EVALUATION OF THE EFFECT OF CORE STRENGTH TRAINING ON FMS SCORES IN TENNIS ATHLETES

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Abstract

This study investigated the effects of core strength exercise programmes on functional movement analysis in tennis athletes playing in a private sports club in Istanbul. A total of 40 volunteers participated in the study. The participants were divided into two groups as core strength group (SG) (n=20) and control group (CG) (n=20). The mean age of the 20 participants in the CG was 15.15±0.81 years, body weight was 42.36±2.21 kg and height was 140.25±8.41 cm. The mean age was 14,87±0,88 years, body weight was 42,63±1,96 kg and height was 138,81±7,91 cm. In the study, height-weight, reach-reach, Y-balance, sit-up, plank and FMS tests were taken as pre-post tests and core strength training was applied to SG 2 days a week for 8 weeks. As a result of the analyses, statistically significant differences were found for sit and reach (t=4,565, p<.05), plank (t=6,778, p<.05), sit-up test (t=5,944, p<.05), FMS (t=5,136, p<.05), while no difference was found for Y-balance test right foot (t=-1,054, p>.05), Y-balance left foot (t=0,274, p>.05). As a result of the study, it was determined that core strength training programmes were effective on FMS scores in athletes. It is thought that it can be used in addition to strength training in athletes.

Keywords: Tennis, functional movement screen, core, strength training.

INTRODUCTION

Tennis is a sport played on a hard and smooth ground using a piece of equipment called a racket. In this sport, a small felt-covered ball is hit and the ball passes over or around the 91 cm high net in the centre of the court (Kermen, 2002). Tennis, like other sports, is a branch that requires high performance and includes tactical, technical and physical skills to ensure that athletes win. It is also known as a visually impressive and popular sport due to its aesthetic movements. Tennis is a sport that impresses spectators and attracts the participation of many people. This sport is played in many countries around the world and increases the tourism potential of these countries. Tennis

competitions are supported by big organisations and promotions, and big prizes are awarded (Ölçücü et al., 2012). Tennis is one of the most popular sports branches for both professional and recreational purposes (İmamoğlu, 2009). In recent years, it has been seen that athletes apply training techniques such as the core training model to improve their performance. Studies show that core training improves basic motoric characteristics and increases the performance of athletes (Görür, 2020; Hsu et al., 2018; Alpşahin, 2018).

Core exercises target the muscles that regulate and control the movement of the hips, lower back and abdomen. These exercises are a common method of strengthening the muscles used to stabilise the hips and spine. These muscles work together to stabilise the body during movement. Unlike weight training, the core training method aims to improve athletic performance and maintain strength during rehabilitation (Egesoy et al., 2018). The core plays an important role as an area that provides strength between the upper and lower body. The entire movement flow of athletes is transferred from the core to the extremities. As in daily life activities, it is important for athletes to have strong core muscles for waist stabilisation during weight training. Core training includes abdominal, thoracolumbar, hip and pelvic musculature, which provide stability for mixed body movements, including swinging and throwing movements. Healthy individuals need strong and durable core training to prevent injuries and improve athletic performance. Strength training improves the nerve pathway (drive) and the magnitude and rate of impulses sent to the target muscle. The increase in nerve conduction is manifested by an increase in the rate of action potentials and is associated with both an increase in muscle force production and an increase in the rate of force production. In order to improve these characteristics, various training methods are applied and evaluated in terms of performance improvement. There are various test materials used to make these evaluations. Functional Movement Assessment (FMS) is a system used to evaluate human movement in the field of sport and health worldwide and is accepted and applied by many international health and fitness institutions.

Therefore, many teams use FMS tests to evaluate athlete performance. This study was conducted to determine the effect of core strength training on FMS scores in tennis athletes. The aim of this study was to evaluate the effect of core strength training on

FMS scores in tennis athletes. The effects of core strength exercises on the functional movement system were compared in a core strength group and a control group for 8 weeks.

METHOD

Research Model

In this study, experimental design, one of the quantitative research methods, was used. Quantitative research is a type of research that makes the phenomenon discussed objective, observable and measurable. The issues addressed in quantitative research projects are presented in a way that can be expressed with numerical data. The experimental design is based on quantitative research on determined groups (Özmen & Karamustafaoğlu, 2019). Firstly, height, weight, Y-balance, plank, sit-up, push-up, vertical jump (CMJ) tests were taken in the morning session and single repetition maximal strength tests were taken in the afternoon. After 8 weeks of strength training, the tests were repeated. After the participants were reminded about the training programme protocol before starting their training, each participant performed the training protocol of the group they were included in the main phase after the standard warm-up phase and the preparation phase and completed the training with the cooling phase. For the warm-up phase, light jogging on a treadmill (Lifefitness, USA) at a speed of 6 km.sec-1 for 5 min, 6 dynamic stretching movements based on large muscle groups with 4 repetitions each for weight lifting preparation, 2 sets of jack knife and superman movements with 10 repetitions as preparation for training lifts were performed. For the cooling phase, 10 static stretching movements involving large muscle groups, each lasting 6-8 seconds, were performed while standing.

