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Original Article

Examination of the effect of fascial therapy on some physical fitness parameters in taekwondo athletes

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ABSTRACT

One of the objectives of this study is to determine the effect of the eight-week fascial therapy program on flexibility, vertical jump, standing long jump, speed and anaerobic strength parameters in taekwondo athletes. Another aim of the research is to create a therapy protocol that can be used in athletes related to performance development through the relaxation of the fascial system, which is considered an indicator of physical fitness and has numerous functions in the body. This study included 32 taekwondo players who were licensed, actively attending taekwondo training. In the study, two groups were formed as fascial therapy group (FTG) ($n = 16$) and control group (CG) ($n = 16$). After the groups were randomized, fascial relaxation techniques were applied to the fascial therapy group for eight weeks, up to twice a week, and for 30 min. According to the findings obtained as a result of the research, FTG ([−0.36 ± 0.17] seconds [s]) for the 20 m (m) Sprint (T2–T1) had a lower mean time than CG (0.00 ± 0.07) s, FTG (0.06 ± 1.95) for the Flamingo Balance Test (T2–T1) had a lower mean fall than CG (1.25 ± 1.13), FTG ([3.56 ± 2.37] centimeters [cm]) for the Sit & Reach Test (T2–T1) had a lower mean fall than CG ([−0.19 ± 1.28] cm), FTG ([5.75 ± 2.54] cm) had a higher jump distance than CG ([1.88 ± 8.11] cm) according to the results of Vertical Jump Test (T2–T1) and finally FTG ([9.13 ± 5.56] cm) had a longer distance than CG ([−0.31 ± 1.85] cm) according to the results of Standing Long Jump Test (T2-T1). The result of our study has shown that fascial techniques can be used safely by experienced physiotherapists and can be included in the training program. It is recommended that coaches of sports disciplines work with experienced physiotherapists on this subject and include fascial methods in their training programs.

1. Introduction

Taekwondo is a combat sport with high physiological intensity, especially in the lower extremities, where movements are performed at high speed.[1–4]

The physical demands and specificity of taekwondo require athletes to be efficient in different aspects of physical fitness, including lower extremity strength, aerobic and anaerobic power, flexibility, speed, and agility.[5] For this reason, it is necessary to improve athletes' physical fitness parameters to increase their performance.[6] Taekwondo competition, which is exhibited as a high performance to achieve victory, consists of 3 circuits. Each circuit is 2 min, and there is a 1-min rest between circuits.[7] Taekwondo athletes try to win the competition in this short competitions with technical-tactical practices that require mostly anaerobic power (70%–80%) with short rest intervals.[8] The continuity and adequacy of these technical-tactical practices depend on physical performance parameters such as speed, explosive power, flexibility, agility, aerobic and anaerobic endurance.[9]

It is emphasized that the most distinguishing feature of an experienced and successful athlete is the ability to train the amount of relaxation with the ability to contract and relax their muscles quickly.[10] This ability is also necessary to achieve speed in kicking and punching. The formation of this ability depends on the fascial system.[11]

The main protein found in fascial tissue is Type 1 collagen, and fibroblasts are the primarily responsible cells for collagen production and organization.[12] Collagen and elastin, which have proteins in their structure, support the layers of the fascial continuum and surrounding structures to stretch and slide over each other during any movement.[13] Fibroblasts, which form the basis of the fascial system, are also responsible for tension transmission.[14] At the same time, fibroblasts can also dynamically affect connective tissue tension.[14,15] Connective tissue is able to control the direction of muscle fibers.[16]

Fascial continuity and integrity is necessary for transferring and transmitting muscle strength, correct motor coordination and protection of organs in their own regions. The transmission of force is provided by

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Abbreviations:

FTG	fascial therapy group
CG	control group
n	number
s	seconds
m	meters
cm	centimeters
min	minutes
HA	hyaluronic acid
FM	fascial manipulation
W	watts
h	hours
TLF	Thoracolumbar fascia
SD	standard deviation
ES	effect size
CNS	Central Nervous System

the fascial integrity expressed by the motor activity produced.[16–20] The fascial system influences approximately 2% of maximum voluntary contraction and approximately 1% of muscle tone at rest.[21] Proper motor coordination, transmission and transfer of muscle force is ensured by fascial continuity and fascial integrity.[16–18] Studies have emphasized the importance of the connective tissue surrounding the muscles during contraction.[18,22] Altered fascial stiffness leads to poor muscle biomechanics, altered muscle coordination and reduced strength.[23]

