Journal of **S**ports for **A**ll and **R**ecreation
Herkes için Spor ve Rekreasyon Dergisi

2024, 6(3)
Araştırma Makalesi / Research Article

e-ISSN: 2687-6027

The Effect of Pilates Exercises on Eccentric Knee Flexor Muscle Strength (Nording Hamstring) and Bilateral Balance in Athletes

Pilates Egzersizlerinin Sporcularda Eksantrik Diz Fleksör Kas Kuvveti (Nordic Hamstring) ve Bilateral İnbalansına Etkisi

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ABSTRACT

The aim of this study was to investigate the bilateral strength asymmetry of the knee extensors and flexors, to determine the imbalance difference between the two legs, and to investigate the effect of 6 weeks of Pilates exercises on the strength of the hamstring muscles and the balance imbalance during the preparation process. In this study, a total of 23 professional soccer players were divided into two groups. Group 1 (soccer+Pilates) was asked to continue their routine soccer training (n=12), while group 2 (soccer) was asked to perform Pilates exercises for 25-30 minutes 3 days per week in addition to soccer training (n=11). After the athletes were anthropometrically measured (height, weight and BMI) and eccentric knee flexor muscle strength was determined using the NordBord (ValdPerformance, Australia) hamstring device, Pilates exercises were performed on the mat for 6 weeks prior to pre-season training and the same tests were performed again after the pre-season training period. Data were analyzed using the SPSS 24 package program at a significance level of p<0.05. The t-test for independent samples was used to compare the groups. According to the results, although there was a significant difference between the Pilates and soccer groups in the left max. Force (t=-2.096; p=0.048), there was a significant difference between the Pilates and soccer groups in Left Max. Strength (t=-2.947; p=0.008) and Right Max. Force (t=-2.509; p=0.020) on the posttest scores (t=-2.096; p=0.048). In addition, it was found that the Pilates group performed better than the soccer group with a mean difference of 3.91 on the posttest score for imbalance. As a result, Pilates training was found to make a significant difference in left Max. Force values and the post-test Left Max. Force and Right Max. Force values of the soccer players.

Anahtar Kelimeler: Pilates, Football, Nordic Hamstring, Sport

ÖZET

Bu çalışmanın amacı diz ekstansörleri ve fleksörlerinin bilateral kuvvet asimetrisini araştırmak, iki bacak arasındaki imbalans farkını belirlemek ve hazırlık sürecinde 6 hafta boyunca yapılan Pilates egzersizlerinin hamstring kas kuvveti ve denge inbalansı üzerindeki etkisini incelemektir. Bu çalışmada toplam 23 profesyonel futbolcu iki gruba ayrıldı. Grup 1'e (futbol+Pilates) rutin futbol antrenmanlarına devam etmeleri istenirken (n=12), grup 2'ye (futbol) futbol antrenmanlarına ek olarak haftada 3 gün, 25-30 dakika Pilates egzersizleri yapmaları istenmiştir (n=11). Sporcuların antropometrik ölçümleri (boy, kilo ve BKI) yapıldıktan ve eksantrik diz fleksör kas kuvveti NordBord (ValdPerformance, Avustralya) hamstring cihazı ile belirlendikten sonra, sezon öncesi hazırlık döneminden önce 6 hafta boyunca mat Pilates egzersizleri uygulanmış ve aynı testler hazırlık dönemi sonrasında tekrar yapılmıştır. Veriler SPSS 24 paket programı kullanılarak p<0.05 anlamlılık düzeyinde analiz edilmiştir. Grupların karşılaştırılmasında bağımsız örneklem t testi kullanılmıştır. Sonuçlara göre, Pilates ve futbol grupları arasında sol max. Kuvvet değerlerinde anlamlı bir fark olmasına rağmen (t= -2,096; p=0,048), son test skorlarında Pilates ve futbol grupları arasında Sol Max. Kuvvet (t=-2,947; p=0,008) ve Sağ Max. Kuvvet (t=-2,509; p=0,020) değerlerinde anlamlı bir fark bulunmuştur (t=-2,096; p=0,048). Ayrıca, Pilates grubunun son test imbalans skoru, futbol grubuna göre ortalama 3,91'lik bir farkla daha iyi performans gösterdiği bulunmuştur. Sonuç olarak, Pilates eğitiminin futbolcuların sol Max. Kuvvet değerlerinde ve son test Sol Max. Kuvvet ile Sağ Max. Kuvvet değerlerinde anlamlı bir fark yarattığı tespit edilmiştir.

