European Journal of Physical Education and Sport Science
ISSN: 2501 - 1235
ISSN-L: 2501 - 1235
Available on-line at: www.oapub.org/edu

DOI: 10.46827/ejpe.v7i5.4068 Volume 7 | Issue 4 | 2021

EFFECT OF DYNAMIC TRAINING PROGRAM DESIGNED BASED ON THE TABATA PROTOCOL ON BALANCE AND STRENGTH PARAMETERS OF ELITE LEVEL COMBAT ATHLETES

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Abstract:
The purpose of this study was to investigate the effects of a 6-week dynamic training program designed based on the Tabata protocol on balance and strength parameters of elite level combat athletes. This randomized controlled experimental study with pre-test and post-test was conducted with 25 randomly selected elite level combat athletes who volunteered to participate in the study, 12 in the experimental group (5 wrestling, 2 judo, 2 karate, 3 taekwondo) and 13 in the control group. In the pre-test and post-test stages of the study, Biodex Balance SD (Biodex Inc., Shirley, NY) balance device was used to determine static and dynamic balance performances of the athletes. The strength performance of the athletes was determined by measuring back, leg, and grip strength using a back-leg dynamometer (TKK 5402) and a hand grip dynamometer (Takei). After data collection, SPSS 25.0 was used for statistical analysis of the data and the significance level was set at $p<0,05$. At the end of the study, it was determined that the differences between pre-test and post-test body weights and eyes open and closed dynamic balance levels of the experimental group athletes were statistically significant ($p<0,05$), whereas the differences between the measurement results of control group athletes were not significant ($p>0,05$). The Tabata protocol is a high intensity interval training technique and is effective on aerobic-anaerobic energy systems. The movement determined for the session is repeated intensely, rhythmically, and continuously during the exercise

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window. As a result, the Tabata protocol supports dynamic balance and strength improvement of elite combat athletes through dynamic exercises.

Keywords: Tabata protocol, strength, balance, performance development

1. Introduction

1.1 Background and Literature Review

Training is a set of activities that are performed systematically and regularly in order to improve athletic performance. Performance usually refers to carrying out a high-level skill and may require limits to be pushed. For example, activities such as running more than 5000 metres within 14 minutes or completing 21 km as quickly as possible describe athletic performance (Billat, 2001). The goal here is to be able to complete a particular activity as quickly as possible, or to increase the intensity, volume, or scope of the skills to be performed within a given period of time.

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 (Göksu et al., 2018; Ölmez et al., 2017; Ölmez, 2017; Pion et al., 2014; Reid & Schneiker, 2008; Weterings et al., 2019). Interval training is a very effective training technique to achieve the target performance.

The principle behind interval training is to re-load the organism while the effects of the previous loading continue and the organism has not yet returned to its normal state by means of resting (Muratlı et al., 2007). Although Foster et al. (2015) reported that steady-state (20 min at 90% ventilatory threshold) and high intensity interval training (HIIT) programs at submaximal (Meyer et al., 1990) and maximal (Tabata et al., 1996) intensity yielded similar results in terms of performance gains in sedentary participants, it is widely believed that HIIT is highly successful in achieving aerobic and anaerobic gains (Eather et al., 2019; Smith et al., 2009; Jabbour et al., 2017).

When designed using the appropriate method, HIIT provides aerobic endurance athletes such as long distance runners or cyclists with physical and physiological gains in terms of aerobic parameters (Weston et al., 1996; Westgarth-Taylor et al., 1997; Laursen et al., 2002; Lindsay et al., 1996). However, the effects of HIIT on balance and strength development in elite level combat athletes have not been adequately explained and need to be illuminated. In addition, quantitative research shows that training interventions aimed at performance improvement focus on sub-elite level athletes, recreational individuals, or sedentary individuals. This may be due to elite athletes' hesitancy to make changes to their training programs for scientific research purposes (Hawley et al., 1997). Therefore, recommendations made by exercise scientists to coaches and athletes are largely based on anecdotal information from some successful coaches, or training studies conducted with sub-elite level individuals or athletes (Hawley et al., 1997). For this reason, this study is quite important to understand the reactions of elite athletes to a training program designed based on the Tabata Protocol, a popular HIIT technique, and to determine its effects on strength and balance improvement.

2. Material and Methods

2.1. Research Pattern

The study was designed as a pre-test and post-test experimental study with control group (randomized controlled trial) (Figure 1).