Participants

In the study, 40 volunteers aged between 14-16 years, who did not have any cardiovascular disease, blood disease, chronic disease or joint injury in the last 1 year, participated in a private tennis centre located in Bakırköy district of Istanbul province.

The mean age of the core strength group was 15.15±0.81 years, body weight was 42.36±2.21 kg and height was 140.25±8.41 cm. The mean age of the control group was 14.87±0.88 years, body weight was 42.63±1.96 kg and height was 138.81±7.91 cm.

Participants were asked to eat at least 2 hours before the tests. The participants were divided into 2 groups, each consisting of 20 people, as control group (CG) and core strength group (SG) by simple random sampling method. It was assumed that all individuals participating in the study understood the importance of the study and the tests. It was assumed that all individuals participating in the study performed maximal performance during the tests and performed strength training voluntarily. The study was limited to individuals who regularly attended training at least 3 days a week for at least 1 year. All participants were informed in detail about the purpose and importance of the study, possible risks and the ability to withdraw from the study at any time in accordance with the Declaration of Helsinki, and a consent form was filled out and signed. Nişantaşı University Ethics Committee approval was obtained for the study (No 20240104-178).

Data Collection Tools

Height, weight, flexibility, balance, plank, sit-up and FMS scores were obtained for the pre- and post-tests.

Height-Weight Measurement

'Participants' height and body weight were measured using a stadiometer (Holtain, UK) with an accuracy of 0.1 cm and a digital scale (Seca, Vogel and Halke, Hamburg) with an accuracy of 0.1 kg. Height measurements were recorded in metres in anatomical posture, bare feet, feet completely on the ground, heels together and in contact with the wall, knees tense and body in an upright position, with reference to the point where the tip of the head touches the stadiometer table. Body weights were measured in light sportswear (shorts and t-shirt), bare feet and anatomical posture. Each measurement was performed twice and the mean of these measurements was used as descriptive statistics.

Y Balance Test

The 'Y Balance Test', which is a method used to evaluate dynamic postural control, uses a 'Y' shaped pattern drawn on the floor with the help of tape. Numbers in centimetres are placed on this pattern and measurements are made using these numbers during the movements of the athletes. During the balance test, the participants are asked to keep their hands at waist level and place their heels on the floor. They are also

required to make a light touch to the farthest point with the fingertip of the reaching foot. The measurements are performed in a series of movements in which the athletes reach barefoot in three different directions: anterior (ANT) reach measures the distance the participant reaches from the toe of the toe in the centre, while posterolateral (PL) and posteromedial (PM) reach measures the distance from the heel of the foot to the farthest point they can reach. Athletes perform the test three times in each direction, totalling nine times. Errors such as athletes transferring their body weight to the reaching foot, separating the heel of the stance foot from the ground, or separating their hands from the hips during the measurement are not accepted and the measurement is repeated if such errors are recognised (Enquist et al., 2015). 'The leg length of each participant is recorded by measuring the distance from the anterior superioriliac point to the distal part of the medial malleolus bilaterally in the supine position.' All reaching distances are recorded in centimetres and once the data are obtained, the distances obtained in each direction are normalised using the formula 'Best Reach Distance/Leg Length × 100 = % Most Reach Distance' to remove the effect of leg length (Gribble and Hertel, 2004).

Core Zone Plank Test

Plank test' is an exercise based on maintaining the balance of the body in a prone position towards the floor, on the elbows and feet, with the heels and head forming a straight line. During the test, the participant takes the plank position with the start command. If the position is disturbed (such as the hips falling down or rising upwards), a warning is given. The test is terminated for the athlete who receives three warnings. How long the participant stayed in the plank position was recorded in seconds (Boyacı, A. & Tutar M., 2018).

Sit and Reach

The torso (waist and hips) is tilted forward and it is asked to reach as far forward as possible without bending the knees, with the hands in front of the body. The subject tries to reach the farthest point in this way and waited 2 seconds at the last point and recorded.

Functional Movement Analysis

For the Functional Movement Assessment (FMS) test, a protocol consisting of 7 basic movements including deep squatting, high stepping, stepping forward in a straight line, shoulder mobility, active straight leg raising, trunk stability and rotation stability was applied (Peate et al., 2007; Warren et al., 2018).