Keywords: Pilates, Futbol, Nordic Hamstring, Spor

Citation: Yıldırım, S. (2024) The Effect of Pilates Exercises on Eccentric Knee Flexor Muscle Strength (Nording Hamstring) and Bilateral Balance in Athletes, *Herkes için Spor ve Rekreasyon Dergisi*, *6*(3), 363-369.

Gönderme Tarihi/Received Date: 02.09.2024

Kabul Tarihi/Accepted Date: 29.09.2024

Yayımlanma Tarihi/Published Online: 30.09.2024

https://doi.org/10.56639/jsar.1542541

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INTRODUCTION

Soccer is considered an interval sport, where aerobic and anaerobic exercises are used together and factors such as strength, speed, endurance, flexibility, agility, coordination, quickness and balance are intertwined, with game and movement analysis also required. Looking at these characteristics in general, strength, power and acceleration of the lower extremities are important performance components for soccer players (Dilber et al., 2016). Sprints, accelerations, decelerations and jumps are the most important movements performed quickly during the game of soccer (Taş et al., 2013).

Hamstring injuries, one of the most common injuries in soccer players, are undesirable in soccer. If this injury is not fully treated, it is likely to recur and recovery may be delayed. For this reason, the detection of health experts before the athlete makes his own statement and the preparation of a protective rehabilitation program in advance against the risk of a possible injury will pave the way to minimize the financial loss that occurs after the loss of range of motion due to hamstring muscle injuries of one of the players in the club (Şenel & Akyüz, 2010). Looking at both the total distance covered and the high-intensity activities performed in short bursts within the game, it is clear that soccer uses different energy systems in a common way (Bishop & Girard, 2013).

Bilateral strength asymmetry of the knee extensors and flexors is used in sports medicine to measure functional deficit after knee injury and/or surgery, to monitor the effectiveness of sports rehabilitation programs, and to decide whether an athlete is ready to return to competition (Yıldırım et al., 2022). If we take into account the need to think and act quickly, which is one of the requirements in soccer, i.e. the ability to make immediate decisions, we can say that the fast power function is a great advantage for the soccer industry (Aydın, Can, & Bayrakdaroğlu, 2023). When we consider the continuity of strength, it is important for soccer players to maintain their performance until the end of the game because the game of soccer is a long-term game (Phelps et al., 2023). The quadriceps/hamstring muscles, which are the most commonly used leg muscles in soccer players, as well as the strength and endurance generated by the upper body muscles, are important to maintain the athlete's performance at the highest level during the game (Weineck, 2011).

A high level of maximal strength capacity of the muscles of the lower and upper extremities is an important factor in preventing injuries in soccer players (Gurau et al., 2023). While coaches are trying to improve soccer players' performance, they also need to protect them from injuries that could keep them off the field. The intensity of training and competition schedules during the season leave little time for recovery for young athletes. Therefore, the training programs implemented by coaches at the beginning of the season should be of a quality that helps protect athletes' athletic performance and health (Diker et al. 2021).

