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Effects of Functional Balance Training on Static and Dynamic Balance Performance of Adolescent Soccer Players

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Abstract

Aim: The purpose of the study was to investigate the effects of functional balance training on static and dynamic balance performance, kicking velocity and to define the relationship between balance ability and kicking velocity of adolescent soccer players.

Material and Methods: Sixteen male players randomly divided into 2 groups (Control Group: age 14,23±0,44; Training Group: age 14,31±0,48). While the control group (n=8) followed regular soccer training, the training group (n=8) performed a functional balance training program additively. The balance training was performed on both stable ground and unstable surface (BOSU ball). SportKat2000 system were used to elicit static and dynamic balance scores of right, left and both leg stance of the soccer players.

Results: All static balance variables (dominant, non-dominant and both leg) of training group and one variable (non-dominant leg) of control group showed statistically significant differences ($p<0,05$) after training. Dynamic dominant leg scores of training group and dynamic non-dominant leg scores of control group were statistically significant as well. Ball velocity of training group improved %5.6 in training group and %3.7 in control group. Besides, dominant leg ball velocity correlated with dynamic dominant ($p<0.05$; r: -0,767) and both leg ($p<0.05$; r: -0,787) balance ability for training group. Non-dominant ball velocity also correlated with dynamic dominant ($p<0.01$; r: -0,844) and dynamic non-dominant leg ($p<0.05$; r: -0,778) balance ability in training group after training period.

Conclusion: As a conclusion, functional balance training performed three times in a week positively affect the balance ability and kicking performance of adolescent soccer players.

Keywords

Balance ability, Kicking performance, Dominant leg, Nondominant leg, Ball velocity,

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Fonksiyonel Denge Antrenmanının Adölesan Futbolcuların Statik ve Dinamik Denge Performansları Üzerine Etkileri

Özet

Amaç: Bu çalışmanın amacı fonksiyonel denge antrenmanının adölesan futbolcuların statik-dinamik denge performansları ve vuruş hızları üzerine etkilerini incelemek ve denge yeteneği ile vuruş hızı arasındaki ilişkiyi ortaya koymaktır.

Materyal ve Yöntem: Onaltı erkek futbolcu rastgele iki gruba ayrıldı (Kontrol Grubu: yaş 14,23±0,44; Antrenman Grubu: yaş 14,31±0,48). Kontrol Grubu (n=8) rutin futbol antrenmanlarına devam ederken Antrenman Grubu (n=8) buna ek olarak fonksiyonel denge antrenmanı uyguladı. Denge antrenmanları hem sert zemin hem de BOSU topları üzerinde gerçekleştirildi. Futbolcuların sağ, sol ve çift bacak statik ve dinamik denge skorlarını belirlemek için SportKat 2000 denge ölçüm sistemi kullanıldı.

Bulgular: Antrenman sonrası deney grubunun tüm değişkenlere (dominant, dominant olmayan, çift bacak) ilişkin statik denge skorları ve dominant bacağa ilişkin dinamik denge skorları, kontrol grubunun ise dominant olmayan bacağa ait hem statik hem de dinamik denge skorları istatiksel olarak anlamlıydı ($p<0,05$). Antrenman grubunun top hızı değerleri %5.6 oranında kontrol grubunun ise %3.7 oranında gelişim gösterdi. Antrenman grubunun dominant bacak top hızları dinamik dominant ($p<0.05$; r: -0,767) ve çift bacak ($p<0.05$; r: -0,787) denge skorları ile; dominant olmayan bacak top hızları ise dinamik dominant ($p<0.01$; r: -0,844) ve dinamik dominant olmayan ($p<0.05$; r: -0,778) denge skorları ile ilişki gösterdi.

Sonuçlar: Sonuç olarak, haftada üç kez yapılan fonksiyonel denge antrenmanlarının adölesan futbolcuların denge yetenekleri ve vuruş performanslarını olumlu yönde geliştirdiği görüldü.