Training the fascial system and fascia tissue is very important for athletes. It is known that the changes in the fascial mechanical properties (stiffness, altered thickness) can affect flexibility, muscle contraction and can limit the range of motion.[24,25] If a person's fascia is well trained to ensure optimal flexibility and elasticity, their performance can be effectively improved and they can largely protect themselves against injury.[26,27] According to Chia,[28] Qi (chi), defined as our life energy, is the indicator of our fascial level. It's been said that less resistance to the flow of bioelectric energy in the body is between the fascial sheaths. ‘Fascia is extremely important in the Kung-fu technique called Iron Shirt Chi Kung because it is known to be a tissue that distributes Qi along acupuncture meridians and can penetrate throughout the body.[28] It is believed that Qi which is produced and stored in the fascial tissues, acts as a pillow to protect tissues from injuries.[28]

Hyaluronic acid (HA) is the main thing that provides the lubricity of the facial tissue.[29] If there is a decrease in the HA lubrication task, the viscosity of the fascia also decreases. The main expected effect in fascial therapy is an increase in fluidity and therefore slipperiness due to HA heating.[30] Manuel fascial therapy also contributes to the reduction of metabolic expenditure, may increase decreased exercise intolerance and motor coordination.[31] The pressure in the fluid (HA) between the muscle and fascia during fascial therapy causes the fluid gap to expand. Thus, the thickness between the two fascial layers also increases. The increase in the thickness of the fluid space can improve the sliding system and allow the muscles to work more efficiently.[32] Research has shown that regular fascial intervention loads applied to the fibers can trigger a younger collagen structure[33] and assumes that it can greatly increase the elastic storage capacity.[34]

Many techniques are applied for the training and therapy of fascial tissue.[18] Fascial Manipulation (FM) is one of the manual therapy techniques used for musculoskeletal disorders, developed by Italian physiotherapist Luigi Stecco. Manual manipulation of fascial tissue is known to reduce exercise intolerance and improve motor coordination.[31] Because it is known that a change in the fascial tissue can changes proprioceptors and fibroblasts can directly affect mechanical force transmission of the muscle.[25,31]

It is known that fascia is not just a passive, dysfunctional membrane and has a special relationship with the underlying muscles.[35] Until today, sports science and sports education have mainly focused on the triad of classical muscle training, cardiovascular conditioning and neuromuscular coordination.[11] But in recent years, training of the fascial system has gained importance. Yet, when the literature is examined, it's seen that there are very limited studies in osteopathic fascial techniques called fascial mobilization/manipulation, are used for performance improvement. Studies have shown that many physiological mechanisms play a role in the development of muscle pain and poor muscle performance, as the nociceptive afferents of the facial system can modulate the afferent response of the central nervous system.[18,36,37] Since it's known that the fascia affects every movement and any tension in the fascia can affects muscle performance,[20,26,38] we think that fascial relaxation may affect muscular performance.

The strength, speed and flexibility of the lower extremity are especially important for successful taekwondo performance and high and rotational kicks.[39] Therefore, the main purpose of this study was to investigate the effect of fascial therapy applied for eight weeks on some physical performance parameters such as flexibility, balance, speed, anaerobic power (standing long jump and vertical jump) of taekwondo athletes. Our study hypothesis is that fascial therapy, which can reduce fascial tissue stiffness in the lower extremity, provides a more efficient expression of speed, balance, flexibility and explosive force produced. At the same time, fascial therapy will reduce tissue tension and improve selected performance parameters. We aimed to obtain data that will help to create fascial therapy and relaxation prescription for athletes. Furthermore, we aimed to contribute to the progress of studies on the use of fascial techniques in sports sciences and to contribute to the literature with new information.

2. Materials and methods

In this study, pretest-posttest experimental design with experimental and control groups was used. In this model, physical examinations of the groups before and after the study, performance values were measured and intra- and inter-group comparisons were made. The study was planned as a prospective, randomized controlled study.

2.1. Participants

Young taekwondo athletes in the 18–19 age group who were licensed athletes of Aldemir Sports Club participated in this study. A total of 32 taekwondo athletes, 16 female and 16 male athletes, voluntarily participated in the study. Participants' age of experience, training level, belt level and experience were similar. Demographic characteristics of the athletes (age, height, body weight, gender, etc.) were recorded before and after the fascial therapy program (Table 1). The participants were selected from the athletes who signed the consent form read to them, actively competed in domestic and international taekwondo competitions, were in the active pre-competition training season, did not have cuts, wounds and sensitivity on the skin of the lower extremities and lumbar region that would affect the treatment, did not take drugs or active substances that would affect performance, and whose consent was obtained that they would not take them during the process. Athletes who had undergone surgery involving the lower extremity in the last 6 months, had open wounds in the lower extremity and lumbar region, and were taking medications that would affect performance were not included in the study. Participants were selected by randomization and two different groups of 16 participants each were formed. A total of 16 people were divided into the Fascial Therapy Group (FTG) and 16 people were divided into the Control Group (CG) (FTG: 16 people [8 Male + 8 Female] and CG: 16 people [8 Male + 8 Female]).

