Karya J Health Sci. 2020; 1(1): 1-5
ARAŞTIRMA MAKALESİ/RESEARCH ARTICLE e-ISSN:2717-9540

KARYA JOURNAL OF HEALTH SCIENCE

journal homepage: www.dergipark.org.tr/kjhs

THE EFFECTS OF CORE AND PLYOMETRIC TRAINING PROGRAM ON PERFORMANCE AND STRENGTH IN MALE ELITE SOCCER PLAYERS

ERKEK ELİT FUTBOL OYUNCULARINDA KOR VE PLİYOMETRİK EGZERSİZ PROGRAMININ PERFORMANS VE KUVVETE ETKİLERİ

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ABSTRACT

Objective: The aim of this study was to compare the 3-weeks effects of the isolated core training program and plyometric combined core training program on speed, balance, agility and muscle strength of the elite soccer players.

Material and methods: Elite soccer players were divided into two groups with an average age of 15.33 ± 0.48 and 16.66 ± 0.48. One group performed isolated core training (G1), while the other performed additional plyometric exercises (G2). Training programs were implemented 2 days a week for 3 weeks. Illinois agility test, 30 meters sprint test, tandem gait test, T test and muscle strength values of deltoideus, triceps, biceps, iliopsoas, gluteus maximus, hamstring, quadriceps femoris muscles were compared at baseline and after 3 weeks of training.

Results: Both groups had a statistically significant improvement in Illinois agility test, 30-meters sprint test, tandem gait test, T test and muscle strength values (p=0.001) after training program according to the baseline, except for the T test values of the players in G2 (p=0.130). However, the changes were not statistically different between the groups (p>0.05).

Conclusion: The 3-weeks core exercise program improved performance based agility, speed, balance and muscle strength, while the 3-week plyometric exercises did not create additional significant changes in these parameters. Detailed analyzes such as electromyographic activity of the muscles are needed.

Keywords: Exercise, performance, strength

ÖZ

Amaç: Bu çalışmanın amacı üç haftalık izole kor antrenman programı ve pliyometrik egzersizlerle kombine edilen kor antrenman programının elit futbol oyuncularının koşu hızına, denge-koordinasyonuna, çeviklik düzeylerine ve kas kuvvetine etkilerini karşılaştırmaktı.

Yöntem: Yaş ortalaması 15.33±0.48 ve 16.66±0.48 olan 15'er kişilik 2 gruba ayrılan elit futbolcular çalışmaya dahil edildi. Bir grup sadece kor antrenmanı yaparken (G1) diğer grup ek olarak pliyometrik egzersizler yaptı (G2). Antrenmanlar 3 hafta, haftada 2 gün gerçekleştirildi. Başlangıç ve 3 haftalık antrenman sonrası Illinois çeviklik testi, 30 metre sprint test, tandem yürüyüş testi, T testi ve deltoideus, triceps, biceps, iliopsoas, gluteus maximus, hamstring, quadriceps femoris kas kuvvet değerleri karşılaştırıldı.

Bulgular: G2 oyuncularının T testi değerleri hariç (p=0.130) her iki grupta başlangıç ve antrenman sonrası llinois çeviklik testi, 30 metre sprint test, tandem yürüyüş testi, T testi ve kas kuvveti değerlerinde istatistiksel olarak anlamlı değişme vardı (p=0.001). Ancak bu değişimler gruplar arası farklı değildi (p>0.05).

Sonuç: Üç hafta uygulanan kor egzersiz programı çeviklik, hız, denge ve kas kuvvetinde gelişme sağlarken ek olarak uygulanan pliyometrik egzersiz programı bu parametrelerde ek değişimler yaratmamıştır. Daha uzun süreli eğitim programları ve detaylı analizler uygulanan çalışmalara ihtiyaç duyulmaktadır.