Anahtar Kelimeler

Denge yeteneği, Vuruş performansı, Dominant bacak, Dominant olmayan bacak, Top hızı,

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INTRODUCTION

The terms of "*postural control*" and "*balance*" are used in the same manner in most of the

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studies in the literature (Winter et al., 1990; Ricotti, 2011). Static balance can be defined as "*the ability to maintain a base of support with minimal movement*'' and the definition of dynamic balance is "*to perform a task while maintaining a stable position*'' (Winter et al., 1990; Bressel et al., 2007; Ricotti, 2011). The balance ability plays a crucial role and might be considered as an indicator of performance in soccer (Paillard et al., 2006). Because soccer is a bipedal stance (kicking a ball standing on one leg) required sport (Bressel et al., 2007), soccer players demonstrate better static and dynamic balance ability than other players whose sport is required unipedal stance (Matsuda et al., 2008). This performance could be based on the idea that soccer requires athletes to stand on one leg to kick the ball, whereas other sports do not require such locomotor ability and players do not need to correct their body sway during performing a specific skill (Matsuda et al. 2008). During a match, football players frequently perform lower extremity actions such as passing, shooting, and dribbling skills with football cleats on grass field (Orchard and Seward, 2002). Therefore, they must maintain a position of balance as they run at high speed and then powerfully kick the ball, stop or change their direction. In this context, the type of balance training for soccer players has a crucial role in increasing soccer performance.

In the perspective of biomechanics, there are several studies investigated kicking leg (Lees and Nolan, 1998) and support leg kinematics (Inoue at al., 2014) and EMG activities (Cerrah et al., 2011; Katis et al., 2012) during soccer kicks; however; few researches have focused on the relation between balance and kicking performance (Barfield et al., 2002; Tracey et. al. 2012). Barfield (1995) reported a significant correlation between medio-lateral ground reaction forces and maximum kicking velocity on the dominant kicking leg but not for the non-dominant kicking leg in skilled soccer players. Tracey et al. (2012) also found similar results with Barfield (1995) that dominant leg kicking performance correlated with contralateral leg stability but non-dominant leg kicking performance did not show a similar correlation.

Studies showed that balance ability is one of the most important parameters for soccer kicking performance. There are studies that evaluate the current balance performance of the athletes from different sports (Perrin et al., 2002; Bressel et al., 2007; Gerbino et al., 2007) different types of exercise have been performed to improve balance ability of athletes from different age groups (Davlin, 2004; Romero-Franco et al., 2013) and comparison of athletes and non-athletes (Vuillerme et al., 2001; Vuillerme and Nougier, 2004; Biec and Kuczynski, 2010). Kibler et al. (2006) argued the role of trunk and core muscles which have a vital role in generating power, controlling and transferring forces to perform a powerful kick. Putnam (1993) also discussed that the core region could be thought as an anatomical base for movement patterns of distal segments such as throwing or kicking. It is believed that soccer players have a relatively strong core region and it will efficiently transfer the energy to the upper and lower limbs. Hence, allowing one to perform difficult and powerful movement patterns such as rapid movement changes during a sprint or avoiding tackles while dribbling (Vleeming et al., 1995). In the past few years, the popularity of functional balance training has increased due to its sport-specific movement patterns content. Yet, the rapid rise of this training method in soccer has not been correlated with a corresponding increase in the number of the studies that target training effects, especially in adolescent soccer players. Since BOSU ball is the first and foremost equipment in soccer training, functional balance training has been performed by using this equipment.

The purpose of the study was to investigate the effects of functional balance training on static and dynamic balance performance and to define the relationship between balance ability and kicking velocity of adolescent soccer players. We hypothesized that the training group would show: (1) better static balance performance than the control group (2) better dynamic balance performance than the control group (3) higher ball velocities than the control group and (4) a moderate to higher correlation between non-dominant leg balance ability and dominant leg kicking velocity.