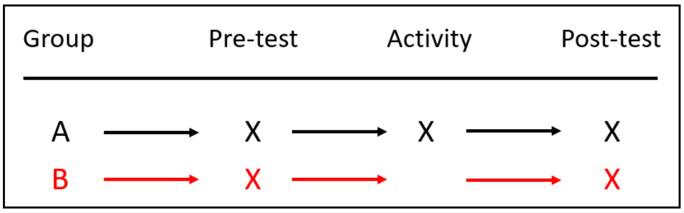

Figure 1: Research pattern

2.2. Participants

The study was conducted with 25 randomly selected elite level combat athletes who volunteered to participate in the study, 12 in the experimental group (5 wrestling, 2 judo, 2 karate, 3 taekwondo) (mean age = 21,08±1,17 years) and 13 in the control group (4 wrestling, 2 judo, 4 karate, 3 taekwondo) (mean age = 21,54±1,71 years). All athletes were informed about the study and were explained about the possible benefits and risks of the research. After expression, all athletes were given a written informed consent from which was prepared according to the Declaration of Helsinki. The study was conducted in compliance with the ethical principles of the European Convention and the Helsinki Declaration (ethics principles regarding human experimentation). It was confirmed by the Bioethics Commission of the Gazi University (no: 91610558-302.08.01).

2.3. Procedure

Both the experimental and control group athletes participated in their routine training programs specific to their respective branches; however, the experimental group athletes also participated in a 6-week high intensity interval training program designed based on the Tabata protocol 3 days per week in addition to their routine training programs.

Tabata training was performed as 20-second maximum loading and 10-second rest for 8 repetitions. The training program was implemented as sprints, crunches, burpees, plank, mountain climbing, half squats, jumping jacks and push-ups in each training session for 6 weeks. During the 6-week program, the number of sets was increased by one at the end of each week and 1 minute rest time was given between the sets. The athletes warmed up for 15 minutes before the training and cooled down for 10 minutes at the end.

Table 1: Tabata training program

Week	Loading	Rest between repetitions	Rest between sets	Number of sets and repetitions	Loading
1st Week	20 seconds	10 seconds	1 min	4 sets, 8 repetitions	Maximal (all out effort)
2nd Week	20 seconds	10 seconds		4 sets, 8 repetitions	
3rd Week	20 seconds	10 seconds		5 sets, 8 repetitions	
4th Week	20 seconds	10 seconds		5 sets, 8 repetitions	
5th Week	20 seconds	10 seconds		6 sets, 8 repetitions	
6th Week	20 seconds	10 seconds		6 sets, 8 repetitions	

2.4. Body Composition Measurements

In order to determine the body composition of the athletes, their height, body weight, body mass index, body fat percentage, and body fat mass values were determined.

The height of the athletes was measured with a Holtain brand (UK) stadiometer, while body mass index, body fat percentage, and total body fat measurements were performed using the foot-to-foot bioelectrical impedance analysis (Tanta Body Composition Analyzer) at 9.00 AM.

2.5. Determination of Balance Performance

The dynamic and static balance performance with eyes open and closed were determined using a Biodex brand (Biodex, Inc., Shirley, New York) balance system. This system has a moving balance platform that can tilt the surface up to 20°, has a 360° joint motion span, and is equipped with a monitor which shows the user as a representative dot. The screen of the Biodex balance system is divided into 4 zones and 4 quadrants, showing various directions and degrees of difficulty (Figure 1).

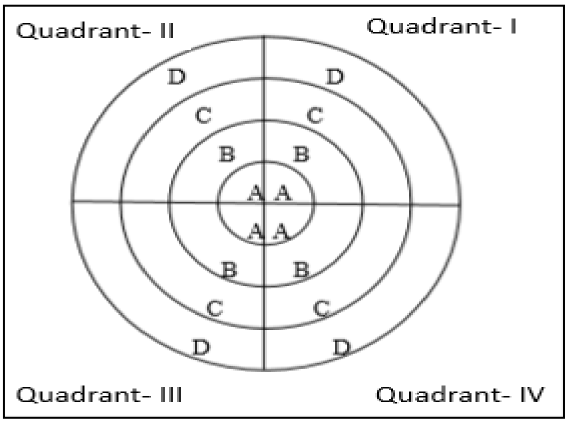

Figure 1: Screenshot of the Biodex balance system’s screen during implementation

Balance zone A: 0°-5° incline	1st Quadrant: right-front 90° zone
Balance zone B: 6°-10° incline	2nd Quadrant: left-front 90° zone
Balance zone C: 11°-15° incline	3rd Quadrant: left-rear 90° zone
Balance zone D: 16°-20° incline	4th Quadrant: right-rear 90° zone