Anahtar kelimeler: Egzersiz, performans, kuvvet

INTRODUCTION

Soccer is a team sport where the quickness, agility, balance and coordination are important for the players. The soccer players are expected to perform high-intensity activities including jumps, acceleration and deceleration running, change of directions in 90 minutes. The non-contact injuries generally occur in the course of acceleration/decelaration or pivot movements [1,2]. Regarding this, various training methods were introduced for injury protection and performance improvement.

One of the popular training methods is plyometric training which combines the eccentric, amortization and concentric phase. ATP is stored in the eccentric contraction (tension) phase by contractile structures and provides the explosive energy in the concentric (acceleration) phase. During plyometric training intramuscular and neuromuscular adaptations, such as improvement in muscle activation and musculotendinosis stiffness, come into existence. As the time (amortization phase) between the eccentric and concentric phase is reduced, activation of the central nervous system and muscular functions improve. Hence, athelete becomes faster and more powerful [3,4]. Therefore, plyometric training includes sports-specific activities that boost the skill performance and provide injury protection in soccer players, who are expected to be able to perform sudden and strong movements with explosive power [5]. Research suggests that plyometric training improves agility, change of speed direction and

Makale Bilgisi/Article Info
Yükleme tarihi/Submitted: 15.07.2020, **Revizyon isteği/Revision requested:** 10.08.2020, **Son düzenleme tarihi/Last revision received:** 16.08.2020, **Kabul/Accepted:** 24.08.2020, **Çevrimiçi yayım tarihi/Published online:** 30.08.2020.

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studies including detailed plyometric training protocol with professional athletes.

Core training is spesifically defined training for core muscle activity, which is responsible for force transfer between upper and lower part of body. It has taken a great deal of attention in recent years and has become an essential part of training protocols for athletic performance enhancement and maintaining strength during the rehabilitation process [9]. Research suggests that adequate core stability is in relation with dynamic joint stability, lower extremity alignment and low back pain. While the reduced core endurance was found associated with increased risk of injury in soccer players [10]. It has been reported that soccer training contains core exercises that improve hip muscle strength, vertical jump, sprint, hop test performance and reduce the strength asymmetries [11,12]. Nonetheless, there has not been an agreement for the optimal dozage and the content of a core training for athletes.

To achieve the targeted improvements and to optimize the interventions, the investigation of the dose-response effects of the training programs is important. Nonetheless, there is no consensus on optimal dosage and exercise type in the training programs and most of research investigated the effects of long term effects of different combinations of trainings. There is a need for studies which investigate the effects of short term isolated core training and plyometric exercises combined core training program. We hypotesized that the 3 weeks isolated core training program would improve the agility, speed, balance and muscle strength in soccer players. The second hypotesis was that the plyometric exercise combined core training program would be more effective.

MATERIALS AND METHODS

This study was carried out at Kasımpaşa Sport Club between November and December 2018. 30 male elit soccer players aged between 15 and 17 years who play football at least for 2 years, were included. Participants were excluded if they had (i) lower extremity and spine injury during the study (ii) history of musculoskeletal related surgery and (iii) systemic disease. The present study complies with the Declaration of Helsinki. Theinformed and written consent was taken from all participants and their parents

Table 1. Core exercises

Squat x 10 repetitions
Side plank crunch x 10 repetitions
One-legged plank x 10 repetitions
Resistance plank x 10 repetitions
Superman x 10 repetitions
Reserve crunch x 10 repetitions

Table 2. Plyometric exercises

Body part / Side	Type of exercises
Both feet	Straight forward jump from 20 cm height jump barrier x 5 repetitions Lateral jump over 20cm height jump barrier (right) x 5 repetitions Lateral jump over 20cm height jump barrier (left) x 5 repetitions
Right extremity	Straight forward jump from 20 cm height jump barrier x 5 repetitions Lateral jump over 20cm height jump barrier (right) x 5 repetitions Lateral jump over 20cm height jump barrier (left) x 5 repetitions
Left extremity	Straight forward jump from 20 cm height jump barrier x 5 repetitions Lateral jump over 20cm height jump barrier (right) x 5 repetitions Lateral jump over 20cm height jump barrier (left) x 5 repetitions

Procedure

The players were randomised into two groups (G1 and G2). While the 15 players in G1 implemented core exercise program demonstrated in table 1, other 15 participants in group G2 applied plyometric training, shown in table 2, in addition to core exercises. All participants in both groups applied the exercise program for 3 set/day, 3 day/week and 3 weeks.