METHOD

Participants: Sixteen male soccer players randomly divided into 2 groups (Control Group: age 14.23 ± 0.44 years training age 2.83 ± 0.71 years, height 160 ± 9.91 cm, body mass 48.49 ± 9.64 kg; Training Group: age 14.31 ± 0.48 years, training age 2.91 ± 0.75 years, height 161.69 ± 10.01 cm, body mass 49.27 ± 9.64 kg). This study has been carried out during the pre-season period on 2014-2015 from July to August. All participants were athletes of the same team competing in an academy league and the functional balance training was given to their regular training additionally. Static and dynamic balance tests, and ball velocity have been measured in the morning hours as well as not the day after regular training. Additionally, a standardized warm up protocol was performed before all the measurement. We restricted caffeine and similar stimulants intake of the players before the tests. All players and their parents have been informed about the protocol of the training, possible benefits, risks and written informed consents have been signed either by players or their parents. This study was approved by the local Ethics Committee of Osmangazi University (Faculty of Medicine - 80558721/167) and carried out in accordance with the Declaration of Helsinki.

Training Protocol: The balance training was performed on stable ground and unstable surface (BOSU ball). Static and dynamic balance performance and ball velocity variables have been evaluated before and after the training period. While the control group (*n*=8) followed the regular soccer training (3 days a week), the training group (*n*=8) performed a balance training program (6 weeks, 3 times per week, 35 minutes per session) before the regular training. Table 1 shows the periodization of functional balance training.

Table 1. Functional Balance Training Periodization

Periodization									
Week	1			2			3		
Session	1	2	3	4	5	6	7	8	9
Training Mode	FG	FG	FG	BBA	BBA	BBA	BBA+ TA	BBA+ TA	BBA+ TA
Week	**4**			**5**			**6**		
Session	10	11	12	13	14	15	16	17	18
Training Mode	B+TA+ RSA	B+TA+ RSA	B+TA+ RSA	SBA+ BaPA	SBA+ BaPA	SBA+ BaPA	SBA+ BaPA	SBA+ BaPA	SBA+ BaPA
Flat Ground: FG; Basic Bosu Actions: BBA; Transition Actions: TA; Reverse Side Adaptation: RSA; Soccer Ball Actions: SBA; Bosu and Progression Actions: BaPA									

Training schedule and the content of functional balance training protocols are summarized in Table 2. All movements have been demonstrated and performed for the players visually by experienced soccer coaches or conditioners.

Table 2. Training Schedule

Flat Ground	Sets	Rep	Rest(sec)
Standing on one leg (Each)	1-3	10	30
Keeping arm front	1-3	10	30
Keeping arm side	1-3	10	30
Keeping arm up	1-3	10	30
Keeping leg front	1-3	10	30
Keeping leg side	1-3	10	30
Keeping leg side	1-3	10	30
Lunge	1-3	10	30
Squat	1-3	10	30
Basic Bosu Action	**Sets**	**Rep**	**Rest(sec)**
Standing on one leg (Each)	1-3	10	30

Keeping arm front	1-3	10	30
Keeping arm side	1-3	10	30
Keeping arm up	1-3	10	30
Keeping leg front	1-3	10	30
Keeping leg side	1-3	10	30
Keeping leg side	1-3	10	30
Lunge	1-3	10	30
Squat	1-3	10	30
Keeping arm front and kicking	1-3	10	30
Basic Bosu Act. + Transition Act. + Reverse Side Adap.	**Sets**	**Reps**	**Rest(sec)**
Moving to Front Side and Standing on Bosu with Both Legs			
Header	1-3	10	30
Kicking with the upside of the foot	1-3	10	30
Kicking with the inside cut of the foot	1-3	10	30
Jumping on Bosu from Flat Ground			
Header	1-3	10	30
Kicking with the upside of the foot	1-3	10	30
Kicking with the inside cut of the foot	1-3	10	30
Soccer Ball Action + Bosu and Progression Action	**Sets**	**time(sec)**	**Rest(sec)**
On One Leg and Eyes On			
Ankle movement (Front and Back)	1-3	30	30
Waiting on one leg	1-3	30	30
Ankle movement (Side to Side)	1-3	30	30
Reverse arm actions (Left and right, up and front)	1-3	10	30
On One Leg and Eyes off			
Ankle movement (Front and Back)	1-3	30	30
Leg actions on one leg	1-3	30	30
Jumping and landing on each Balance tools with each and both feet (Front)	1-2	30	30
Jumping and landing on each Balance tools with each and both feet (Side)	1-2	30	30

Sets are increased gradually in every two weeks.