2.5. Implementation of the Test

The athletes were allowed to perform 2 trials before the actual implementation in order for them to adapt to the balance system. The athletes were allowed to rest for 20 seconds between the trials, and the actual implementation was initiated. 3 actual measurements were made and the best performance was used in the assessment. Overall balance index, anterior-posterior (forward-backward) balance index and medial-lateral (inward-outward) balance index results were obtained with the measurement. The implementation was carried out in level 8 mode with a duration of 30 seconds and rest intervals of 15 seconds.

2.6. Determination of Strength Performance

Grip strength: The grip strength was measured using an isometric dynamometer (Takei-Hand Grip) with athletes standing upright and an angle of approximately 45° between the arm and the body. The athletes used their dominant hand (Heyward, 2002).

Back strength: A back and leg (Takei-Back & Lift) dynamometer was used for measuring the back strength. After placing their feet on the dynamometer's stand with their knees and arms stretched, their backs straight, and their torso in a slightly forward tilted position, the athletes pulled the dynamometer bar vertically upwards with full strength to perform the measurement. The athletes were reminded to pull the bar trying to get their backs into extension position, not their arms or legs (Heyward, 2002).

Leg strength: A back and leg (Takei-Back & Lift) dynamometer was used for measuring the leg strength. For leg strength measurements, the athletes were asked to place their feet on the dynamometer stand with their knees bent at an angle of 130°-140°, to hold their arms stretched, their backs straight, and their bodies slightly forward tilted, and then to pull the dynamometer bar vertically while trying to bring their legs to the extension position. Athletes were reminded to pull the bar using their legs without using their backs and arms during the measurement (Heyward, 2002). All strength measurements were repeated 3 times and the best results were recorded in kg.

2.7. Statistical Analysis

The normal distribution of the data was controlled before the analysis using the Shapiro-Wilk normality test. The Paired Samples T-Test was used for parametric data and the Wilcoxon test was used for non-parametric data within the groups, while the Independent Samples T-Test was used for parametric data and the Mann Whitney U Test was used for non-parametric data between the groups. Parametric data were presented as mean and standard deviation, and non-parametric data with median values. SPSS 25 was used for statistical analysis and the level of significance was set at $p<0,05$.

3. Results and Discussion

The athletes' body composition values and balance (eyes closed-open, dynamic-static) and strength (hand grip, back, leg) performance results were determined with in-group and inter-group measurements.

Table 2: Body composition values of the athletes

Variables	Groups	1st Measurement			2nd Measurement			1st measurement x 2nd measurement	
		mean	Sd.	p	mean	Sd.	p	Change (%)	p
Body Weight (kg)	EG (n=12)	70,53	5,60	0,663	71,41	5,58	0,786	1,24	0,033*
	CG (n=13)	72,42	6,62		72,61	6,82		0,25	0,506
Height (cm)	EG (n=12)	174,58	5,04	0,219	174,58	5,04	0,219	-	-
	CG (n=13)	177,31	5,68		177,31	5,68		-	-
BMI (kg/m2)	EG (n=12)	23,58	1,18	0,369	23,58	1,50	0,253	-0,04	0,156
	CG (n=13)	23,12	1,59		23,15	1,64		0,13	0,620
Body Fat (%)	EG (n=12)	11,69	2,71	0,957	10,59	3,47	0,703	-9,41	0,182
	CG (n=13)	11,74	4,23		10,87	3,97		-7,40	0,196
Fat Mass	EG (n=12)	8,28	1,86	0,892	7,48	2,25	0,430	-9,76	0,209
	CG (n=13)	8,59	3,38		8,05	3,36		-6,36	0,221

BMI = Body Mass Index; *p<0,05

According to the 1st measurement results related to body compositions of the athletes, there was no significant difference between the control group and experimental group in terms of body weight, height, body mass index, body fat percentage, and total fat mass (p>0,05). According to the 2nd measurement results, there was a significant difference between the control group and experimental group in terms of body weight (p>0,05), whereas no significant difference was found in terms of height, body mass index, body fat percentage, and total fat mass (p>0,05) (Table 2).