Pilates is a complex exercise system that aims to strengthen the whole body by targeting the central muscle groups (core). The movements of this exercise system are low impact on the musculoskeletal system and aim to develop muscle strength as well as flexibility, balance and coordination (Sim, Kim, & Jeon, 2022). Pilates exercises contribute to the active work of the hamstring muscles through the combined use of isometric and isotonic exercises. In addition, these exercises activate the eccentric and concentric contraction cycle. This increases the strength of the hamstring muscles (Manzak et al., 2024). In addition, the hamstring muscles, which can be weaker than the quadriceps muscles, are strengthened with Pilates exercises and provide balance in the overall muscle ratio (Jandova & Bartizalova, 2024). Thanks to this balance, the hip and knee joints are stabilized and the risk of injury is reduced. Pilates increases the elasticity of the hamstring muscle group and the stretching potential of the muscle through intensive flexibility exercises. This increase enables the muscle to generate force over a greater range of motion (Tacchino et al., 2024).

In line with this information, this study was conducted to investigate the effect of Pilates exercises on eccentric knee flexor strength (Nordic hamstring) and bilateral imbalance in athletes. It is anticipated that the knowledge gained will make important contributions to the planning of training loads and programs for soccer players and can be used both in rehabilitation processes and in the design of training programs to enhance athletic performance.

METHOD

Research Design: The study was conducted in a pretest-posttest experimental design in two groups as study and control.

Research Group: In this study, a total of 23 professional footballers were divided into two groups. Group 1 (soccer+Pilates) was asked to continue their routine soccer training (n=12), while group 2 (soccer) was asked to do Pilates exercises for 25-30 minutes 3 days a week in addition to soccer training (n=11). The soccer players were selected according to specific health criteria and included in the study on a voluntary basis. Athletes with injuries and illnesses were not included in the study.

Table 1. 6 Week Pilates Exercise Program

Weeks	Training 1	Training 2	Training 3
1.week	Bridding/Pelvic Lift 2*8 Toe Touch 2*8 Side Leg Bananas (in both directions) 2*7 Hundred 2*10	Roll Up 2*7 Leg Circles (two legs separately) 2*7 Single Leg Stretch (two legs separately) 2*7 Double Leg Stretch 2*7	Single Straight Leg Stretch 2*7 Double Straight Leg Stretch 2*7 Criss Cross (two legs separately) 2*6 Double Leg Kick 2*6
2.week	Bridding/Pelvic Lift 2*8 Toe Touch 2*8 Side Leg Bananas (in both directions) 2*7 Hundred 2*10	Roll Up 2*7 Leg Circles (two legs separately) 2*7 Single Leg Stretch (two legs separately) 2*7 Double Leg Stretch 2*7	Single Straight Leg Stretch 2*7 Double Straight Leg Stretch 2*7 Criss Cross (two legs separately) 2*6 Double Leg Kick 2*6
3.week	Bridding/Pelvic Lift 2*8 Toe Touch 2*8 Side Leg Bananas (in both directions) 2*7 Hundred 2*10	Roll Up 2*7 Leg Circles (two legs separately) 2*7 Single Leg Stretch (two legs separately) 2*7 Double Leg Stretch 2*7	Single Straight Leg Stretch 2*7 Double Straight Leg Stretch 2*7 Criss Cross (two legs separately) 2*6 Double Leg Kick 2*6
4.week	Bridding/Pelvic Lift 2*8 Toe Touch 2*8 Side Leg Bananas (in both directions) 2*7 Hundred 2*10	Roll Up 2*7 Leg Circles (two legs separately) 2*7 Single Leg Stretch (two legs separately) 2*7 Double Leg Stretch 2*7	Single Straight Leg Stretch 2*7 Double Straight Leg Stretch 2*7 Criss Cross (two legs separately) 2*6 Double Leg Kick 2*6
5.week	Bridding/Pelvic Lift 2*8 Toe Touch 2*8 Side Leg Bananas (in both directions) 2*7 Hundred 2*10	Roll Up 2*7 Leg Circles (two legs separately) 2*7 Single Leg Stretch (two legs separately) 2*7 Double Leg Stretch 2*7	Single Straight Leg Stretch 2*7 Double Straight Leg Stretch 2*7 Criss Cross (two legs separately) 2*6 Double Leg Kick 2*6
6.week	Bridding/Pelvic Lift 2*8 Toe Touch 2*8 Side Leg Bananas (in both directions) 2*7 Hundred 2*10	Roll Up 2*7 Leg Circles (two legs separately) 2*7 Single Leg Stretch (two legs separately) 2*7 Double Leg Stretch 2*7	Single Straight Leg Stretch 2*7 Double Straight Leg Stretch 2*7 Criss Cross (two legs separately) 2*6 Double Leg Kick 2*6