The demographics including age, height and weight for all players were recorded. Illinois agility test, the T test, 30-meter sprint test, tandem gait test were conducted at baseline and after 3 weeks exercise program.

Measurements

Illinois Agility Test: To test the agility of the players Illinois agility test (IAGT) was used. The area of the course was marked with 4 cones (for start and finish points and 2 turning points) at the corners. Length of test course was 10 meters and the with was 5 meters (between the start and finish cones) ®. Another 4 cones were centered with equal distance apart. The participants started with the command, ran quickly forward to the first mark and touch with feet. After that they required to turn back to the first cone and to move quickly the other center cones in an order and to finalize the test the participants were asked to turn around and run to the finish cone. The time was noted between the start and finish points [13]. The IAGT was found reliable in soccer players (ICC=0.96) [14].

30-m Sprint Test: Sprinting ability was determined with 30-m sprint test. Soccer players were asked to run quickly during 30 meters distance three times. There was 60 seconds rest period between the trials and the shortest time was recorded [15]. 30-m sprint test had a moderate to strong correlation with jump ability (r=0.706) [16].

Tandem Gait Test: Tandem gait test reflects different aspects of balance and postural stability in soccer players. It is a useful method to detect functional movement problems after concussion [17]. Participants were asked to walk forward with heel to toe gait along line 3 meters long and return to starting point as quickly as possible.

T Test: To test the directional agility, the T-test was implemented based on the protocol described by Semenick [16]. A T shaped area 10 meters wide and 10 meters long was marked with 4 cones. Players were asked to move as quickly as possible to the center cone to the right cone, which is located at the 5 meters right away from the center cone. and touch the base of the cone sidestep to the 10 meters far to the left cone and touch the base of the cone back to the center cone and backpedals to the finish line. Players were asked to move as quickly as possible to the center cone sidestep. The test was assumed to be unsuccesful if the participants crossed legs, did not touch the base of the cone, failed to face at the same direction, and did not reach the finish line. Each player completed two trials and the fastest time was recorded. The T test is a reliable method (ICC=0.92) to test the soccer players' change of direction ability [15,18].

Muscle Strength Test: Hand-held dynamometer was used to test muscle strength. Hand-held dynamometry is a valid and reliable method to test isometric muscle strength for both upper and lower limb muscles [16, 19]. M. deltoideus, m. biceps, m. triceps, m. gluteus maximus, m. iliopsoas, m. quadriceps femoris and hamstring muscles in right and left extremities were measured by using Baseline Hydraulic LCD Push-Pull dynamometry.

Statistical Analyses

For data analyses Statistical Package for Social Sciences (SPSS) Version 16 (SPSS inc. Chicago. IL. USA) statistical program was used. Wilcoxon test was used for changing of outcomes of baseline and after 3 weeks of training for both groups. Mann Whitney U test was conducted to compare the effects of exercise programs. The significance level was set at 0.05 for all tests.

RESULTS

The descriptives of the demographic data (age, height, body weight, arm length and leg length) of soccer players were shown in Table 3. All demographics showed similarity between in G1 and G2.