The examination of the dynamic balance performance of the athletes with eyes closed showed that there was no significant difference between the control group and the experimental group in any of the dimensions measured in the 1st and the 2nd measurement (p>0,05). The 1nd and 2nd intra-group measurements, on the other hand, showed that while there was no significant difference between the 1st and 2nd measurements of the control group athletes, a significant difference was found between the 1st and 2nd measurements of the experimental group athletes in terms of overall balance, medial-lateral balance (inward and outward swing), balance zone A (0°-5° incline), and balance zone B (6°-10° incline) (p<0,05) (Table 3).

Table 3: Results of the eyes closed-dynamic balance measurements

Variables	Groups	1st Measurement			2nd Measurement			1st measurement x 2nd measurement	
		Mean/ median	Sd.	p	Mean/ median	Sd.	p	Change (%)	p
Overall balance	EG (n=12)	5,52	1,50	0,870	11,13		0,132	-19,79	0,028
	CG (n=13)	6,01	2,38		14,73			-8,58	0,421
Anterior-Posterior	EG (n=12)	3,78	1,44	0,605	11,38		0,224	-16,74	0,125
	CG (n=13)	4,06	1,56		14,50			-4,92	0,666
Medial-Lateral	EG (n=12)	3,13	1,06	0,785	2,42	0,87	0,075	-22,67	0,016
	CG (n=13)	3,56	1.73		3,09	0,93		-13.17	0,363
Balance zone A (% sec.)	EG (n=12)	48,92	20,04	0,892	65,75	14,97	0,167	34,41	0,008
	CG (n=13)	49,54	23,57		56,69	16,62		14,44	0,208
Balance zone B (% sec.)	EG (n=12)	41,83	17,18	0,210	12,96		0,380	-32,67	0,009
	CG (n=13)	34,69	12,76		13,04			-9,53	0,462
Balance zone C (% sec.)	EG (n=12)	6,58	7,03	0,412	4,25	3,98	0,308	-35,44	0,085
	CG (n=13)	9,08	8,30		6,15	5,03		-32,20	0,168
Balance zone D (% sec.)	EG (n=12)	11,67		0,326	11,50		0,184	-31,25	0,752
	CG (n=13)	14,23			14,38			-13,79	0,799
1st quadrant (% sec.)	EG (n=12)	12,96		0,978	13,88		0,682	15,03	0,638
	CG (n=13)	13,04			12,19			9,76	0,889
2nd quadrant (% sec.)	EG (n=12)	33,08	22,54	0,892	13,42		0,931	-29,97	0,224
	CG (n=13)	31,15	19,31		12,62			-27,65	0,173
3rd quadrant (% sec.)	EG (n=12)	21,25	20,79	0,301	24,58	13,93	0,641	15,69	0,432
	CG (n=13)	26,46	14,76		28,08	21,77		6,10	0,724
4th quadrant (% sec.)	EG (n=12)	12,58		0,785	13,29		0,962	13,74	0,386
	CG (n=13)	13,38			12,73			23,86	0,442

*p<0,05; **p<0,01

The examination of the dynamic balance performance of the athletes with eyes open showed that there was no significant difference between the control group and the experimental group in any of the dimensions measured in the 1st and the 2nd measurement (p>0,05). The 1nd and 2nd intra-group measurements, on the other hand, showed that while there was no significant difference between the 1st and 2nd measurements of the control group athletes, a significant difference was found between the 1st and 2nd measurements of the experimental group athletes in terms of overall balance, anterior-posterior balance (forward-backward swing), medial-lateral balance (inward and outward swing), 2nd quadrant, and 4th quadrant (p<0,05) (Table 4).