Acquisition of data: The measurements of the study were carried out in the fitness center of the sports club. The athletes were informed about the study, including the possible risks and the necessary rules. Informed consent forms were completed and anthropometric measurements (height, weight and BMI) were taken on the same day. Then the Nordbord-Hamstring device system, the other instrument for data collection, was introduced and the preparation process and fitting for the measurements were taught. On the second day, the athletes were again present at the sports club's fitness center for the measurements and the measurements began after the test protocol was demonstrated again. Eccentric knee flexor strength was measured using the NordBord (ValdPerformance, Australia) hamstring machine and the data obtained was recorded as a pre-test. After completing the measurements, the athletes were given 6 weeks of mat Pilates exercises before the start of pre-season training. After preparation, the same tests were performed again and the data obtained was recorded as a post-test. During data collection, the same conditions prevailed for all athletes (e.g. constant temperature, shorts, T-shirt**).**

Height: The height of the soccer players was measured with a manual stadiometer without shoes and in shorts and T-shirt (Taş et al., 2011).

Body weight measurement: The body weight of the soccer players was measured with a Tanita Body Composition Analyzer BC418 device, barefoot and wearing thin clothing (Taş et al., 2011).

Eccentric knee flexor muscle strength: Measured with the NordBord (ValdPerformance, Australia) hamstring tester. The NordBord hamstring Tester assessed the athlete's hamstring muscle strength wirelessly and in real time using its advanced sensors. In the test protocol: Before the test, athletes were given a standard warm-up protocol (5 minutes of cycling at submaximal intensity, squats, 10 repetitions of forward lunges for each leg, 30 seconds of stretching and 2 repetitions of the Nordic hamstring exercise at low resistance). The person being tested was asked to stand on the plank in a kneeling position with both ankles attached to the hooks of the plank. The athlete was asked to swing forward as far as they could bear without flexing their hips and to fall onto their hands at the point they could no longer control. Maximal repetitions of bilateral northern hamstring exercises were encouraged for maximum effort during performance. Participants performed one set of three repetitions. The device provided real-time values for hamstring muscle strength in Newtons (N) for both legs and maximal force was evaluated. The NordBord (ValdPerformance, Queensland, Australia) hamstring device for measuring participants' eccentric knee flexor muscle strength provided a moderate to highly reliable method with an intraclass correlation coefficient (ICC) between 0.83 and 0.90 with a 95% confidence interval (Opar et al., 2013). The value of relative eccentric knee flexor muscle strength was calculated as the ratio of the maximum value of eccentric knee flexor muscle strength (N) (REDFKK) to body weight (kg) (Başkan & Kefal, 2023).

Figure 1. Nordic Hamstring measurements of soccer players with Nordbord device

Data analysis: The data analysis was evaluated in the SPSS 24 package program according to the significance level $p<0.05$. Descriptive statistical values were calculated for all variables. The values obtained from 23 soccer players were analyzed. The skewness left -0.05 rıghyt - 0.053 inbalance 1.489 kurtosis values left -0.113 right -0.586 inbalance 1.396 distribution was determined. When testing the normality of the data, it was found that the values for skewness and kurtosis were less than ± 1.5, so that the t-test for independent samples, one of the parametric tests, was used to compare the groups.

Ethics of Research: Ethics committee approval was obtained from Manisa Celal Bayar University Non-Interventional Clinical Research Ethics Committee (decision date: 20.12.2023 decision no: 20.478.486/2145).