Table 3. The demographics ofthe soccer players in G1 and G2

Parameter	G1 (mean±SD)	G2 (mean±SD)
Age (years)	15.33±0.48	16.66±0.48
Height (cm)	168.8±2.83	170.80±4.36
Body weight (kg)	60.53±4.24	62.66±5.36
Arm length (cm)	57.53±1.50	57.86±1.92
Leg length (cm)	84.60±2.64	85.80±3.27

Table 4. The comparison of the effects of the exercises programs on performance tests

Test		G1 (mean±SD)	P*	G2 (mean±SD)	P*	p[ł]
Illionis Test (sc)	**Baseline**	15.73 ± 0.87	**0.001**	15.03 ± 1.60	**0.001**	0.590
	3rd week	14.98 ± 0.72		14.45 ± 1.29		
30-m Sprint Test (sc)	**Baseline**	4.45 ± 0.67	**0.001**	3.35 ± 0.68	**0.001**	0.197
	3rd week	4.21 ± 0.53		3.21 ± 0.63		
	3rd week	0.90 ± 0.15		0.77 ± 0.28		
Tandem Gait Test (sc)	**Baseline**	4.14 ± 0.75	**0.001**	4.08 ± 1.03	**0.001**	0.164
	3rd week	3.95 ± 0.60		3.74 ± 0.58		
T-test (sc)	**Baseline**	13.18 ± 1.52	**0.001**	11.97 ± 1.28	0.130	0.068
	3rd week	12.66 ± 1.35		11.64 ± 1.10		

*: Wilcoxon test was used to compare the outcomes of baseline and 3rd week in groups
[ł] Mann Whitney U test was conducted to compare the effects of exercise groups.

The comparison of the baseline and 3rd week performance tests was demonstrated in the Table 4. When compared the outcome measurements of before and after exercise program, the significant decrease in time for all test results was shown. There was significant shortening in the Illinois test (p=0.001), the 30-m sprint test (p=0.001), the tandem gait test (p=0.001) and the T-test time (p=0.001). According to the comparison of the effects of the training programs on the test time, there were not significant differences in any tests between the groups (p>0.05).

The comparison of the muscle test results was shown in Table 5. There was a significant increase in muscle test results for all tested muscle groups between the baseline and 3rd week in both groups. However, the change level of muscle power between groups was not significant (p>0.05).

DISCUSSION

The main findings of this study were that two different training programs which were applied for 3-weeks resulted in improvement of agility, sprint time (30 m), balance and muscle strength in both groups. However, plyometric exercises did not provide additional improvement in any outcome measures.

Dose-response investigations in athletes training and rehabilitation have gained importance. Nevertheless, a consensus have not been achieved due to the diversity of exercise duration, frequency, and type parameters in the training programs. Otherwise, most of the exercise research focused on the effects of the long-term training periods and there are few studies, which research the effects of short-term programs. 3 weeks-training program was found effective in the development of the maximal isometric strength based on the EMG investigations, which determined normal and abnormal neuromuscular function by reflecting the electrical changes in muscle in healthy individuals [20]. There is need for research, that uses functional and performance tests beside EMG evaluations, to detect the observed changes after short-term training program. The findings of the present study, which designed 3-weeks exercise program and investigated the observed changes in agility, speed, balance and muscle strength, contribute to the literature.

The potential role of core strength for athletes was well explained in previous studies. The core provides the production of appropriate strength during athletic performance, the transmission of power between the upper and lower extremities and injury protection [19,21]. Most of them designed 8 weeks training program and found positive effects on agility and speed. However, there is lack of evidence on cost-

effective core training interventions for athletes. According to the results of this study, 3weeks core training improved agility, speed, balance and muscle strength of upper and lower extremities in soccer players.

Table 5. The comparison of the effects of the exercises programs on muscle test results