Each movement pattern was qualitatively analysed by the researcher and given a score between 0 and 3 according to the degree of movements required to complete the movement or the presence of pain. The scores were then summed and the participants' overall FMS scores were determined. Scoring conditions;

- 3 = Ability to correctly complete the movement pattern without any predefined compensation;
- 2 = Movement with any of the movement pattern specific compensations;
- 1 = Inability to realise the movement pattern;
- 0 = Presence of pain in any part of the movement pattern (Warren et al., 2018; Chang et al., 2015).

Sit-up Test

The number of sit-ups that the participants could perform at maximum repetition in one minute was recorded. The participants lay on their backs on the floor, bent their knees and pressed the soles of their feet to the floor. Afterwards, they were asked to lift their heads upwards and repeat the movement as many times as they could.

RESULTS

Table 1. Comparison of pre and post test values of the groups

	Pre-test				**Post-test**			
	SG (n=20)	**CG (n=20)**			**SG (n=20)**	**CG (n=20)**		
	Mean±Sd	**Mean±Sd**	**t**	**p**	**Mean±Sd**	**Mean±Sd**	**t**	**p**
Sit & Reach (cm)	16,65±3,97	16,60±3,2	0,43	,966	19,10±3,65	17,35±3,06	1,64	,109
Y Balance-Right	82,31±5,92	85,28±5,4	-1,64	,109	83,47±5,49	86,82±5,34	-1,89	,066
Y Balance-Left	83,47±5,85	87,28±6,2	-1,85	,072	84,57±7,18	88,46±6,10	-1,84	,073
Plank (sec)	48,50±8,12	46,80±6,66	0,72	,474	63,60±8,53	48,35±6,76	6,26	,000*
Sit-up (count)	22,0±5,12	21,30±3,37	-0,51	,613	28,00±4,40	22,65±3,39	4,30	,000*
FMS (score)	13,20±3,13	15,82±5,16	-1,92	,062	15,50±2,54	16,44±4,45	-0,79	,461

When the table is examined, no significant difference was found in the pre-test data between the groups, but a significant difference was found in the post-test data in CG (63.60±8.53) and CG (48.35±6.76) (0.000) (p<0.05).

Table 2. In-group comparison of pre-post test values

	SG				CG			
	Pre-test	Post-test			Pre-test	Post-test		
	Mean±Sd	Mean±Sd	t	p	Mean±Sd	Mean±Sd	t	p
Sit & Reach (cm)	16,65±3,97	19,10±3,65	-6,97	,000	16,60±3,29	17,35±3,06	-6,09	,000*
Y Balance-Right	82,31±5,92	83,47±5,49	-3,56	,002	85,28±5,49	86,82±5,34	-8,03	,000*
Y Balance-Left	83,47±5,85	84,57±7,18	-3,67	,002	87,28±6,27	88,46±6,10	-5,27	,000*
Plank (sec)	48,50±8,12	63,60±8,53	-7,66	,000	46,80±6,66	48,35±6,76	-4,50	,000*
Sit-up (count)	22,0±5,12	28,00±4,40	-8,11	,000	21,30±3,37	22,65±3,39	-5,31	,000*
FMS (score)	13,20±3,13	15,50±2,54	-6,09	,000	15,82±5,16	16,44±4,45	-,345	,735

When the table is examined, a significant difference was found in reach-reach (0.000), y-balance right (0.002), y-balance left (0.000), plank (0.000), sit-up (0.000), fms (0.000) data. In the CG group, a statistically significant difference was found in reach-reach (0.000), y-balance right (0.000), y-balance left (0.000), plank (0.000), sit-up (0.000) data.

Table 3. SG ve CG fark ortalamalarının karşılaştırılması

Pre-Post Test	Group	N	Mean±Sd	t	p
Sit & Reach (cm)	**SG**	20	2,45±1,571	4,565	,000*
	CG	20	,750±,550		,000*
Y Balance-Right	**SG**	20	1,15±1,447	-1,054	,299
	CG	20	1,54±,862		,300
Y Balance-Left	**SG**	20	1,34±1,640	0,274	,786
	CG	20	1,22±1,041		,786
Plank (sec)	**SG**	20	15,10±8,807	6,778	,000*
	CG	20	1,55±1,538		,000*
Sit-up (count)	**SG**	20	6,00±3,308	5,944	,000*
	CG	20	1,35±1,136		,000*
FMS (score)	**SG**	20	2,30±1,688	5,136	,000*
	CG	20	0,00±1,076		,000*

When the table is examined, according to the pre-test and post-test results, there is a statistically significant difference in reach reach (t=4,565, p<.05), plank (t=6,778, p<.05), shuttle test (t=5,944, p<.05), FMS (t=5,136, p<.05), while there is no difference

for Y-balance test right foot (t=-1,054, p>.05), Y-balance left foot (t=0,274, p>.05). The differences found were in favor of the research group.

