African Educational Research Journal
Vol. 8(2), pp. 314-321, June 2020
DOI: 10.30918/AERJ.82.20.067
ISSN: 2354-2160
Full Length Research Paper

Analysis of the influence of lower and upper extremity strength on shot styles in tennis

Mustafa Said Erzeybek[1]*, Adnan Ersoy[1], Zehra Gözeltepe[2] and Fatih Kaya[3]

[1]Physical Education and Sports Department, Kütahya Dumlupınar University, Turkey.
[2]Faculty of Physical Education and Sports, Niğde Ömer Halisdemir Üniversitesi Niğde, Turkey.
[3]School of Physical Education and Sports, Erzincan Binali Yıldırım University, Erzincan, Turkey.

Accepted 1 June, 2020

ABSTRACT

The aim of this study is to investigate the influence of lower and upper extremity strength on shot styles in tennis. 54 males and 19 females training regularly as experimental group and 24 male and 9 female volunteers as control group participated in the study. 24 training sessions were applied to the experimental group participants. Every week in a unit training, accurate and effective shot, practically forehand and backhand, was applied to the subject suitable for the technique and style by shooting 50 balls from the ball machine. The service was performed for each subject from the service point on the baseline line of the court in 20 units in one unit training. Maximum number of heart 30 to 50% of the beats were allocated for 10 min of general warming, and 70 to 80% of the maximum number of heart beats were allocated for quick strength; moreover, practices towards upper and lower extremity were applied beforehand and finger strength trainings. Voluntary participants in the control group were not subjected to any training program. Paired t-test was used for intra-group comparisons in the analysis. Two-way ANOVA was used to compare pre-test and post-test changes in groups with gender effect. Mean and standard deviation were used as descriptive statistics. Significance was determined as $p \leq 0.05$. In conclusions, effective service training should be supported with a good ball thrower and effective material. Therefore, this study is important in terms of evaluating the effect of the tennis ball thrower on the performance of the athletes to correct the shoot techniques and improve their performance.

Keywords: Tennis education, lower and upper extremity, grip, strength.

*Corresponding author. E-mail: msaid.erzeybek@dpu.edu.tr.

INTRODUCTION

In addition to being a popular racquet sport in recent years, tennis has become a branch dominated by new perspectives. In terms of tennis game character, rapid start and stop, repetitive movements, multiple strokes are associated with multiple different muscle groups, short-term periods (ball stroke stage) close to maximal violence, long-term periods (total match duration) are moderate to low intensity activities (Abrams et al., 2011). Forehand, backhand and service development, basic techniques used in tennis, are very important (Kellor et al., 1971). One of the techniques that are completely individual in the tennis game is the service. In order to increase the speed of the racket and ball during the service, the upper limbs should be very strong. The upper limbs must be very strong, flexible and co-ordinated to produce a high speed (Kibler et al., 2007; Reid et al., 2007). It is very important to have the highest strength and technical capacity during the game. Therefore, new approaches and training models to improve service speed are planned and implemented. One of these methods is submaximal strength in addition to accuracy and flexibility trainings. The components necessary for demonstrating high performance in matches are as follows; combination of strength, durability, flexibility and technical features (Pugh et al., 2003). The tennis game is a sport that encompasses the special strength training

features that many energy systems need to be developed (Reid et al., 2007a). The main goal in the tennis game is to hold the ball in the game and to do effective, strong and economic strokes and movements. There are four regions in the tennis ball that determine the technique and strategies of the ball. These are bottom line, ¾ court, middle court and the front of the file. All strokes vary according to these regions. Strength is a very important parameter for performance in tennis sport and it can be seen as an expression of the amount of performance in a certain period. The lower extremity strength allows the ball to reach the ball as soon as possible, while the strength of the upper extremity can hit the balls more quickly during the match. A robust and accurate racket grip prevents the injury of the wrist and elbow, and ensures the use of rackets and, in particular, the racket balance in off-center strokes (Reid et al., 2007). Competitive players playing in the performance tennis have to improve their physical requirements, in other words, strength, speed, strength, flexibility and muscular durability in order to be successful (Reid and Schneiker, 2008; Kovacs and Ellenbecker, 2011). Nowadays, especially strength development is as important as strength and speed for continuity during tennis game (Abrams et al., 2011; Cardoso, 2005). Strength training includes different training methods (resistance rubbers, health ball exercises and light weights and dumbbell exercises). Service speed development can be achieved with these training methods (Fernandez, 2013; Treiber et al., 1998). In terms of sportive performance, the right technical sub-extremity hand grip, finger strength, combining with the racket grip will increase the percentage of accurate stroke and for this reason in a game of tennis, especially in the game to win the game of the opponent's set is known to win the set and even match. However, effective hand grip strength and finger strength are known to be effective in basic and strategic strokes in terms of strokes dynamism. It is thought that this activity will contribute to the athletes' stroke and severity activity with the balls to be taken in different intensities and styles. Tennis sports is an individual sports branch that pushes the limits of the technical, tactical, physiological and psychological abilities of the human and the physical, mental, emotional and social characteristics of the athlete when it is planned and programmed. In the tennis game, the athletes achieve optimal performance and are in good condition as a physical condition in order to be successful (Reid and Schneiker, 2008). In the tennis sport, besides the high anaerobic and aerobic strenghts, it is necessary to be strong in the muscles forming the force (Chu, 1995; Ferrauti and Maier, 2002; Zorba, 1993).