2.2. Ethical approval

In this study, all participants were informed verbally and in writing

Table 1
Descriptive statistics for FTG and CG.

Group	Gender	variables	Min	Max	Mean	*SD*
FTG	Female	Age (years)	18	19	18.125	0.35355
		Body Weight (kilograms [kg])	52	65	60.575	5.91457
		Height Length (centimeters [cm])	160	181	168.875	5.91457
	Male	Age (years)	18	18	18	0
		Body Weight (kg)	52	67.5	60.625	5.15994
		Height Length (cm)	165	181	172.85	7.43424
CG	Female	Age (years)	18	19	18	0
		Body Weight (kg)	46	70	55,5	9.57676
		Height Length (cm)	161	168	164.75	2.96407
	Male	Age (years)	18	18	18	0
		Body Weight (kg)	46	80	61.5	12.81666
		Height Length (cm)	161	183	170.6875	8.27622

FTG: Fascial Therapy Group; CG: Control Group; kg: kilograms; cm: centimeters; Min: Minimum; Max: Maximum; *SD*: Standard deviation.

about the purpose, nature and process of the study. Before the study, the "Informed Consent Form" developed by the physiotherapist responsible author was read and signed by the participants. On the first day, the fascial therapy procedure was explained to the participants and the tests to be performed were explained. Ethics committee approval for the study was obtained from Ankara University Faculty of Medicine Human Research Ethics Committee dated **10.03.2022** and numbered **İ03-103-22,** and our study was conducted by the principles defined in the Declaration of Helsinki. After the ethics committee approval document and study permissions were obtained, all participants underwent motoric tests and physical measurements before and after the study. Information about the data collection methods and tools to be used in the collection of the data of the study is given in the following section.

2.3. Measurements

All participants were physically examined and the biomechanical condition of the athletes' fascial systems was evaluated by the physiotherapist corresponding author. For a meaningful interpretation of the study findings and results, the participants' performances were evaluated 72 h before and 72 h after the fascial therapy program started and ended, respectively, at Mersin Edip Burhan Indoor Sports Hall. For familiarization, all tests and warming movements were demonstrated and repeated three times the day before the study. The order of the tests was determined as balance, flexibility, sprint, standing long jump and vertical jump, respectively. Before the tests, fascial preparation movements[40] were given as warm-up for 15 min (Table 2). A rest period of 5 min was given between the tests. All the tests was repeated twice and the best value was recorded. All measurements were taken consecutively in a single day due to pandemic conditions.

- *Assessment of Balance /Flamingo Balance Test*: Flamingo balance test with high reliability coefficient ($rxy = 0.73$) was applied in order to determine the static balance abilities of the athletes.[9] The athletes stood on the wooden test material which was 50 cm long, 3 cm height and 4 cm wide. The atheletes were told to balance on their dominant leg with bare foot, the free leg was flexed at the knee, pulled it towards the hip and held it with the hand on the same side. As soon as this position was achieved, the time was started with a stopwatch and the athletes were asked to maintain this position for 1 min. The stopwatch was stopped for each time the atheletes lost their balance and started again when they maintained the balance. Every athlete performed two attempts, the number of falls were recorded, and they were averaged for analysis.[41]
- *Flexibility Assessment /Sit & Reach Test:* Flexibility measurements of the participants were performed with the sit & reach test with a high reliability coefficient ($rxy > 0.90$)[42] and with using a sit & reach box. The test was first described by Wells and Dillon.[43] The participants were told to sit barefoot in the long sitting position with the soles of their feet pressed flat against the sit-and-reach box. Participants were instructed to slowly reach forward with their palms down, as far as possible with their knees in full extension. The most distant point (in centimeters [cm]) reached with the fingertips was recorded. The participants performed two trials, and their best score was used for analysis.[44]
- *Speed Assessment /20 m (m) Sprint Test:* The speed performance of the participants was determined by 20 m sprint test. Photocell was placed at the beginning and end of the 20 m course and participants were asked to start running as fast as possible from 50 cm behind the starting line.[45] The participants performed two trials, and their best score was used for analysis.
- *Anaerobic Power Assessment*
  - ➢ *Standing Long Jump (Double leg) Test (cm):* The standing long jump test is a widely used test to determine explosiveness performance in the lower extremities.[46] A 300 cm long tape measure was used to create the test area. The reliability of this test was reported as 0.70–0.94.[47] The athletes were asked to jump forward with both legs, in squad position to the furthest distance with the help of their arms and feet. After the movement was performed, the distance from the heel of the athlete's reach to the starting line was measured in cm. The participants performed two trials, and their best score was used for analysis.
  - ➢ *Vertical Jump Test (cm):* One of the most widely used tests to measure strength and explosiveness is the vertical jump test.[46] The vertical jump test of the athletes was performed on Apple Iphone 8 Plus phone using My Jump 2 (IOS app) program.[48] When the literature is examined, valid and reliable results have been obtained in the studies conducted to determine the validity and reliability of the My Jump 2 application.[49] Camera recording was started over the My Jump 2 application and the athletes were asked to make a quick squatting motion to form an angle of approximately 90° in the knee joint, in the normal upright position with their hands on the waist and jump up with maximum force. From the moment the athlete made the jump from the ground, the jumping time and the point of contacting the ground again were calculated by the application. Two jump attempts were made, and the best value was recorded in cm. With the results obtained from the vertical jump test, the anaerobic power values of the athletes were calculated using the Lewis formula ($rxy = 0.83$) and the result was recorded in watts (W).[50]