FINDINGS

Table 2. Demographic Information of the Groups

		n	Min.	Max.	Mean+ Std. Deviation
Age (years)	Group 1	12	18	32	25±5,24
	Group 2	11	18	32	24,0±5,0
Height Length (kg)	Group 1	12	169	188	178,7±5,03
	Group 2	11	171	189	181,5±5,56
Body Weight (kg)	Group 1	12	63.5	79,4	72,6±5,14
	Group 2	11	66	85,9	77,0±6.74

Group 1: (Football Training); Group 2: (Football Training + Pilates Exercise)

Table 2 shows that the age of the athletes participating in the study in group 1 was 25±5.24 (years), the height was 178.7±5.03 (cm) and the average body weight was 72.6±5.14 (kg), while the age of group 2 was 24.0±5.0 (years), the height was 181.5±5.56 (cm) and the average body weight was 77.0±6.74 (kg).

Table 3. Comparison of Pre-test Values of Groups

		n	Mean	Std. Deviation	t	p
Left Max. Force (N)	Group 1	12	301,08	46,12	-2,096	0,048*
	Group 2	11	343,09	50,02		
Rıght Max. Force (N)	Group 1	12	301,33	44,02	-1,323	0,200
	Group 2	11	333,36	70,22		
Imbalance (%)	Group 1	12	5,08	2,74	-1,899	0,082
	Group 2	11	10,27	8,67		

**=p<0,050 Group 1: (Football Training); Group 2: (Football Training + Pilates Exercise)*

Although a significant difference in the left max. Force values (t= -2.096; p=0.048), a significant difference was found between the groups, the Right Max. Force (t= -1.323; p=0.200) and imbalance (t= -1.899; p=0.082) was found between the groups.

Table 4. Comparison of Post-test Values of the Groups

		n	Mean	Std. Deviation	t	p
Left Max. Force (N)	Group 1	12	308,25	43,93	-2,947	0,008*
	Group 2	11	366,63	51,07		
Rıght Max. Force (N)	Group 1	12	309,91	42,16	-2,509	0,020*
	Group 2	11	359,18	51,89		
Imbalance (%)	Group 1	12	3,58	1,62	-2,090	0,057
	Group 2	11	6,36	4,12		

**=p<0,050 Group 1: (Football Training); Group 2: (Football Training + Pilates Exercise)*

When Table 4 was examined, a significant difference was found between the groups in the left max. Force (t=-2.947; p=0.008) and the right Max. Force (t=-2.509; p=0.020) (t=-2.096; p=0.048). The difference in the imbalance value was not statistically significant (t=-2.090; p=0.057), but the differences in the mean values showed that the mean value was higher after the test with a difference of 2.78.

Table 5. Comparison of Group 1 Pre-Post Test Values

		N	Mean	Std. Deviation
Left Max. Force (N)	Pre-test	12	301,08	46,12
	Post-test	12	308,25	43,93
Rıght Max. Force (N)	Pre-test	12	301,33	44,02
	Post-test	12	309,91	42,16
Imbalance (%)	Pre-test	12	5,08	2,74
	Post-test	12	3,58	1,62

Group 1: (Football Training); Group 2: (Football Training + Pilates Exercise)

Table 5 shows that the mean difference between the pre-test and post-test values of imbalance post-test value of Group 1 was 1.5.

Table 6. Comparison of Group 2 Pre-Post Test Values

		N	Mean	Std. Deviation
Left Max. Force (N)	Pre-test	11	343,09	50,02
	Post-test	11	366,63	51,07
Rıght Max. Force (N)	Pre-test	11	333,36	70,22
	Post-test	11	359,18	51,89
Imbalance (%)	Pre-test	11	10,27	8,67
	Post-test	11	6,36	4,12

Group 1: (Football Training); Group 2: (Football Training + Pilates Exercise)

Examination of Table 6 shows that the mean difference in the post-test imbalance score between the pre-test and post-test scores is better in Group 2, with a difference of 3.91.