DISCUSSION AND CONCLUSION

The aim of this study was to determine the effect of core strength training on fms scores in tennis athletes. The mean age of the core strength group was 15,15±0,81 years, body weight 42,36±2,21 kg and height 140,25±8,41 cm. The mean age of the control group was 14,87±0,88 years, body weight was 42,63±1,96 kg and height was 138,81±7,91 cm. As a result of the independent sample t test, a statistically significant difference was found for reach and reach (t=4,565, p<.05), plank (t=6,778, p<.05), shuttle test (t=5,944, p<.05), FMS (t=5,136, p<.05), while there was no difference for Y-balance test right foot (t=-1,054, p>.05), Y-balance left foot (t=0,274, p>.05). The differences found were in favour of the research group. In the study conducted by Arı and Çolakoğlu (2021), the effects of core training programme applied in addition to technical training on strength parameters in tennis athletes were investigated. Within the scope of the study, the control group participated only in the technical training programme, while the tennis players in the experimental group participated in an 8-week core training programme. At the end of the study, it was determined that tennis players in the experimental group showed a higher increase in abdominal muscle strength, hand grip strength and lower extremity strength compared to the control group.

In the study conducted by Kara and Çelik and Kara (2021), it was aimed to investigate the effects of core training on strength performance in tennis athletes. Forty elite tennis players participated in this study. Elite tennis players in the experimental group participated in core training, while tennis players in the control group participated in the technical training model. Tennis players in both groups continued their training programmes for 12 weeks. At the end of the study, it was determined that the tennis players in the experimental group showed a higher level of improvement in push-ups, hand grip strength and back strength performances compared to the tennis players in the control group. In the study conducted by Eren (2019), it was aimed to examine the effects of core training applied in addition to the technical training programme on motor performance parameters in female and male tennis players. In this study, tennis players

in the control group participated in a technical training programme and tennis players in the experimental group participated in a core training programme. The training programmes of both groups continued for 8 weeks. At the end of the study, it was determined that vertical jump performance, which is an indicator of lower extremity strength, was higher in favour of tennis players in the core training group. In the study conducted by Doğruöz (2019) on tennis players, it was aimed to examine the effects of core training on the development of upper extremity muscle strength. In this study, which was conducted with experimental and control groups, it was found that the improvement in upper extremity strength in tennis players who participated in core stabilisation training was higher than the tennis players in the control group. In the study conducted by Çakır (2021), it was aimed to examine the effects of core training applied to athletes on physical and motor performance parameters. Within the scope of the study, 8 weeks of core training was applied to female handball players. At the end of the training programme, it was determined that there were significant improvements in leg strength, plank, back strength, push-up and sit-up performances of the athletes. In the study conducted by Tunç (2018) on tennis players, it was aimed to examine the effects of core training on the development of muscle strength. In this study conducted on tennis players in the 12-14 age group, it was determined that core training improved strength performance more compared to traditional tennis training. According to the results obtained, significant improvement was observed in both lower and upper extremity muscle strength performance in tennis players in the core training group. In Eren's (2019) study, the effects of core training applied in addition to the technical training programme on the motor performance components of male and female tennis players were examined. In the study, tennis players in the control group participated in the technical training programme and tennis players in the experimental group participated in the core training programme. The training programmes of both groups continued for 8 weeks. In the study conducted by Bilici and Selçuk (2018) on female volleyball players, it was aimed to examine the effects of participation in core training on strength performance. The study was carried out on athletes aged 14-16 years. Within the scope of the study, athletes participated in 10-week core training. At the end of the study, it was determined that there was a significant increase in the lower and upper

extremity muscle strength of the athletes participating in core training, and a performance increase was also observed in the trunk muscles of the athletes. In the study conducted by Başköy (2017), it was aimed to investigate the effects of core training on upper extremity muscle strength and service throw in tennis players. Within the scope of the study, a higher level of improvement in upper extremity muscle strength was observed in tennis players who participated in core training compared to athletes who applied traditional tennis training, and it was determined that this improvement positively affected the serve throw performance. In the study conducted by Kır (2017), it was aimed to investigate the effects of core training on the development of strength performance in young tennis players. Within the scope of the study, tennis players in the control group performed technical tennis training according to the traditional training model, while tennis players in the experimental group participated in core training. The trainings applied by both groups continued for 10 weeks. At the end of the study, it was determined that there were significant differences in squat jump and vertical jump performances, which are indicators of lower extremity strength, in favour of the tennis players in the core training group. In the study conducted by Söğüt (2009), the effects of core training on tennis-related performance parameters in male and female tennis players were investigated. Fourteen tennis players aged 13-15 years participated in the study and were included in sport-specific core training.