Muscle test		Left (mean±SD)					Right (mean±SD)				
		G1	P*	G2	P*	p[I]	G1	P*	G2	p*	p[I]
Deltoideus	Baseline	25.79 ± 1.28	**0.001**	27.24 ± 1.48	**0.001**	0.210	26.00 ± 1.25	**0.001**	27.64 ± 1.36	**0.001**	0.573
	3rd week	26.08 ± 1.21		27.59 ± 1.51			26.36 ± 1.19		28.02 ± 1.32		
Triceps	Baseline	24.85 ± 0.87	**0.001**	26.03 ± 1.71	**0.001**	0.771	25.11 ± 0.97	**0.001**	26.48 ± 1.57	**0.001**	0.851
	3rd week	25.31 ± 0.76		26.47 ± 1.82			25.46 ± 0.96		26.83 ± 1.56		
Biceps	Baseline	25.63 ± 1.05	**0.001**	26.66 ± 1.76	**0.001**	0.228	25.70 ± 0.94	**0.001**	27.08 ± 1.54	**0.001**	0.108
	3rd week	25.93 ± 1.00		27.09 ± 1.84			25.96 ± 0.96		27.70 ± 1.62		
Iliopsoas	Baseline	23.74 ± 1.86	**0.001**	26.07 ± 3.38	**0.001**	0.617	24.07 ± 1.76	**0.001**	26.47 ± 3.29	**0.011**	0.868
	3rd week	24.14 ± 1.75		26.42 ± 3.50			24.40 ± 1.75		26.86 ± 3.39		
Gluteus maximus	Baseline	23.11 ± 1.84	**0.001**	25.38 ± 3.56	**0.001**	0.755	23.43 ± 1.94	**0.001**	25.67 ± 3.40	**0.001**	0.574
	3rd week	23.59 ± 1.69		25.87 ± 3.80			23.84 ± 1.86		26.23 ± 3.72		
Hamstring	Baseline	25.50 ± 2.05	**0.001**	26.95 ± 3.32	**0.001**	0.279	25.59 ± 2.31	**0.001**	27.28 ± 3.23	**0.001**	0.349
	3rd week	26.00 ± 2.20		27.43 ± 3.47			26.23 ± 2.40		27.76 ± 3.32		
Quadriceps Femoris	Baseline	26.54 ± 1.96	**0.001**	28.56 ± 4.36	**0.001**	0.417	26.82 ± 2.12	**0.001**	28.27 ± 3.72	**0.001**	0.787
	3rd week	27.01 ± 1.97		28.90 ± 4.43			27.34 ± 2.20		28.74 ± 3.88		

*: Wilcoxon test was used to compare the outcomes of baseline and 3rd week in groups
[I]: Mann Whitney U test was conducted to compare the effects of exercise groups.

In the literature, there are various evidence that support the plyometric exercises' positive effects on neuromuscular, kinematic properties and perfomance. It was demonstrated that plyometric exercise improved the isometric maximum voluntary torque, rate of torque development, impulse over time, maximum voluntary contraction [21,22]. Additionally, Blazevich et al. stated that high speeds of movements cause more muscular rate of force development that increase in electromyographic investigations [23]. Although the plyometric exercises in this study characterised with high-speed movements, we could not detect any significant difference regarding performance tests and muscle strength when compared the training groups. One of the possible explanations for this may be the 3 weeks period is not adequate. Significant changes would be observed if the athletes trained longer exercise periods The other reason may be the responsiveness of the agility, speed, balance and muscle strength tests we used as outcomes are not sensitive in more detailed measurements such as electrical activity. If we had used EMG analyses, we could have determined differences in myoelectric activity of muscles. We need further studies which investigate the plyometric exercises mechanism on intrinsic mechanical properties in additon to performance tests.

CONCLUSION

The findings of the present study indicate that the soccer player benefitted from 3-weeks training program in improving performance and muscle strength. Although we designed 3 weeks exercise program without progression for both groups, the agility, speed, balance and muscle strength of the ahletes were improved. Nonetheless, 3 weeks plyometric training did not create significant increase in outcome measures when compared the isolated core training.

***Acknowledgements*:** None.

Conflict of Interest: The authors have declared no conflicts of interest for this article.

***Funding*:** None.

Author Contribution: *Concept:* TÖ, TKÇ, EB; *Desing:* TÖ, EB, TKÇ, GGÖ; *Data collecting:* TÖ, EB, GGÖ, MMB; *Statistical analysis:* TÖ, TKÇ, GGÖ; *Literature review:* TÖ, EB, GGÖ, MMB; *Writing:* TÖ, EB, GGÖ, MMB, TKÇ; *Critical review:* TKÇ, TÖ.

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