DISCUSSION

Due to the nature of the game of soccer, the hamstring muscles are heavily stressed by sudden changes of direction (cutting), stopping (sprint deceleration) and acceleration. The hamstring muscles play a crucial role in flexing the knee joint and extending the hip joint during sprinting, helping to stabilize the lower extremities while maintaining speed (Perkins & Canavan, 2023). This muscle group (biceps femoris, semitendinosus and semimembranosus) is located at the back of the thigh and has a direct impact on the performance of soccer players who must have high levels of muscular strength, agility, speed and endurance (Iatropoulos and Wheeler, 2024). The hamstring muscles can lead to risky situations such as muscle fiber injuries due to the rapid transitions in the stretch-stretch cycle during the game (Widodo et al., 2022). In addition, the hamstring muscles increase the speed and accuracy of the movement by generating force during knee flexion and hip extension during the ball throw (Edouard et al., 2022).

Pilates exercises are a complicated exercise system that aims to strengthen the whole body (Sim, Kim, & Jeon, 2022). However, it not only increases muscle strength but also improves nerve-muscle coordination. This helps the hamstring muscles to work in a more coordinated and efficient manner (Liang et al., 2024; Liu et al., 2024). Improved neuromuscular coordination improves reflexes and reduces the risk of hamstring injury during sudden movements or rapid changes in direction (Akbaş et al., 2024). In light of this information, our study aims to investigate the effects of Pilates exercises on hamstring muscle strength in athletes. It is expected that the knowledge gained will guide the planning of training loads and programs of soccer players and contribute to both rehabilitation processes and the design of training programs to enhance athletic performance. A total of 23 active professional soccer players were included in the study, 11 players for the Pilates exercise group and 12 players for the control group. The demographic profiles of the participants were as follows: Age 25±5.24 (years), height 178.7±5.03 (cm) and body weight 72.6±5.14 (kg) for the soccer group, age 24.0±5.0 (years), height 181.5±5.56 (cm) and body weight 77.0±6.74 (kg) for the Pilates group (Table 2).

According to the results of the pre-tests of the groups (group 1: (soccer training); group 2: (soccer training + Pilates exercise)), there was a significant difference in the left max. Strength values (t= -2.096; p=0.048), while the difference between the groups in the right Max. Force (t= -1.323; p=0.200) and imbalance (t= -1.899; p=0.082) was not significant (Table 3). When analyzing the post-test values of the groups, there was a significant difference between the groups in left max. Force (t=-2.947; p=0.008) and the right Max. Force (t=-2.509; p=0.020) (t=-2.096; p=0.048). There was no difference in the imbalance value (t=-2.090; p=0.057) (Table 4). In addition, the mean difference in the imbalance posttest score between the pretest and posttest scores of group 1 was 1.5 (Table 5), while the mean difference in the imbalance posttest score between the pretest and posttest scores of group 2 was 3.91 (Table 6).

If we look at the literature, we come across studies that link the strength of the eccentric knee flexors to body mass index. Buchheit et al (2016) reported that the eccentric knee flexor strength of soccer players measured by Nordbord was largely dependent on body mass. This could be related to the fact that a higher body mass usually indicates a higher body weight, which may increase the load on the hamstring muscles and increase the risk of injury.

In another study, Roe et al. (2017) examined the strength profiles of the eccentric knee flexors of 341 male soccer players and assessed how body mass and previous hamstring injuries affected performance. According to the results of the study, a significant difference in maximum and mean strength was found between the under-14 age group and all other age groups, except for players under the age of 15. Opar et al. (2015) emphasized that the strength of the eccentric knee flexors may change during the season and the strength of the hamstring muscles increases more in players who were not previously injured. It can be emphasized that training load, training type and some individual differences in athletes may have an influence on this change. Ribeiro-Alvares et al. (2021) investigated the eccentric knee flexor muscle strength of professional soccer players with and without a previous hamstring injury and found that players with a history of hamstring injury had lower eccentric knee flexor muscle strength in the injured limb. The results of these studies show that athletes' injury history affects hamstring strength. Another factor that affects hamstring muscle strength is the type and intensity of exercises performed.