Balance Test: Sport KAT 2000® (OEM Medical, Carlsbad, USA, 2008) testing system was used to evaluate static and dynamic balance index scores of right, left and both leg stance before and after the training period. Tests were performed during 20 seconds on 4 psi balance resistance level of Sport KAT 2000® and test scores were recorded by the software. Both static and dynamic tests were performed in eyes open and athletes took visual feedback from the screen of the system. They were bare foot during the testing procedure and all players were asked to keep their hands on their shoulders to avoid any beneficial influence of arm movements on balance ability. The working principle of the system is, the lesser balance index scores the better balance performance.

Ball Velocity: The soccer kick test was performed in an indoor sport area before and after the functional balance training protocol. Following a warm up (10 min jog) and 5 soccer specific stretching exercises (10 min), players performed 3 in-step kicks and the fastest kicks were saved for further analysis. All kicks were performed at a 30-45 degree approaching angle with two steps to a stationary ball towards a target (width 3.00 m, height 2.44 m) 15 m away with a full-size soccer ball (number 5) approved by the International Football Federation. Ball pressures were adjusted to 11 psi with a pressure measurement device (Rucanor, Netherlands, 1998). Subjects were asked to kick the ball with maximal velocity so as to strike the target. Ball velocity was measured by a radar gun (Jugs Pro, USA, 2001) held behind the player. Each player performed 3 maximal kick with his dominant and non-dominant leg on a synthetic grass pitch. When player misses the target, another kick has been performed until he got the target. There was no a time limitation so that players could perform the strikes when they relaxed and felt ready.

Statistical Analyses:

Since data showed normal distribution Paired t-test was used in order to identify balance ability and ball velocity differences between pre, and post-test. Pearson's correlation coefficient was calculated with the level of statistical significance set at $p<0.05$ to evaluate the relationship between ball velocities and balance performance. Pearson's Correlation coefficient was interpreted according to Domholdt (2000): 0.00–0.25 = little if any correlation, 0.26–0.49 = weak correlation, 0.50–0.69 = moderate correlation, 0.70–0.89 = strong correlation, 0.90–1.00 = very strong correlation. SPSS for Windows, version 18.0 (SPSS, Inc., Chicago, IL) was used for statistical analyses.

RESULTS

Both training and control group were similar regarding their descriptive data. Control Group: age: 14,23 ± 0,44 years, training age: 2,83 ± 0,71 years, height: 160 ± 9,91 cm, weight: 48,49 ± 9,64 kg; Training Group: age: 14,31 ± 0,48 years, training age: 2,91 ± 0,75 years, height: 161,69 ± 10,01 cm, weight: 49,27 ± 9,64 kg. Two main results were obtained regarding static and dynamic balance values of training and control group: (1) Only two variables (static non-dominant leg, dynamic non-dominant leg) showed statistically significant differences ($p<0,05$) between pre and post-test in the control group while four variables (static dominant leg, static non-dominant leg, static both leg, dynamic dominant leg) showed statistical significant differences ($p<0,05$) between pre and post-tests in the training group (Table 3).

Table 3. Pre and Post Test Paired T Test Balance Values

	Variables	Mean ± SD	p
Control Group	Pre-Post Static-Dom	206,50±80,77 / 152,31±95,14	0.424
	Pre-Post Static-NonDom	198,24±82,21 / 171,60±110, 24	**0.019**
	Pre-Post Static-BothLeg	147,38±68,55 / 103,84 ±25,86	0.060
	Pre-Post Dynamic-Dom	941,33±121,38 / 871,00 ± 138,39	0.609
	Pre-Post Dynamic-NonDom	1008,11±184,40 / 966,00±202,74	**0.043**
	Pre-Post Dynamic-BothLeg	672,61±169,12 / 594,61±81,46	0.960
Training Group	Pre-Post Static-Dom	194,04±73,46 / 142,38±87,75	**0.032**
	Pre-Post Static-NonDom	213,70±89,81 / 159,75±101,95	**0.001**
	Pre-Post Static-Both	140,13±61,71 / 102,00 ± 24,41	**0.029**
	Pre-Post Dynamic-Dom	945,21±11,38 / 874,50±125,39	**0.048**
	Pre-Post Dynamic-NonDom	987,83±176,72 / 942,75 ± 188,64	0.754
	Pre-Post Dynamic-BothLeg	678,12±151,19 / 595,56±84,57	0.159