The following formula of Lewis was used to calculate anaerobic power.[50]

"Anaerobic Power: $\sqrt{4.9}$. (W) $\sqrt{D}$. W=Body Weight (kilogram [kg]), D = Splash Distance (cm)".

2.4. Intervention

In the 8-weeks study; fascial mobilization/fascial manipulation techniques were applied to the fascial therapy group athletes at most twice a week, with each session lasting an average of 30 min. The fascial therapy group of the study was studied while continuing their individual

Fig. 1. Osteopathic fascial techniques.

taekwondo training 4 days a week, and the fascial therapy session was always performed before training. The fascial techniques applied were prepared by the needs of the athletes and the sport. The participants in the CG did not receive any fascial release techniques during the study period. The control group participants continued their individual taekwondo training for 8 weeks and did not receive any additional intervention.

Fascial tissue mechanoreceptors are sensitive to a certain pressure. Applying a pressure above or below the mechanoreceptor stimulation threshold of the physiotherapist can not initiate the relaxation process and the expected result cannot be achieved.[51] For this reason, the practicing physiotherapist should have well-developed fingertip sensitivity and be experienced in this field. Osteopathic fascial therapy program' preparation and application of the methods was done by the responsible author, who is a physiotherapist with 8 years of experience, and completed her master's degree in sports science and has a Certificate of Competence to Practice Osteopathic Facial Techniques. In order to increase the production of collagen synthesis and allow adequate collagen regeneration, it is recommended to properly stimulate the facial tissues once a week, no more than twice.[52] Therefore, we were decided to have at least 72 h between the days of the fascial therapy sessions. For this reason, the days were chosen to be the two most distant days from each other (Monday and Thursday). Considering the optimal time required for muscle development and in order to see a significant performance improvement,[53] it was found appropriate for the study to last 8 weeks.

Table 2
Fascial warming movements.

Fascial Warm-up and Preparatory Movements	aims
1. Preparatory Contrasting Movement: Elastic retraction-arm-leg swings	In this movement, it is aimed to increase the catapult effect and elastic retraction dynamics of the fascial tissue. For this purpose, before performing the movement, it is first started with a slight pre-tension in the opposite direction. Leg and arm swings are recommended to increase the catapult effect.
2. Ninja Principle: Stair Dance	In this exercise, to ensure rapid fascial retraction, one should be quieter and smoother when going up and down the stairs, almost like dancing. In addition, bare plantar foot contact is used during this process.
3. Swinging Sword: Lumbodorsal fascia	This exercise is one of the basic exercises for elastic retraction, especially in the lumbodorsal fascia. The aim is to be fast and fluid, like a sword being swung, without muscular effort or tension.

Due to the competition preparation period of the athletes, the athletes continued their own training and competitions. They were assured by the coach not to do any strength training during the training sessions that could affect the results. It was ensured that the participants in the experimental group did not apply any massage-like intervention that would have a positive or negative effect on the results, except for the fascial therapy program prepared for this study. The control group did not receive any fascial intervention during the 8-weeks period and continued the same training regimen as the experimental group.