The tennis player is expected to move in all possible directions. If the position cannot be got at the required time in the field, the ball cannot be hit well. Tennis sport is a game that can be played on different courts such as soil, hard and grass courts and with its characteristic features, sudden and fast start and stop and repetitive sprint runs. Tennis is also a game that involves maximal or maximal close-up activities with different muscle groups working together, with the same movements being repeated (forehand and backhand strokes) (Cooke and Davey, 2005). The aim of this study is to investigate the influence of lower and upper extremity, hand grip and finger strength on shot styles in tennis. It is thought that the data obtained by applying the pre and post-test model to the new master university students in tennis, assuming that the effect of speed, speed, direction change and continuity of the force on the stroke styles, ball kick performance and again effective service winning in tennis sport is also very important factor. This study is deigned to assess the hypothesis that lower and upper extremity strength will affect the shot and the performance of tennis players.

MATERIALS AND METHODS

Participants

The research universe is adult male and female tennis players who have just started tennis in the borders of Dumlupinar University School of Physical Education and Sports in Kütahya. In order to investigate the effect of 12 weeks of lower and upper extremity, 54 males and 19 females training regularly as experimental group and 24 male and 9 female volunteers as control group participated in the study strength on strokes styles, the mean age of the experimental group was 22.05 years, the mean body weight was 72.28 kg and the mean height was 175.31 cm. and the mean age of the control group was 22.45 years and the mean body weight was 69.48 kg and the mean height was 173.50 cm, and the experimental group was determined as 73 experimental group.

The subjects were informed about the test at least one day before the measurements. Voluntary participation in the tests was provided by giving information about the absence of any health hazards of the tests applied to the subjects and their approval with minimum informed consent form.

The day before the assessments, the participants were informed about the test and were told that the tests would cause no problems for their health. The study implemented pre-test and post-test protocol. Pre-test assessments were performed 72 hours before initiating the training protocols, and after that, training protocols were implemented. During training, no measurement was taken. Post-test measurements were performed with in the week when the training protocol was completed. The participants attended the training protocol on a regular basis and none of them missed a training session.

The participants were asked to continue their routine diet throughout the study, and no participant took ergogenic

aids that could affect training and assessment results or cause a change in performance. 48 hours before test days, the participants stopped to take food or liquid supplements containing alcohol, caffeine or intense stimulants.

Measurements and tests

It was determined that there were no health conditions in terms of pre-conditions of participation in the tests. Warming was applied for 10 min prior to measurements. During the measurements process the test subjects were provided complete rest between measurements. Detailed information was given to the subjects before starting the test.

Hand grip strength measurement

Takkei brand hand dynamometer was used to measure hand grip strength (Tamer, 2000). Tested twice for both hands and the best score was recorded (Figure 1).

Figure 1. Hand grip strength measurement.

Measurement of shoulder strength

The measurements were made using Takkei brand back dynamometer (Özer, 2001). Test protocol for shoulder force was performed twice and the best score was recorded (Figure 2).

Figure 2. Shoulder strength measurement.

Leg strength measurement

The measurements were made using the Takkei brand leg dynamometer (Fernandez et al., 2006). Test protocol for leg strength was done twice and the best score was recorded (Figure 3).

Measuring finger strength

The finger grip strength will be measured with the pinch meter (Baseline) held between the thumb and the index finger (Abrams et al., 2011; Zorba, 1993). The test protocol was performed twice for both finger strength and the best score was recorded (Figure 4).