A review of the literature found no study that examined the effects of Pilates exercises on the eccentric strength of the knee flexors of soccer players. However, there are studies investigating the effects of different types of exercise on hamstring muscle strength. Augustsson and Andersson (2023) investigated the differences in maximum knee flexor strength between combined ECNHE (Eccentric-Concentric Nordic Hamstring Exercise) and ENH (Eccentric Nordic Hamstring Exercise) exercises. According to the results of the study, the force assessed at the ankle was significantly different, while the force around the knee joint was not significantly different between ENH and ECNHE.

In their study with thirty female volleyball players, Demir and Çili (2018) randomly divided the athletes into two groups (15 in the experimental group and 15 in the control group) and performed Pilates exercises for two hours a week for 12 weeks. At the end of the twelve weeks, the athletes were subjected to a pre-test and a post-test. It was found that there were statistically significant positive differences between all pre- and post-test values of the biomotor characteristics and technical performance of the athletes in the experimental group. When comparing the percentage improvements in the parameters where differences were found in the experimental and control groups, it was found that there was a higher rate of improvement in the experimental group.

Dilber et al. (2016) examined the performance-related physical fitness variables of 8 weeks of core training in 16 male soccer players, flexibility, right hand claw, back strength, balance, vertical jump distance, anaerobic power, plank, the t-test and the Illinois test ($p \leq 0.05$), while there was no statistically significant difference between the results of the body weight, body mass index, left hand claw strength, leg strength, 30-second push-ups and 30-second sit-ups measurements ($p > 0.05$). According to these results, the effect of the 8-week core training on the athletes' performance-related physical fitness variables showed positive results and it was recommended to include the training program in normal soccer training. Bayrakdar et al. (2020) stated that including core exercises in football training could be beneficial due to their positive effects on protective and functional capacity, and that strength training could be useful to increase the stimulation and use of core muscles.

In their study on the effects of Pilates on dynamic balance in healthy adults, Johnson et al. (2007) examined two groups and applied Pilates exercises to one group for five weeks. In this group, they found significant positive changes in the balance parameter during the Pilates exercises. In their study, Phrompaet et al. (2010) examined forty healthy male and female sedentary subjects; they randomly divided them into two groups, twenty subjects and twenty controls. They had the Pilates group do Pilates exercises for 45 minutes twice a week for eight weeks. According to the pre-test reports, they recorded a significant increase in flexibility and stabilization of the lumbar pelvis as a percentage, especially in the Pilates training group compared to the control group. Özcan found that core stabilization improved with the use of Pilates exercises in 2022 elite basketball athletes and also found a statistically

significant difference in balance and shooting performance. He found that Pilates exercises and local core stabilization exercises used during the season in addition to basketball training can make an additional contribution.

Conclusion: As a result of our study, a significant difference in the Left Max. Force of the soccer players according to the results of the Pilates exercise program before the test (t= -2.096; p=0.048), the results of the post-test showed a significant difference between the groups in Left Max. Force (t=-2.947; p=0.008) and Right Max. Force (t=-2.509; p=0.020) (t=-2.096; p=0.048). It was also found that the mean difference in post-test imbalance between the pre- and post-test values in the soccer group was 1.5, while the mean difference in post-test imbalance between the pre- and post-test values in Group 2 (soccer+Pilates) was better with a difference of 3.91. When the source of the differences was examined, it became clear that the mean scores of the athletes in Group 2 (soccer+Pilates) were higher than the mean scores of the athletes in the soccer group. In conclusion, we believe that properly planned pre-season training programs reduce the risk of injury in athletes and have a positive effect on the mobilization of basic movements such as sprinting, shooting, ball control and passing in soccer players, leading to an increase in athletic performance. However, a review of the literature shows that studies investigating the effects of exercises on left max. Force, Right Max. Force, Right Max. Strength and Imbalance in male soccer players. We believe that in an industry such as soccer, where lower extremity muscle performance is critical, detailed studies of these muscle groups and the exercises that contribute to the development of these muscle groups will be beneficial to coaches and soccer players in terms of athletic success and overall health, so we believe that studies in this area should be expanded quantitatively and qualitatively.

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