2.5. Osteopathic fascial therapy program

In the fascial therapy group (FTG) of our study, a program including osteopathic fascial therapy and relaxation techniques for the lower extremity was applied for eight weeks. It was observed that there is no effective fascial therapy and release plan for taekwondo athletes in the literature. For this reason, the osteopathic fascial therapy plan was prepared by the physiotherapist responsible author, taking into account the fascial manipulation techniques developed by Italian physiotherapist Luigi Stecco.[54] The lower extremities are thought to be in communication with the fascia system, especially the Thoracolumbar fascia (TLF). Therefore, TLF mobilization has been especially included in the training plan. In order for the fascial therapy to have a better effect and to provide fascial elasticity, the athletes were asked to continue the three fascial preparation movements (Table 2) which are shown as warm-up movements, on the therapy days as well. In the 3rd, 4th, 5th, 6th,7th and 8th weeks, the fascial therapy day was determined as a single day, and in the 1st and 2nd weeks, it was applied as two days. In the first and second weeks, the therapies were determined as 2 times a week in order for the athletes' fascia to get used to the therapist's hand and for the increase of the fluidity of the HA. The therapies were applied one day a week so that appropriate stimulation could occur in the following weeks. Since the relaxation time determined for each fascia and each technique is 90–120 s[55] and the fascial relaxation time varies according to the individual, the session duration is limited within itself. Each osteopathic technique was applied for an average of 90–120 s and until relaxation was felt, at a single point, in a single area, and each technique was applied only once during the session. The content of the osteopathic fascial therapy program is given in Table 3.

The osteopathic fascial mobilization program for the fascial therapy group was applied before training for each athlete and in the same order every week. The program started on Mondays and Thursdays at 8:00 a.m. and the athletes received the fascial interventions and went to taekwondo training respectively. Athletes who had individual taekwondo training four days a week (Monday, Wednesday, Thursday, Saturday) received the fascial interventions individually and started their individual training 5 min after the end of the therapy.

Table 3
Osteopathic fascial therapy program.

Week	Day and Applied Fascial Therapy Techniques
1–2	-Monday and Thursday *Superficial dorsal fascia mobilization:* Release of the fascia covering the tendons of the long extensor muscles of the foot (Extensor hallucis longus and anterior peroneus longus) Fig. 1A). *Plantar fascia manipulation:* Release of the fascia on the sole of the foot. (Fig. 1B). *Deep fascia (foot) manipulation:* This part of the fascia covers the metatarsal bones and interosseous muscles (Fig. 1C). *Mobilization of the Interesseous membrane of the leg*: This part of the fascia includes the tibia-peroneal interosseous membrane (Fig. 1D). *Femoral condyle mobilization:* This part of the fascia includes thickening of the capsule at each condyle level (Fig. 1E) *Mobilization of the superficial fascia of the anterior thigh:* Releasing the fascia of the inguinal ligament and quadriceps muscle group (Fig. 1F). *Mobilization of the posterior thigh superficial fascia-Hamstring muscle fascia*: Releasing the Popliteal fossa and Hamstring muscle fascia (Fig. 1G) *Tensor Fascia Lata (TFL) and Iliotibial Band (ITB):* Relaxation of the TFL muscle fascia, relaxation of the iliotibial band in the fascia lata complex (Fig. 1H) *Thoracolumbar fascia mobilization (TLF):* Relaxation of the common fascia of the Latissimus dorsi and Gluteus maximus muscles (Fig. 1I). *Sacrum technique and whole body fascial release:* Facial mobilization of the sacral region and manual fascial vibration starting from the shoulder.
3-8	-Monday • Thoracolumbar fascia mobilization • TFL and ITB manipulation • Plantar fascia manipulation • Superficial dorsal fascia mobilization • Foot deep fascia manipulation • Mobilization of the interosseous membrane of the leg • Femoral condyle mobilization • Mobilization of the superficial fascia of the anterior thigh • Posterior thigh superficial fascia-Hamstring muscle fascia release • Sacrum technique-general relaxation

Fig: Figure; TFL: Tensor Fascia Lata; ITB: Iliotibial Band; TLF: Thoracolumbar fascia.

2.6. Data analysis

All data obtained from our study were analyzed with the SPSS 25 package program. First, the normality distribution of the data was evaluated to determine whether the test used in the comparison of the data was parametric or non-parametric. This normality distribution evaluation was tested with Shapiro Wilk since the number of participants in both groups was below 50. As a result of the normality assessment, non-parametric tests were preferred. In our study, the 'Wilcoxon Signed Ranks' test was used to compare the pre-test and post-test results of the fascial therapy group and the control group between the groups, while the 'Mann-Withney *U*' test was used to compare between the groups. Mean ± standard deviation (*SD*) and effect size (*ES*) values for these variables are also given. The significance level of our study was accepted as $p < 0.05$.

3. Results

In the findings, the averages of the first measurement (T1), the last measurement (T2) and the differences between measurements (T2–T1) of physical fitness parameters were included.

Table 4 shows the results of the Mann-Whitney *U* test performed to determine the statistically significant mean differences between the research groups and physical fitness parameters. When the findings were analyzed, there was a significant mean difference between the research groups in all physical fitness parameters ($p < 0.001$). When these differences were examined, it had seen that FTG had significantly higher

Table 4
Mean differences between research groups and physical fitness parameters.