The first pre-training strength values will be determined from the participants. After 10 weeks, the above measurements were revaluated.

Figure 3. Leg strength measurement.

Training program

Participants in the experimental group participated in tennis training on Monday, Wednesday and Friday of the

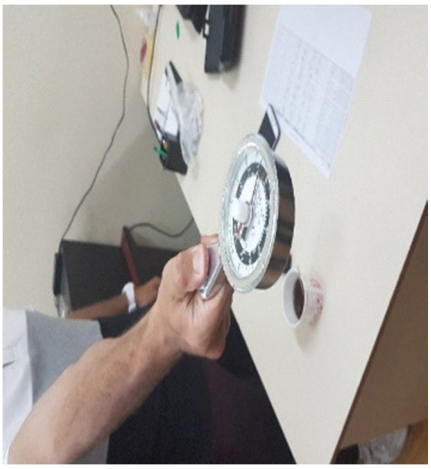

Figure 4. Finger strength measurement.

Figure 5. The distribution pattern of remote control tennis ball throwing machine.

week. In the remaining days, they were included in the strength training program on Tuesday, Thursday and Saturday. The participants in the control group continued their normal routine lives.

Tennis education program

The tennis ball throwing machine was used effectively. It is possible for the balls to hit 20 different points on the tennis court due to the remote control feature of the tennis ball throwing machine (Figure 5). Shot for the correction of styles in education 50 tennis balls were thrown from the throwing machine to the court in the form of randomise, slice, spin, lobe, short and deep. The participants were asked to make a forehand and backhand with a tennis racket for each of the 50 throwing balls according to their standing positions on the field. Subsequently, the services were carried out as 20 services in one unit training for each participant from the service point on the baseline line of the court. Tennis training was applied for three days a week throughout a total of 12 weeks. General and special warming for 15 min before tennis training and 10 min of cooling afterwards were carried out. The experimental and control groups that participated in the study participated in the tennis training protocol mentioned above. (Figure 6)

Strength training protocol

Experimental group athletes applied the following strength training program after 30 to 50% of their maximum heart rate and 15 min of general and special warm-up. Following 70 to 80% of the maximum heart rate, rapid strength training, and strength exercises for upper and lower extremities, and also training for hand and finger strength were applied. Volunteer participants in the control group were not subjected to any training program. Participants in the experimental group completed 1a-Squat, 1b-Side Toss, 2a-Explosive Leg Press, 2b-Resistance Band Rotation Up, 3a-Walking Lunge, 3b-Resistance Band Rotation Side movements (Figure 7) as a super set before ending the training protocol with the 4th Hand Strengthening (Figure 8). In the exercises performed as a super set, 1 minute rest was given between two same number exercises and 2 to 3 min rest was given between the sets. Each double super set exercises are applied as 3 sets. When the dual super set exercises were completed, station 4 was applied. At the end of the program, 10 min of cooling was carried out.

1a. Squat: The Olympic Bar was loaded with a weight that you can do 10 repetitions with 50% of the maximum repetition and controlled the descent part of the movement in an explosive way.

1b. Side toss: A 1-2 kg health ball was used. The athlete, with arms stretched, the body rotated and the knees bent from the bent position and the body was upright, threw the ball against the wall. The athlete contributed to the rotation by turning on the toes behind to put into effect more hip strength. After finishing 12 repetitions on the right side and the athlete passed to the other side.

2a. Explosive leg press: In the leg press machine, a weight that you can do 10 repetitions with 50% of the maximum repetition was loaded and landing part of the explosive exercise was carried out in a controlled manner. 1st and 2nd week load intensity was started with 50% of 1 Maximum repeat. The loading intensity was increased by 5% every two weeks.