Table 4: Results of the eyes open-dynamic balance measurements

Variables	Groups	1st Measurement			2nd Measurement			1st measurement x 2nd measurement	
		Mean/ median	Sd.	p	Mean/ median	Sd.	p	Change (%)	p
Overall balance	EG (n=12)	13,63	-	0,683	0,97	0,67	0,421	-45,54	0,006
	CG (n=13)	12,42	-		1,22	0,83		-17,28	0,271
Anterior-Posterior	EG (n=12)	13,63	-	0,682	12,63	-	0,966	-40,54	0,023
	CG (n=13)	12,42	-		13,35	-		-30,37	0,069
Medial-Lateral	EG (n=12)	13,83	-	0,585	0,38	0,35	0,109	-63,78	0,006
	CG (n=13)	12,23	-		0,65	0,43		-22,04	0,122
Balance zone A (% sec.)	EG (n=12)	13,00	-	1,000	14,00	-	0,276	0,08	0,317
	CG (n=13)	13,00	-		12,08	-		-8,47	0,285
Balance zone B (% sec.)	EG (n=12)	13,00	-	1,000	12,00	-	0,276	-100,00	0,317
	CG (n=13)	13,00	-		13,92	-		2750,00	0,285
Balance zone C (% sec.)	EG (n=12)	0,00	0,00	1,000	0,00	0,00	-	0,00	1,000
	CG (n=13)	0,00	0,00		0,00	0,00		0,00	1,000
Balance zone D (% sec.)	EG (n=12)	0,00	0,00	1,000	0,00	0,00	-	0,00	1,000
	CG (n=13)	0,00	0,00		0,00	0,00		0,00	1,000
1st quadrant (% sec.)	EG (n=12)	29,42	23,82	0,369	12,63	-	0,889	11,05	0,959
	CG (n=13)	37,92	25,19		13,35	-		-8,52	0,834
2nd quadrant (% sec.)	EG (n=12)	37,75	27,45	0,414	11,42	-	0,290	-74,17	0,003
	CG (n=13)	27,69	17,24		14,46	-		-34,44	0,101
3rd quadrant (% sec.)	EG (n=12)	12,67	-	0,827	12,75	-	0,895	33,47	0,824
	CG (n=13)	13,31	-		13,23	-		75,26	0,092
4th quadrant (% sec.)	EG (n=12)	11,67	-	0,382	14,88	-	0,387	144,30	0,019
	CG (n=13)	14,23	-		11,27	-		8,95	0,937

*p<0,05; **p<0,01

The examination of the dynamic balance performance of the athletes with eyes open showed that there was no significant difference between the control group and the experimental group in any of the dimensions measured in the 1st measurement (p>0,05), whereas a significant difference was found in the 2nd measurement in terms of medial-lateral balance in favor of the experimental group (p<0,05). The 1nd and 2nd intra-group measurements showed that there was a significant difference between the 1st and second measurements of the control group and the experimental group athletes in terms of 3rd quadrant and 4th quadrant (p<0,05) (Table 5).

Table 5: Results of the eyes open-static balance measurements

Variables	Groups	1st Measurement		2nd Measurement		1st measurement x 2nd measurement	
		Median	p	Median	p	Change (%)	p
Overall balance	EG (n=12)	13,04	0,977	13,42	0,489	-33,94	0,528
	CG (n=13)	12,96		12,62		-49,88	0,104
Anterior-Posterior	EG (n=12)	13,00	1,000	13,00	-	0,00	1,000
	CG (n=13)	13,00		13,00		0,00	1,000
Medial-Lateral	EG (n=12)	13,04	0,977	13,42	0,489	-33,94	0,528
	CG (n=13)	12,96		12,62		-49,88	0,104
Balance zone A (% sec.)	EG (n=12)	12,54	0,744	12,58	0,492	23,76	0,458
	CG (n=13)	13,42		13,38		22,16	0,144
Balance zone B (% sec.)	EG (n=12)	13,00	1,000	13,00	-	0,00	1,000
	CG (n=13)	13,00		13,00		0,00	1,000
Balance zone C (% sec.)	EG (n=12)	13,54	0,298	13,00	-	-100,00	0,317
	CG (n=13)	12,50		13,00		0,00	1,000
Balance zone D (% sec.)	EG (n=12)	13,29	0,834	13,42	0,492	-33,94	0,458
	CG (n=13)	12,73		12,62		-49,63	0,144
1st quadrant (% sec.)	EG (n=12)	13,00	1,000	13,00	-	0,00	1,000
	CG (n=13)	13,00		13,00		0,00	1,000
2nd quadrant (% sec.)	EG (n=12)	13,00	1,000	13,00	-	0,00	1,000
	CG (n=13)	13,00		13,00		0,00	1,000
3rd quadrant (% sec.)	EG (n=12)	13,75	0,580	14,63	0,135	-87,87	0,046
	CG (n=13)	12,31		11,50		-99,99	0,043
4th quadrant (% sec.)	EG (n=12)	12,25	0,580	11,38	0,135	34,45	0,046
	CG (n=13)	13,69		14,50		15,04	0,043

*p<0,05; **p<0,01

The examination of the static balance performance of the athletes with eyes closed showed that there was no significant difference between the control group and the experimental group in any of the dimensions measured in the 1st and the 2nd measurement (p>0,05). The 1nd and 2nd intra-group measurements showed that there was no significant difference between the 1st and 2nd measurements of the control group athletes, whereas a significant difference was found for the experimental group athletes in terms of 3rd quadrant and 4th quadrant (p<0,05) (Table 6).