Ball velocities of the training and control group were quite similar to each other before training protocol. Ball velocities of the training group showed statistically significant differences between pre, and post-tests ($p<0,01$), (Table 4)

Table 4. Pre and Post-Test Paired T Test Ball Velocity Values (km/h)

	Variables	Mean ± SD	p
Control Group	Pre-Post Dom	73,13±7,04 / 75,88±8,25	0,1537
	Pre-Post Non-Dom	59,63±5,42 / 61,00±7,86	0,4000
Training Group	Pre-Post Dom	72,63±10,34 / 76,75±7,27	**0,0091**
	Pre-Post Non-Dom	58,00±6,76 / 61,63±6,46	**0,0016**

Table 5 shows the relationship between balance ability and ball velocities. There were no significant relationship between ball velocities and balance ability variables in both groups before training period. However, after training period, we obtained a statistical significant strong correlation between dominant leg ball velocities with dynamic dominant ($p<0.05$; r: -0,767) and dynamic both leg ($p<0.05$; r: -0,787) balance ability in the training group. Furthermore, there was also statistically significant strong correlation between non-dominant leg ball velocity with dynamic dominant ($p<0.01$; r: -0,844) and dynamic non-dominant ($p<0.05$; r: -0,778) leg balance ability in the training group.

Table 5. Correlation between Balance Ability and Ball Velocities

	Variables	Pre-Test		Post-Test	
		Dom-Ball Velocity	NonDom-Ball Velocity	Dom-Ball Velocity	NonDom-Ball Velocity
Control Group	Static_Dom	-0,056	0,227	-0,070	0,071
	Static_NonDom	0,225	0,576	-0,057	-0,127
	Static_BothLeg	0,007	0,295	0,080	0,217
	Dynamic_Dom	-0,116	0,087	-0,271	-0,496
	Dynamic_NonDom	-0,033	-0,059	-0,602	-0,660
	Dynamic_BothLeg	-0,625	0,602	-0,444	-0,295
Training Group	Static_Dom	0,480	0,152	-0,018	-0,320
	Static_NonDom	0,649	0,079	0,336	0,498
	Static_BothLeg	0,197	-0,187	0,056	0,201
	Dynamic_Dom	-0,020	-0,318	**-0,767***	**-0,844****
	Dynamic_NonDom	-0,362	-0,689	-0,510	**-0,778***
	Dynamic_BothLeg	-0,060	0,038	**-0,787***	-0,381

*:p<0.05; **:p< 0.01

DISCUSSION

The purpose of the study was to investigate the effects of functional balance training on static and dynamic balance performance, kicking velocity and to define the relationship between balance ability and kicking velocity of adolescent soccer players. Obtained data provided support for four hypotheses developed: (1) static balance performance was significantly better (p<0,05) in training group who practiced functional balance training three times in a week for all dominant, non-dominant and both legs while in control group it was better only for non-dominant leg between pre and post-tests; (2) dynamic balance improvements were statistically significant just for the dominant leg in training group and for the non-dominant leg in control group (3) ball velocities of the training group were significantly different after functional balance training period (p<0,01) (4) dominant and non-dominant leg ball velocity correlated with dominant dynamic and both leg dynamic balance ability in training group at post-tests strongly. Similarly, non-dominant leg ball velocity of the training group also correlated with dominant and non-dominant leg dynamic balance ability.