2b. Cable down-up twist: Cable cross machine was loaded with a weight that you can do 10 repetitions with 50% of 1 maximum repetition and landing part of the explosive exercise was carried out in a controlled manner. Week 1 and Week 2 load intensity started with

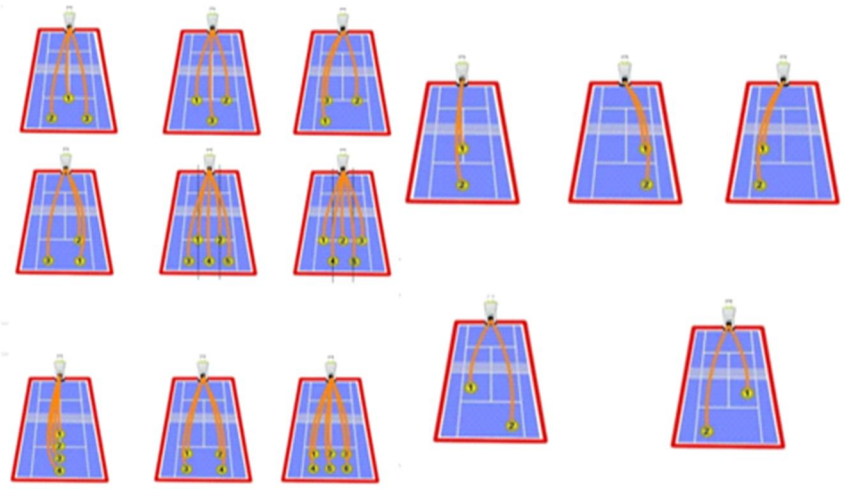

Figure 6. Shoot exercises with tennis ball throwing machine.

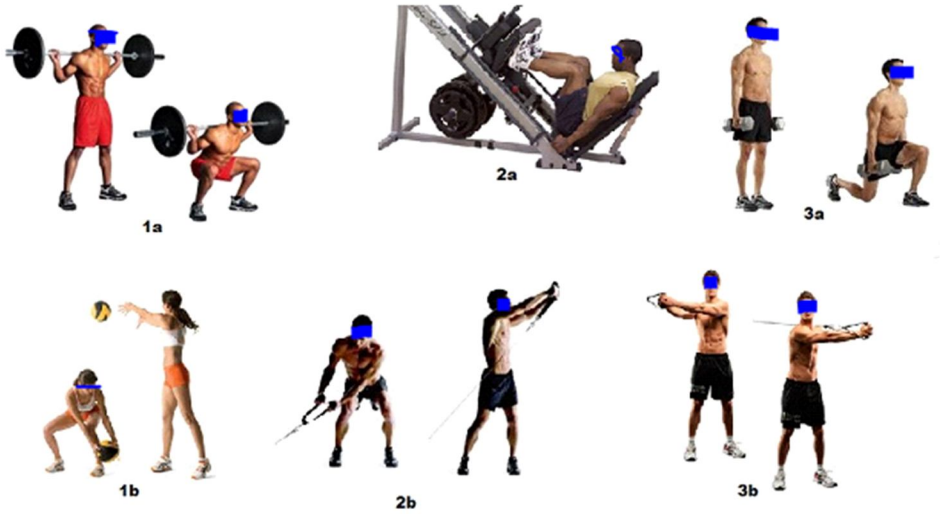

Figure 7. Lower extremity and trunk rotation exercise.

Figure 8. Hand strengthening exercise.

50% of Maximum repetition. The loading intensity was increased by 5% every two weeks. After finishing 12 repetitions on the right side and the athlete passed to the other side.

3a. Walking lunge: A long step forward was taken with dumbbells in each hand, and the knee in front was bent to 90 degrees. From this point, the body was pushed upwards and forward, by stepping forward the other leg, and the athlete continued to step and in total 12 steps were taken. 1st and 2nd week loading intensity of dumbbells was started with 50% of 1 Maximum repetition. The loading intensity is increased by 5% every two weeks.

3b. Cable twist: Cable cross machine was loaded with a weight that you can do 10 repetitions with 50% of 1 maximum repetition and landing part of the explosive exercise was carried out in a controlled manner. Week 1

and Week 2 load intensity started with 50% of Maximum repetition. The loading intensity was increased by 5% every two weeks. After finishing 12 repetitions on the right side and the athlete passed to the other side.

Hand strengthening

In order to improve hand grip and fingers resistance, a 30-s exercise was applied to the right and left hand with an apparatus made of rubber material. A total of 30 s × 3 sets of programs were carried out for each hand. 30 to 45 s rest was given between sets.

FINDINGS

Paired t-test was used for intra-group comparisons in the analysis. Two-way ANOVA was used to compare pre-test post-test changes in groups with gender effect. Mean and standard deviation were used as descriptive statistics. Significance was determined as $p \leq 0.05$

As shown in Table 1, the mean age of the experimental group was 22.05 ± 2.09 years, the mean body weight was 72.28 ± 13.22 kg and the mean height was 175.31 ± 9.54 cm. and the mean age of the control group was 22.45 ± 2.48 years and the mean body weight was 69.48 ± 11.34 kg and the mean height was 173.50 ± 5.82 cm, and the experimental group was determined as 73 experimental group.