Veriables	Groups	Mean	*SD*	*Z*	*p*	*ES*
20 m Sprint (T2–T1) (seconds [s])	FTG	−0.36	0.17	**−4.770**	**< 0.0001**	**2.76**
	Control	0.00	0.07			
Flamingo Balance Test (T2–T1)	FTG	0.06	1.95	**−2.168**	**< 0.0001**	**0.74**
	Control	1.25	1.13			
Sit and Reach Test (T2–T1) (centimeters [cm])	FTG	3.56	2.37	**−4.453**	**< 0.0001**	**1.96**
	Control	−0.19	1.28			
Vertical Jump Test (T2–T1) (cm)	FTG	5.75	2.54	**−3.956**	**< 0.0001**	**0.64**
	Control	1.88	8.11			
Standing Long Jump (T2–T1) (cm)	FTG	9.13	5.56	**−4.767**	**< 0.0001**	**2.27**
	Control	−0.31	1.85			
Anaerobic Power (T2–T1) (Watts)	FTG	587.93	250.59	**7.749**	**< 0.0001**	**2.73**
	Control	17.12	154.95			

FTG: Fascial Therapy Group; CG: Control Group; s: Seconds; cm: centimeters; *SD*: Standard deviation; *ES*: Effect size; *p*: *p*-value; *Z*: *Z*-score.

Table 5
Mean differences between first measurement (T1) and last measurement (T2) for FTG.

Veriables	Measurement	Mean	*SD*	*Z*	*p*	*ES*
20 m Sprint (seconds [s])	T1	4.48	0.21	**−3.517**	**< 0.0001**	**1.63**
	T2	4.12	0.23			
Flamingo Balance Test	T1	4.38	2.09	−0.639	0.523	
	T2	4.44	1.15			
Sit and Reach Test (centimeters [cm])	T1	35.69	4.51	**−3.528**	**< 0.0001**	**0.74**
	T2	39.25	5.05			
Vertical Jump Test (cm)	T1	35.50	3.25	**−3.424**	**0.001**	**1.71**
	T2	41.25	3.44			
Standing Long Jump (cm)	T1	176.75	15.43	**−3.520**	**< 0.0001**	**0.51**
	T2	185.88	19.57			
Anaerobic Power (Watts)	T1	366 9	505	**−3.407**	**< 0.0001**	**1.15**
	T2	425 7	511			

FTG: Fascial Therapy Group; s: Seconds; cm: centimeters; *SD*: Standard deviation; *ES*: Effect size; *p*:*p*-value; *Z*: *Z*-score.

flexibility ($ES = 1.96$), balance ($ES = 0.74$), anerobic power (vertical jump and standing long jump distance) ($ES = 2.74$) and lower mean time for 20 m sprint compared to CG ($ES = 2.76$).

Table 5 shows the results of the Wilcoxon Signed Ranks test performed to determine the statistically significant and high mean differences between the first measurement (T1) and the last measurement (T2) values for FTG ($p < 0.001$). There is a significantly high mean difference between T1 and T2 values of 20 m Sprint ($ES = 1.63$), Sit and Reach Test ($ES = 0.74$), Vertical Jump Test ($ES = 1.71$) and Standing Long Jump ($ES = 0.51$).

Table 6
Mean differences between first measurement (T1) and last measurement (T2) for CG.

Veriables	Measurement	Mean	*SD*	*Z*	*p*
20 m Sprint (seconds [s])	T1	4.45	0.15	−0.142	0.887
	T2	4.45	0.12		
Flamingo Balance Test	T1	4.50	1.59	−2.987	0.003
	T2	5.75	1.77		
Sit and Reach Test (centimeters [cm])	T1	36.19	4.48	−0.556	0.577
	T2	36.00	4.93		
Vertical Jump Test (cm)	T1	32.94	8.10	−0.265	0.791
	T2	34.81	1.52		
Standing Long Jump (cm)	T1	174.00	11.95	−0.519	0.604
	T2	173.69	12.37		
Anaerobic Power (Watts)	T1	3 620	756	−0.357	0.721
	T2	3 637	748		

CG: Control Group; s: Seconds; cm: centimeters; *SD*: Standard deviation; *ES*: Effect size; *p*: *p*-value; *Z*: *Z*-score.

Table 6 shows the results of the Wilcoxon Signed Ranks test conducted to determine the statistically significant mean differences between the first measurement (T1) and the last measurement (T2) values for the CG. When the findings obtained are examined, it is seen that there is no statistically significant mean difference between T1 and T2 measurement values in any parameter for the control group.

4. Discussion

In our study in which we investigated the effect of fascial release on some physical fitness parameters in taekwondo athletes, fascial mobilization/manipulation techniques, which are fascial release techniques, had a positive effect on performance. The findings of this study revealed that fascial therapy of the lower extremities significantly improved flexibility, sprint, standing long jump, vertical jump and anaerobic power performance compared to the control group. Therefore, manual fascial tissue release was found to be beneficial in terms of improving these physical performances. It can be suggested that the observed improvement in performance may be due to a significant change in the tension and stiffness of the lower extremities.