Table 6: Results of the eyes closed-static balance measurements

Variables	Groups	1st Measurement		2nd Measurement		1st measurement x 2nd measurement	
		Median	p	Median	p	Change (%)	p
Overall balance	EG (n=12)	15,42	0,106	12,67	0,843	-53,56	0,137
	CG (n=13)	10,77		13,31		-23,20	0,779
Anterior-Posterior	EG (n=12)	13,00	1,000	13,00	-	0,00	1,000
	CG (n=13)	13,00		13,00		0,00	1,000
Medial-Lateral	EG (n=12)	15,42	0,106	12,67	0,843	-53,56	0,137
	CG (n=13)	10,77		13,31		-23,20	0,779
Balance zone A (% sec.)	EG (n=12)	10,54	0,100	13,00	0,840	66,42	0,137
	CG (n=13)	15,27		13,00		10,00	0,672
Balance zone B (% sec.)	EG (n=12)	13,50	0,563	13,04	0,955	-66,67	0,414
	CG (n=13)	12,54		12,96		-85,71	0,317
Balance zone C (% sec.)	EG (n=12)	13,00	1,000	13,04	0,955	0,00	1,000
	CG (n=13)	13,00		12,96		-66,67	0,317
Balance zone D (% sec.)	EG (n=12)	15,00	0,172	12,96	0,840	-45,84	0,205
	CG (n=13)	11,15		13,04		-13,86	0,933
1st quadrant (% sec.)	EG (n=12)	13,00	1,000	13,00	-	0,00	1,000
	CG (n=13)	13,00		13,00		0,00	1,000
2nd quadrant (% sec.)	EG (n=12)	13,00	1,000	13,00	-	0,00	1,000
	CG (n=13)	13,00		13,00		0,00	1,000
3rd quadrant (% sec.)	EG (n=12)	14,13	0,443	13,54	0,433	-96,11	0,028
	CG (n=13)	11,96		12,50		-65,55	0,091
4th quadrant (% sec.)	EG (n=12)	11,88	0,443	12,46	0,433	41,19	0,028
	CG (n=13)	14,04		13,50		14,69	0,091

*p<0,05; **p<0,01

The examination of the strength balance performance of the athletes showed that there was no significant difference between the control group and the experimental group in any of the dimensions measured in the 1st measurement (p>0,05), whereas a significant difference was found in the 2nd measurement in terms of back strength in favor of the experimental group (p<0,05). The 1nd and 2nd intra-group strength measurements showed that there was no significant difference between the 1st and 2nd measurements of the control group and the experimental group athletes (p<0,05) (Table 7).

Table 7: Strength performance values

Variables	Groups	1st Measurement			2nd Measurement			1st measurement x 2nd measurement	
		Mean	Sd.	p	Mean	Sd.	p	Change (%)	p
Back strength (kg)	EG (n=12)	143,03	17,76	0,092	151,15	20,31	0,006*	5,67	0,182
	CG (n=13)	130,98	26,01		130,62	12,23		-0,28	0,600
Leg strength (kg)	EG (n=12)	134,34	26,04	0,550	143,26	16,87	0,703	6,64	0,158
	CG (n=13)	129,49	26,76		139,07	18,12		7,40	0,152
Grip strength-right (kg)	EG (n=12)	44,24	8,54	0,463	48,84	10,10	0,550	10,41	0,071
	CG (n=13)	42,70	7,08		47,36	9,00		10,93	0,101
Grip strength-left (kg)	EG (n=12)	44,20	6,89	0,231	44,68	9,48	0,957	1,08	0,754
	CG (n=13)	41,27	4,13		44,96	8,48		8,96	0,116

*p<0,05

4. Recommendations

Similar studies with different groups and with athletes at different levels, from different sexes and age groups need to be conducted in order to obtain clearer findings about the effects of Tabata training on athletic improvement. In addition, the implementation of Tabata training over a longer period of time may yield different results related to the athletic gains.