As shown in Table 2, the results of the pre-test post-test hand left and leg strength scores of the experimental group were not statistically significant ($p > 0.05$), but other variables were significantly different ($p < 0.05$). Accordingly, the pinch left, pinch right, hand, and shoulder strength scores of the experimental group were significantly increased from pre-test to post test. In the control group, no statistically significant difference was found between pre-test and post-test ($p > 0.05$).

While the pre-test and post-test AOS score and AOS grade scores of the experimental group changed statistically significantly ($p < 0.05$), there was no statistically significant difference in the control group ($p > 0.05$) (Table 3). (https://www.ttf.org.tr, 2019)

Table 1. Demographic features.

Group		Height (cm)	Bodyweight (kg)	Age (year)
Experimental n=73	Mean (Sd)	175.31 ± 9.54	72.28 ± 13.22	22.05 ± 2.09
Control n=31	Mean (Sd)	173.50 ± 8.76	69.48 ± 11.34	22.45 ± 2.48
Total N=104	Mean (Sd)	174.77 ± 9.31	71.45 ± 12.70	22.17 ± 2.21

Table 2. Pre-test and post-test changes after 10-weeks strength and tennis mainstroke training program in groups.

		Pre-post differences		t	df	P
		Mean	Std. deviation			
Experimental n=73	Pinch left pre-1 – pinch left post-2	-1.09	1.41	-6.583	72	.000
	Pinch right pre-1 – pinch right post-2	-1.10	1.85	-5.052	72	.000
	Hand left pre-1 – hand left post-2	-0.98	5.05	-1.664	72	.100
	Hand right pre-1 hand right post-2	-2.88	3.99	-6.175	72	.000
	Shoulder pre-1 – shoulder post-2	-4.97	18.15	-2.338	72	.022
	Leg pre-1 – leg post-2	-1.60	11.55	-1.180	72	.242
Control n=31	Pinch left pre-1 – pinch left post-2	0.09	0.59	.825	30	.416
	Pinch right pre-1 – pinch right post-2	0.46	1.51	1.683	30	.103
	Hand left pre_1 – hand left post-2	0.46	1.75	1.450	30	.157
	Hand right pre-1 – hand right post-2	0.40	2.14	1.033	30	.310
	Shoulder pre-1 – shoulder post-2	2.07	7.66	1.502	30	.143
	Leg pre-1 – leg post-2	2.47	14.26	.965	30	.342

Table 3. Pre-test and post-test AOS (evaluation of field and tennis playing skills in tennis) scores and changes after 10-weeks strength and tennis main stroke training program in groups.

		Mean	Std. deviation	T	df	P
Exp.	AOS pre point – AOS post point	-20.79	32.03	-4.726	52	.000
	AOS pre grade – AOS post grade	0.47	.90	3.064	33	.004
Cont.	AOS pre point – AOS post point	8.42	43.60	1.110	32	.275
	AOS pre grade – AOS post grade	-0.78	1.20	-1.941	8	.088

DISCUSSION

In recent years, many different types of strength programs and techniques have been tried for service, which is the subject of many scientific studies and which are generally the basic and effective strokes of the tennis game, on which all the coaches persist. However, a certain type of loading has not yet been accepted by all authorities (Girard and Millet, 2009). 10-week strength training and tennis basic strokes and the use of service training in the upper and lower extrusion, hand grip and finger-strength impact styles on the study called the examination of the pre-test in the comparison of tennis players in the pre-test, the final test of the experimental group between the results of a significant differences were found.

In a similar study by they examined the effect of different training methods on the speed and accuracy of service and they determined that different trainings increase service speed (Gullikson, 2003).