Based on the Sit & Reach Test results, the average percentage improvement in flexibility as a result of fascial techniques was 10%. Since the thoracolumbar fascia is connected to the fascia of more than one muscle and we have worked to relax this fascia, the difference in flexibility of the lower extremities' is actually an expected result. Because fascia is the sheath surrounding muscles, a muscle under a tense and stiff fascia would not be expected to be flexible. We believe that fascial treatments can prevent injuries in athletes[26] by increasing muscle strength and endurance. According to our results, we can say that fascial mobilization has a positive effect on flexibility, but long-term studies are needed to know whether this situation will continue in the long term.

Gluteal, adductor and vastus muscle groups provide the greatest contribution in terms of both force production and muscle activation in explosive movements such as vertical jumping.[56] For this reason, we applied fascial therapy on to these muscles in our study. Taekwondo athletes with good lower limb explosive power will be able to generate more force during kicking, which will give them an advantage during competition.[57] It has been said in many studies that explosive power is one of the important determinants of taekwondo competition performance.[1,58] At the end of eight weeks, there was an average increase of 16.19% in the vertical jump value in the fascial therapy group and an average increase of 5.15% in the standing long jump distance in the fascial therapy group. In order to achieve success in international competitions, taekwondo athletes must demonstrate high anaerobic strength characteristics in the lower extremities.[1]

In our study, as a result of fascial interventions, FTG (0.06 ± 1.95) showed less falling (balance impairment) behavior than the CG (1.25 ± 1.13) according to the initial and final measurements of the Flamingo balance test. However, no significant difference was found between the first and last measurement in the balance assessment for FTG. In a similar study by Pawik et al.,[59] a fascial therapy protocol including 17 fascial techniques was applied for 60 min and body balance was evaluated after the intervention in track and field athletes with lower extremity muscle injuries. After the fascial therapy session, it was observed that there was an improvement but the difference in balance distribution was not significant in the study group when the eyes open and closed position before and after the intervention was compared.[59]

Many studies have supported the therapeutic effect of the Fascial Manipulation technique in various painful musculoskeletal conditions.[26,60–72] However, when the literature is examined; there are very limited studies on the effect of osteopathic fascial techniques on performance in athletes, especially in athletes without musculoskeletal problems. In the study conducted by Buscemi et al.,[20] which is one of these limited studies and one of the studies that reached similar results to our study, it was examined whether the explosive force of the extremities could be increased and the tension could be reduced by applying osteopathic fascial therapy technique to the lower extremity muscles in volleyball players for 30 days period; they stated that significant improvements were shown in explosive power and decreased tension in the tissue.[20] Relaxation and training of the fascial system of the lower extremities appeared to result in an improvement in performance by increasing anaerobic power. The results obtained during the vertical jump test showed a statistically significant improvement in the values obtained during the 30-days period, and the measurements increased from (43.08 ± 42) cm at the beginning to (44.6 ± 0.44) cm after 30 days ($p < 0.000\ 1$). We achieved a similar effect in our study.

Sawamura and Mikami[38] investigated the effect of one-week FM on the electrical activity and reaction time of the biceps muscle; FM was found to improve muscle reaction time, motor time, peak activity time and peak force time. The authors also suggest that FM may be more effective than static stretching to improve motor performance.[38] Although we did not directly measure the muscle strength parameter in our study, knowing that fascial manipulation also has an effect on muscle strength will guide us in subsequent studies.

The biggest difference of our study from the studies in the literature was the addition of TLF release to the fascial therapy protocol. In the reviewed literature, it was observed that no fascial tissue intervention was applied to the TLF and TFL in the studies. It was stated that attention should be paid to the fascial system of the lower limbs, communication with the whole body and especially with the thoracolumbar fascia.[35] The TLF transfers force from multiple muscles to multiple facet joint capsules. It is crucial in transferring forces between the spine, core (trunk muscles), pelvis and lower limbs.[73,74] It is a membrane with a strong connective tissue layer that connects two of the largest muscles of the body, the latissimus dorsi and gluteus maximus.[75] The tensor fascia lata is a muscle that functions together with the iliotibial band and gluteus maximus within the fascia lata complex due to its anatomically and functionally integrated structure. These muscles enter the patella through the quadriceps tendon and are all integrated with the fascia lata.[76] For this reason, these two fascia were specifically included in the protocol. We think that these two fascia have a great influence on the strong improvements seen in the findings.

