
- [28] Gryaznykh AV, Mustafin VR. “Determination of visual memory in judoists and grapplers (wrestling)”. *Health, Physical Culture and Sports*. 2020; 19(3): 97-105. doi: 10.14258.
- [29] Valentina A. “Formation of health culture in the process of sports training of Greco-Roman style wrestlers”. *Health, Physical Culture and Sports*. 2020; 2: 178-91.
- [30] Megahed M, Al-Torbany M, Al-Ghool M, Tarek Z. “Effects of high-intensity interval training using ‘Tabata protocol’ on respiratory parameters, special endurance, and 800-m runners’ performance”. *Journal of Human Sport and Exercise*. 2023; 18(4): 842-57. doi: 10.14198/jhse.2023.184.09.
- [31] Gussakov I, Nurmukhanbetova D, Kulbayev A, Yermakhanova A, Lesbekova R, Potop V. “The impact of the high level of intensity training process on the performance and recovery of young swimmers at the national level”. *Journal of Physical Education and Sport*. 2021; 21(1): 440-443. doi: 10.7752/jpes.2021.01044.
- [32] Nugroho S, Nasrulloh A, Karyono TH, Dwihandaka R, Pratama KW. “Effect of intensity and interval levels of trapping circuit training on the physical condition of badminton players”. *Journal of Physical Education and Sport*. 2021; 21(3): 1981-1987. doi: 10.7752/jpes.2021.s3252.
- [33] Alberto A. “24 sessions of monitored cooperative high-intensity interval training improves attention-concentration and mathematical calculation in secondary school”. *Journal of Physical Education and Sport*. 2018; 18(3): 1572-1582. doi: 10.7752/jpes.2018.03232.
- [34] Simakov AM, Simakov DA, Rudenko GV, Korostelev EN. “Technique of development of highspeed endurance in taekwondo at a stage of improvement of sports skill (15-16 Years)”. *Scientific Notes of the University of P. F. Lesgaft*. 2018; 2(156). 219-223.
- [35] Losik L. Taekwondo from Korea's National Martial Art to Olympic Sport: How Taekwondo Helped to Unite a Country. Moscow, Nauka, 2018. [in Russian].
- [36] Koshcheyev A. “The influence of motivation on the state of fitness of athletes in taekwondo”. *Labyrinths of Reality: Collection of Scientific Works*. Edited by Zhurba MA. Montreal: CPM «ASF». 2020; 4(9).
- [37] Koshcheev A, Dolbysheva N. “Comparative characteristics of the development of speed and power capacities in the pre-competitive mesocycle in taekwondo A”. *Port Science and Human Health*. 2021; 6(2): 35-404. doi: 10.28925/2664-2069.2021.24.
- [38] Gorzi A, Rahmani A, Mohammadi Z, Neto WK. “Effects of different lengths of high-intensity interval training microcycles on the systemic and hippocampal inflammatory state and antioxidant balance of immature rats”. *Mol Biol Rep*. 2021; 48(6): 5003-5011. doi: 10.1007/s11033-021-06484-w.
- [39] Tyupa P, Vorozheikin A. “Substantiation of the need to develop a methodology for an individual manner of conducting a competitive combat among athletes in hand-to-hand combat”. *Health, the Formation of Physical Culture and Sports*. 2021; 23(3), 49-56. doi: 10.14258/zosh(2021)3.07.
- [40] Kolimechikov S, Makaveev R, Zaykova D, Petrov L. “Tabata protocol-based high-intensity interval training in freestyle wrestlers”. *Pedagogy of Physical Culture and Sports*. 2023; 27(6): 467-473. doi: 10.15561/26649837.2023.0604.
- [41] Timokhina NV, Shavyrina SV. “System ‘Tabata’ as an effective means of physical education for students of the social faculty of 3-4 courses”. *Science*. 2017; 3(14): 154-159. [in Russian]