Static and dynamic balance performance of soccer players: Main appropriate age ranges for training a special motor skill in children and adolescents was reported by Weineck (2004). He declared that the first pubertal age lasting from 12/13 to 14/15 is a crucial period for improving balance and coordination ability in male adolescents (Weineck, 2004; Ricotti, 2011). On the other hand, the plateau in postural stability was specified between 7 and 12 years of age (Oliver at al., 2008). The findings of our 14-year-old soccer players imply that, when a different rate of postural maturation considered (Riach and Hayes, 1987; Nolan et al., 2005), the ability of static and dynamic balance could be improved by the end of first pubertal age. The static balance improvements of our training group were better for all dominant, non-dominant and both legs. Therefore, the findings of the present study indicated that functional balance training has a positive impact on static balance ability. In line with our study, Yaggie & Campbell (2006) and Gioftsidou et al. (2006) reported better balance ability after different balance training period. However, their evaluation methods and performance parameters were different than the current study. Since the control group was performing regular soccer training and using their support leg intensively during training sections, it is possible that the static balance performance of their non-dominant leg improved and was better in post-test. In terms of dynamic balance, the non-dominant leg balance performance of training group and dominant leg balance performance of control group were better in post-test. The possible reason for control group might be related to their intense use of dominant leg during controlling, passing and shooting the ball in regular soccer training.

Balance ability and kicking performance: Based on the findings of the current study, ball velocities of the training group were significantly different after functional balance training program ($p<0,01$). Ball velocity values of the training group increased %5.6 for dominant leg and %0.6 for non-dominant leg, also for control group it was %3.7 for dominant leg and %0.2 for non-dominant leg. When the effect of regular training was eliminated, the absolute impact of training is %1.9 on ball velocity. Similarly, Prieske et al. (2016) reported %2 ball velocity increment after 9 weeks core strength training. Besides, the positive impact of balance and proprioceptive training on some specific technical soccer skills such juggling, dribbling and passing has been declared by Evangelos et al. (2012). Ball velocity is directly related to the force produced by muscles and effectively transmission of this force to ball in a well-arranged kinematic chain. It has been concluded that performing exercises on unstable surfaces enhances joint stabilization by increasing the synergy between muscles (Anderson, 2004). Furthermore, Kornecki et al. (2001) emphasized the importance of increased stabilization functions for performing voluntary and coordinated movements. In this regard, the positive impact of functional balance training on training group seemed to transfer the force produced by muscles to the ball rather than stabilizing posture. However, kicking performance is not only related to force and balance but also closely related to neuromuscular adaptations that could be obtained after several years of athletic performance (Cerrah et al, 2011).

Tracey et al. (2012) reported significant correlations between single-leg balance ability with kicking accuracy. They showed that support leg balance was more highly correlated to kicking (dominant) leg accuracy. Even though we hypothesized a moderate to a higher correlation between non-dominant leg balance ability and dominant leg kicking velocity the highest correlation was between dominant leg dynamic balance ability and non-dominant leg kicking velocity in the post-test. We concluded that six weeks of functional balance training increased non-dominant kicking velocity by improving dominant leg balance ability of training group. This correlation might be increased due to improved static balance ability of dominant leg. Furthermore, a well-balanced dominant leg localization next to the ball with accurate approaching angle could be another reason for this correlation after training period.

Consequently, results show that six weeks functional balance training, which is performed three times a week before the regular soccer training sessions positively, affected mainly the static balance ability of adolescent soccer players and kicking performance. Moreover, we believe that our study puts forward some evidence for the relationship between kicking performance and balance ability.

CONCLUSION AND SUGGESTIONS

This study was one of the preliminarily researches investigating the effects of functional balance training on static, dynamic balance and kicking performance. Therefore; it has some limitations (1) the functional balance training was limited to six weeks (2) in order to generalize the result, studies with larger sample sizes and different age groups are required. It has been suggested for future studies that the effects of functional balance training should be investigated on different branch of sports, age groups and level of competition. In order to identify the relationship between balance ability and soccer kicking performance, kinematical variables should be investigated via motion analyses systems. In addition to this, soccer specific skills such as sprint, agility, dribbling, passing etc. should be evaluated.

PRACTICAL APPLICATION

We believe that the periodization and training schedule of the functional balance training presented in the methods will be a useful source for coaches to design and modify training programs. Besides, functional balance trainings could be a part of regular training throughout the season since they could improve the joint (hip, knee and ankle) stabilization properties of the players, so that help to prevent injuries.

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