In a study to determine the effect of 4-week resistance training with resistance to light weight on service speed at the maximum service speed (+6.0% compared with -1.8%) and the average speed (+7.9% compared with -2.3%) significantly increased. In both evaluations, it was reported that the maximum service speed and average service speed increased in men. This study in the literature is in terms of similar strength requirements in our 12-week study, especially in terms of both finger strength, dominant hand and shoulder strength with the increase in the appropriate tennis forehand, backhand and service. The increase in the hitting ratio with the studies specific to the strokes revealed that they had a significant improvement in the result of the tennis-specific AOS test (Szymanski et al., 2004)

It was also reported that the speed of service was significantly improved at the end of the study, which examined the effects of the 6-week resistance rubber, core training and health ball exercises on the speed of service in young tennis players. This study, which is parallel to our study, is determined from the statistical point of view of the fact that the upper extrusion force trainings have positively made the service throwing and service to the effective box. The service shot is generally considered to be the most important shot in tennis training programs, however it is predicted to increase speed and hit rate (Abrams et al., 2011).Individual skills can also play an important role in the increase of game play of tennis players (Kovacs and Ellenbecker, 2011).

Since the upper limb kinematics is similar in both service throw and launch technique, strength training will be positively affecting performance for both cases. For this reason, it is very important to determine the strength training for the purpose and to design it as the developer of the service shot (Chow et al., 2009; Elliott, 2006; Ryu et al., 1988). In our 12-week study, especially the tennis-specific upper and lower extrusion force is supportive and enhancing the effective service rate as indicated in this study.

Fast and powerful upper extremities to increase the speed of the racket and the ball during tennis serve positively affect the performance. Upper extremity strength, flexibility and nerve-muscle coordination are required for high power production (Pugh et al., 2003; Kermen, 2002).

In the literature, there are numerous training programs to improve sport performance, and training models to improve sport performance often take into account strength, strength and speed exercises (Mathiowetz et al., 1984). According to tennis sports involves repeated high intensity exercises. The athletes' muscle strength, muscular balance and angle of movement of the joint will give information about the strengths and weaknesses of the players (Bompa, 2007).

However, in the literature, limited number of studies on the subject, especially hand grip finger force combined with the racket grip, it is thought that the lack of sufficient literature on effective shrinkage with the participation of the force of lower extremity contributes to the literature by completing the study. Our study, especially the lower and upper extremity strength can contribute to the performance and style of the strokes of athletes engaged in tennis sports and in this regard will contribute to the effective play of senior tennis athletes.

Conclusions

This study is important for evaluating the effect of intense tennis ball stroke and strength training on physical and accurate impact performance of athletes. In this study, which will be done in this direction, it is aimed to

contribute to the tennis coaches and literature in this field by combining hand grip strength, finger force, lower extrusion force with intense ball stroke training. As a result, effective stroke trainings can be achieved with a good ball thrower and material possibilities. The effective force training to be performed triggers accurate effective strokes with the repeated technical traits and force, so more effective international athletes can be provided with the right training and the right equipment.

Therefore, this study is important in terms of evaluating the effect of the tennis ball thrower on the performance of the athletes to correct the stroke techniques and improve their performance. It is inevitable to use the most effective training method and training tools in order to increase the performance values of the athlete at any time. The contribution of the ball throw machine, which is produced depending on the technological developments, on the stroke will both positively affect the performance and increase the self-confidence of the trainer and the athlete. Forehand, backhand and service strokes, which are advanced main strokes, should be given as the basic education and training program required by level, Later on, it will be supported by motor-enhancing exercises such as strength, quickness, speed and flexibility. The most effective training method and the use of training tools are an inevitable fact especially for strength development in order to increase the performance values of the athlete at any time

REFERENCES

Abrams, G. D., Sheets, A. L., Andriacchi, T. P., and Safran, M. R. (**2011**). Review of Tennis Serve Motion Analysis and The Biomechanics of Three Serve Types With Implications for Injury. Sports Biomechanics, 10: 378–390.

Bompa, T. O. (**2007**). Antrenman Kuramı veYöntemi. Spor Yayınevi, 325-27.

Cardoso, M. M. (**2005**). Strength training in adult elite tennis players. Strength and Conditioning Journal, 27: 34–41.

Chow, J. W., Park, S. A., and Tillman, M. D. (**2009**). Lower trunk kinematics and muscle activity during different types of tennis serves. Sports Medicine, Arthroscopy, Rehabilitation, Therapy and Technology, 13(1): 24.

Chu, D. A. (**1995**). Power tennis training. Human Kinetics Champaign; p. 7-15, 33-45.

Cooke, K., and **Davey**, P. R. (**2005**). Tennis ball diameter: the effect on performance and the concurrent physiological responses. Journal of Sports Sciences, 23(1): 31-39.

Elliott, B. (**2006**). Biomechanics and tennis. British Journal of Sports Medicine, 40: 392-396.