5. Conclusion

The purpose of this study was to investigate the effects of a 6-week dynamic training program designed based on the Tabata protocol on balance and strength parameters of elite level combat athletes. To this end, the balance and strength performances of 25 athletes from wrestling, judo, karate, and taekwondo were examined before and after the 6-week program.

The data collected for the control and experimental group athletes before the experimental stage showed that there was no significant difference between the groups in terms of body composition, balance, and strength, that the control and experimental group athletes had similar body compositions and balance and strength performances (Table 2-7).

The body composition results of the experimental and control group athletes at the end of the 6-week training program showed that there was no significant difference between the groups according to the 2nd measurement results; however, a significant difference was found between the intra-group body weight measurements of the experimental group athletes (Table 2). In spite of a 9.41% decrease in the body fat percentages of the experimental group athletes, their body weight increased by 1.24%, which may be explained by increased muscle hypertrophy caused by the dynamic training program designed based on the Tabata protocol. The fact that a strength improvement was observed for the athletes at the end of the 6-week period, albeit not statistically significant, strengthens the likelihood of muscle hypertrophy (Table 7). It has been known for many years that dynamic and static strength exercises cause skeletal muscle hypertrophy (Rasch & Morehouse, 1957).

The examination of the changes in the dynamic balance performance of the athletes with their eyes closed showed that the experimental group athletes had a significant improvement in overall balance by 19.79% and in medial-lateral (inward-outward) balance by 22.67%. The significant changes in the A and B balance zones of the athletes indicated that the balance performance of the experimental group athletes in the 2nd measurements shifted from zone A (0°-5° incline) to zone B (6°-10° incline). This suggests that the experimental group athletes were able to maintain their balance in a more difficult zone (Table 3).

The examination of the changes in the dynamic balance performance of the athletes with their eyes open showed that the experimental group athletes had a significant improvement in overall balance by 45.54%, in anterior-posterior (forward-backward) balance by 40.54%, in medial-lateral (inward-outward) balance by 63.78% (Table 4).

The examination of the changes in the static balance performances of the athletes showed that there was no significant difference between the intra-group and inter-group performance results with eyes open and closed (Table 5-6). The training parameters designed based on the Tabata protocol consisted of dynamic exercises, which did not contribute to the improvement of static balance, but contributed significantly to the improvement of dynamic balance performance. Studies in the literature report the contribution of dynamic exercises to dynamic balance improvement (Kamide et al., 2009; Forsberg et al., 2016; Mohammadi et al., 2012).

The examination of the performance changes in the strength parameters of the athletes as a result of the dynamic exercises designed based on the Tabata protocol showed that the difference between the improvement rates of the experimental and control group athletes in terms of back strength was significant, and no significant intra-group or inter-group difference was found in terms of other parameters (Table 7). In terms of back strength performance, it can be said that while the experimental group athletes achieved 5.67% improvement at the end of 6 weeks, the control group athletes did not show any improvement. This difference between the groups in terms of back strength performances may have been caused by Tabata-based dynamic exercises performed by the experimental group athletes. The fact that the experimental and control group athletes exhibited similar improvement in other strength parameters, but the experimental group athletes displayed higher improvement in terms of back strength supports this idea. The improvement in grip and leg strength was similar, but the improvement in back strength was different between the groups, which may be due to the training program. This suggests that athletes should pay more attention to exercises that improve back strength in training sessions. It can be said that dynamic exercises designed based on the Tabata protocol eliminated the experimental group's lack of back strength-improving exercises.

The improvement of an athletic skill or performance occurs rapidly in novice athletes, but it is much slower in elite athletes. This is due to the fact that elite athletes are closer to their peak than novices. The present study was conducted with athletes from wrestling, karate, judo, and taekwondo, for which strength and balance performance are highly important. Although the athletes were at the elite level in their respective fields, dynamic exercise groups designed based on the Tabata protocol were found to contribute to the dynamic balance and strength performance of the athletes at various rates. The fact that there was no improvement in static balance, hand and leg strength performance indicates that the type and nature of the exercises that make up the Tabata training should be selected carefully. In conclusion, purposefully planned Tabata training contributes to the balance and strength improvement of athletes.

Conflict of Interest Statement

The authors declare no conflicts of interests.

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