At the end of the study, significant increases were found in the lower and upper extremity strength performances of tennis players when compared with the performance tests taken before core training. In the study conducted by Gür (2015), the effect of core training on strength performance in tennis players and the effects of strength increase in core muscles on balance performance in athletes were investigated. As a result of the research, it was determined that core training supported the increase in strength in core muscles and this increase increased dynamic and static balance performance in tennis players. In the study conducted by Çalışkan (2014), the effects of lower and upper extremity strength training on strength performance of tennis players were investigated.

In the study, it was determined that tennis players who participated in upper and lower extremity strength training had a greater increase in sit-up and upper extremity muscle strength compared to the group that applied traditional tennis training.

Shinkle and friends (2012) examined the effect of core training on strength performance in football players. As a result of the study, significant increases in lower extremity muscle strength performance and push-up performance were observed in athletes participating in core training. In various studies in the literature, it has been reported that different training models increase strength development in tennis players. These studies support that applying core training or different strength development programmes in addition to technical skill training can improve strength performance (Sannicandro et al., 2014; Fernandez-Fernandez et al., 2016).

In tennis, serving is a critical part of the game and having a powerful serve gives the player a significant advantage (Fernández-Fernández, 2016). A maximised serve is associated with a powerful movement and the quality of the kinetic chain that performs this movement (Urartu, 1996). When looking at the kinematics of the serve, body stabilisation, lumbopelvic and core regions play an important role in the serve and help to effectively perform the movements inherent in the serve by providing power development, distal mobilisation and proximal stabilisation (Kovacs & Ellenbecker, 2011). In addition, a good level of body stabilisation helps to reduce the risk of possible injuries (Hibbs et al., 2008). In a study conducted by Başköy in 2018, 24 tennis players between the ages of 12 and 19 were firstly subjected to anterior and lateral abdominal strength tests and tests evaluating the angular velocities of the lower and upper body, and the racket speed values in contact with the ball were recorded. Then, the athletes participated in a lumbo-pelvic stabilisation training programme consisting of 5 levels and lasting 5 weeks. At the end of the training programme, the athletes were again administered the pre-tests. The results showed that at the end of the lumbo-pelvic stabilisation training, the athletes showed an increase in the tests and supported the idea that it positively affected the service speed by increasing the contact speed of the racket with the ball (Başköy, 2018).

In another study, 24 female handball players with an average age of 16 were divided into two groups, a study group of 14 and a control group of 10. Both groups were asked to shoot from a distance of 7 meters and their shooting speeds were measured. The study group practiced core training twice a week for 6 weeks. This training focused on the stability of the rotational position of the body along with basic

core practices. After the core training, the firing rates were measured again and no change was observed in the control group, while the mean firing rate of the study group increased. The results of the study indicated that the lumbo-pelvic region may affect performance by contributing to the rotational velocity of the body and that core stabilization training may have an effect of increasing the firing rate (Saeterbakken et al., 2011).

Okada et al. included 28 male and 28 female participants with a mean age of 24.4 years, who practiced various sports as a hobby and had no injury problems. The aim of the study was to investigate the relationship between core stabilization and functional movement analysis test. However, no correlation was found between core stabilization and functional movement analysis test. One interpretation suggested that people with a strong core musculature may score low on the functional movement analysis test and people with a weak core stabilization structure may do well on the functional movement analysis test. Another interpretation stated that the explanation of the relationship between performance and functional movement analysis and core stabilization is complex (Okada et al., 2011). In their study, Chorba and colleagues (2010) suggested that Functional Movement Analysis (FMA) can be used to predict injury based on a larger sample, including female athletes in sports where the upper extremity is used more intensively. They also stated that FMS may function as a predisposing factor for injury in women. Kiesel and colleagues (2007) found that lower FMS scores predicted significantly higher injury risk in professional soccer players. This study was one of the first to explore the possible predictive value of FMS. The value of this screening test was quickly recognized and widely adopted in major organizations such as the National Football League.

Recommendations

- Adding research examining the effects of core training on the technical skills of tennis players,
- Increasing studies on technical parameters such as service hit rate, service speed, forehand and backhand hitting performance,
- It is recommended to examine performance changes across different age groups and during preparation and competition periods.

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