Fernandez, F.J., Ellenbecker, T., Sanz-Rivas, D., Ulbricht, A., and Ferrauti, A. (**2013**). Effects of A 6-week junior tennis conditioning program on service velocity. Journal of Sports Science and Medicine, 12: 232–239.

Fernandez, J., Mendez-Villanueva, A., and Pluim, B. M. (**2006**). Intensity of tennis match play. British Journal of Sports Medicine, 40: 387-391.

Ferrauti, A., and **Maier**, P. (**2002**). Weber K. Tennis training. Meyer und Meyer Verlag; p. 11-25, 121-138, 185-199.

Girard, O., and **Millet**, G. P. (**2009**). Physical determinants of tennis performance in competitive teenage players. Journal of Strength and Conditioning Research, 23: 1867-1872.

Gullikson, T. (**2003**). Teniste Fiziksel Uygunluk Testleri. Çeviri Yavuz Yarsuvat B. Spor Araştırmaları Dergisi, 7(1): 135–56.

https://www.ttf.org.tr/assets/files/AOS_TESTI_UYGULAMA_PROSEDURU.pdf Date of access: 15.02.**2019**.

Kellor, M., Frost, J., Silberberg, N., Iversen, I., and Cummings, R. (**1971**). Hand strength and dexterity. The American Journal of Occupational Therapy, 25(2): 77-83.

Kermen, O. (**2002**). Tenis, Teknik ve Taktikleri. Nobel Yayınları, Ankara, 3-10.

Kibler, W. B., Chandler, T. J., Shapiro, R., and Conuel, M. (**2007**). Muscle activation in coupled scapulohumeral motions in the high performance tennis serve. British Journal of Sports Medicine, 41(11): 745-749.

Kovacs, M. S., and **Ellenbecker**, T. S. (**2011**). A performance evaluation of the tennis serve: implications for strength, speed, power, and flexibility training. Strength and Conditioning Journal, 33(4): 22-30.

Mathiowetz, V., Weber, K., Volland, G., and Kashman, N. (**1984**). Reliability and validity of grip and pinch strength evaluations. Journal of Hand Surgery, 9(2): 222-226.

Özer, K. (**2001**). Fiziksel Uygunluk, Nobel Yayın Dağıtım; p.61-194.

Pugh, S. F., Kovaleski, J. E., Heitman, R. J., and Gilley, W. F. (**2003**). Upper and lower body strength in relation to ball speed during a serve by male collegiate tennis players. Perceptual and Motor Skills, 97: 867-872.

Reid, M., and **Schneiker**, K. (**2008**). Strength and conditioning in tennis: Current research and practice. Journal of Science and Medicine in Sport, 11: 248–256.

Reid, M., Crespo, M., Lay, B., and Berry, J. (**2007**). Skill acquisition in tennis: Current research and practice. Journal of Science and Medicine in Sport, 10(1): 1-10.

Reid, M., Elliott, B., and Alderson, J. (**2007a**). Shoulder joint loading in the high performance flat and kick tennis serves. Br J Sports Med, 41(12): 884–889.

Ryu, R. K., McCormick, J., Jobe, F. W., Moynes, D. R., and Antonelli, D. J. (**1988**). An electromyographic analysis of shoulder function in tennis players. The American Journal of Sports Medicine, 16(5): 481-485.

Szymanski, D. J., Szymanski, J. M., Molloy, J. M., and Pascoe, D. D. (**2004**). Effect of 12 weeks of wrist and forearm training on high school baseball players. The Journal of Strength and Conditioning Research, 18(3): 432-440.

Tamer, K. (**2000**). Sporda Fiziksel Fizyolojik Performansın Ölçülmesi ve Değerlendirilmesi, Bağırgan yayımevi; p.130-131,139-140.

Treiber, F. A., Lott, J., Duncan, J., Slavens, G., and Davis, H. (**1998**). Effects of Theraband and lightweight dumbbell training on shoulder rotation torque and serve performance in college tennis players. The American Journal of Sports Medicine, 26(4): 510-515.

Zorba, E. (**1993**). Herkes için Spor ve Fiziksel Uygunluk., GSGM Yayınları; no: 149, s.96-159, 324- 443.

Citation: Erzeybek, M. S., Ersoy, A., Gözeltepe, Z., and Kaya, F. (2020). Analysis of the influence of lower and upper extremity strength on shot styles in tennis. African Educational Research Journal, 8(2): 314-321.