Consciously touching the athlete will stimulate the mechanoreceptors in the fascia and as a result of the mechanoreceptors stimulating the Central Nervous System (CNS), a general relaxation will be achieved in the body. As we have already mentioned, applying a pressure above or below the threshold of mechanoreceptor stimulation cannot initiate the relaxation process and the expected result can not be achieved. Furthermore, the fascia may show the property of hardening or tensioning its own structure by manual incorrect interventions. The important part here is that the physiotherapist should have fine palpation skills. We find it useful to say that the significant improvements in results may depend on the physiotherapist.

Fascia and muscles work together for the correct and smooth functioning of the locomotor assembly. So the performance of the movement certainly depends on the state of both.[77] Over a lifetime, fascia can be injured by traumatic events, strenuous physical activity and surgical procedures. In particular, excessive or prolonged loading that athletes are exposed to during their sporting lives can cause serious damage to the fascia. Disturbances and injuries in the fascial system cause a significant loss of performance in high-performance sports and recreational exercises. For this reason, fascial tissue is extremely important in the field of sports sciences. Better understanding of fascial tissue adaptation dynamics; promises valuable advances in injury prevention, athletic performance and sports-related rehabilitation.[78] Our study demonstrated the importance of fascial tissue in terms of selected performance measures.

The strength of our current study is undoubtedly the development of a reproducible protocol, both in terms of techniques and timing. The protocol we created can be applied in two ways: first, in a clinical setting, and secondly, to improve the performance of athletes in the sports setting. New research is required to develop a new therapy protocol suitable for the upper extremities and core. We believe that our study will guide future studies, contribute to the literature on fascial and osteopathic interventions, especially in the field of sports sciences, and support evidence-based practices.

4.1. Limitations

The first limitation of our study was the experimental group characteristics. Since we evaluated professional and competitive athletes, the effect of our program on more amateur or recreational individuals may not be as significant as the results we found. We also had a very young group, and the program may not be effective to older individuals. One of the major limitations of the study is that there is no single universal protocol accepted in the literature regarding the mode and duration of application of performance-oriented fascial therapy for various sports branches. Therefore, a protocol was designed specifically for the purpose of this study.

It is known that fascial tissue is a collagen tissue and fascial interventions increase collagen synthesis. In our study, it was assumed that the diet of the athletes (excessive or low intake of nutrients that increase collagen production) did not change and they did not use collagen supplements.

5. Conclusions

Fascial tissue relaxation was achieved in the sample of taekwondo athletes who were subjected to fascial training of lower extremity muscle groups, superior improvements were observed in the explosive force, flexibility and speed of the limbs. The fact that there was a significant difference between the groups in favor of the fascial therapy group in all physical performance parameters showed that fascial therapy is an important therapy method that can be used in athletes. The result of our study has shown that the protocol we have created is an effective protocol for taekwondo athletes.

Fascia and muscle are inseparable and cannot be considered independent of each other. Fascia has an effect on every movement and thanks to the fascia, movements are performed in a shorter time and more efficiently with less energy expenditure. Our study supports this.

In our study, it was observed that the static balance parameter did not show a significant change. It is thought that more specific studies on this subject are needed.

Considering that flexibility is an effective feature in the prevention of sports injuries, it is thought that flexibility obtained without a decrease in athletic performance may be more effective than classical warm-up applications.

Fascial techniques can be used safely by experienced physiotherapists and can be included in the training program. It is recommended that coaches of sports branches work with physiotherapists on this subject and include fascial methods in their training programs.

We believe that investigating the effects of our study for different periods (between and/or at the end of the competition) in competition and training conditions and the effects of fascial techniques on the performance and technical skills required by different sports branches will make important contributions to sports science and training methods.

Submission statement

The Corresponding Author declares that this manuscript is original, has not been published before (except as an academic thesis) and is not currently being considered for publication elsewhere. The manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. The order of authors listed in the manuscript has been approved by all of authors.

On behalf of the all other authors, the Corresponding Author is the sole contact for the Editorial process and is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs.

Ethical approval statement

In this study, all participants were informed verbally and in writing about the purpose, nature and process of the study. Before the study, the "Informed Consent Form" developed by the physiotherapist responsible author was read and signed by the participants. On the first day, the fascial therapy procedure was explained to the participants and the tests to be performed were explained. Ethics committee approval for the study was obtained from Ankara University Faculty of Medicine Human Research Ethics Committee dated **10.03.2022** and numbered **İ03-103-22,** and our study was conducted by the principles defined in the Declaration of Helsinki.

Authors' contributions

Conceptualization, Y.U. and S.M.; protocol design and methodology, Y.U.; formal analysis, Y.U..; investigation, Y.U. and S.M.; writing—original draft preparation, Y.U.; writing—review & editing, Y.U. and S.M.; visualization, Y.U.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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