ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

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The Relationship Between Anthropometric, Physical, Technique Components and Three Different Agility Tasks in Soccer Players

Futbol Oyuncularında Antropometrik, Fiziksel, Teknik Bileşenler ve Üç Farklı Çeviklik Testi Arasındaki İlişki

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ABSTRACT: Objective: This study was aimed to investigate the relationship between anthropometric, physical, technique components and three agility tasks; planned (PAT), unplanned (UNAT) and unplanned soccer specific reactive agility test (USRAT). Eighteen sub-elite soccer players (age 18±1.28 years) attended to the this study. **Material and Methods:** Anthropometric measurements, linear sprint speed tests (10m static sprint, flying 20m sprint), leg muscle strength tests (depth jump, isokinetic strength test), and running technique tests (zig-zag test) were performed. Planned agility, unplanned agility and agility with one unplanned change of direction with dribbling were used to evaluate agility performances. To investigate the relationship between PAT, UNAT, USRAT and anthropometric, physical, technique components; Pearson or Spearman correlation analysis were used depending on normal distribution. **Results:** Static 10m sprint and PAT showed a statistically significant correlation (r=0.604). UNAT was significantly correlated to flying 20 m test (r=0.513). None of drop jumps components had significant correlations with the agility tests (p>0,05). Moreover, USRAT showed statistically significant correlation (r=-0.502), (p<0.05) with the number of steps taken at the turn movement and no significant relationship with isokinetic variables (p>0.05). **Conclusion:** In conclusion, if a soccer-specific task is involved in an agility test, it may be reported that the performance is most likely to be affected by player's technical skill. Moreover, the results of running technique analysis indicate that to be better at agility task players have to be better at making decisions instead of getting closer to the ground at the turning movement.

Keywords: Planned agility; reactive agility; running technique; soccer

ÖZET: Amaç: Çalışmanın amacı, antropometrik, fiziksel, teknik bileşenler ile önceden planlanmış (ÖPÇT), önceden planlanmamış (PÇT) ve futbola özgü reaktif çeviklik testi (FÖRÇT) arasındaki ilişkiyi incelemektir. Çalışmaya, 2012-2013 sezonunda Eskişehir Anadolu Üniversitesi 19 yaş altı futbol takımında oynayan 18 futbolcu (yaş=18±1,28 yıl) katılmıştır. **Gereç ve Yöntemler:** Antropometrik ölçümler, düz sprint hızı testleri (10m statik sprint, 20m ivmelenme ile sprint), bacak kas kuvveti testleri (40 cm'den derinlik sıçraması, izokinetik kas kuvvet testi) ve koşu tekniği ölçümleri (zig-zag test) uygulanmıştır. Çeviklik performansı ölçümleri; önceden planlanmış çeviklik testi (ÖPÇT), önceden planlanmamış çeviklik testi (PÇT) ve futbola özgü top sürme becerisiyle önceden planlanmamış yön değişikliği içeren FÖRÇT kullanılarak yapılmıştır. ÖPÇT, PÇT, FÖRÇT ve antropometrik, fiziksel, teknik bileşenler arasındaki ilişkiyi belirlemek için normal dağılıma bağlı olarak, Pearson ya da Spearman korelasyon analizi kullanılmıştır. **Bulgular:** Statik 10m sprint testi ÖPÇT ile istatistiksel olarak anlamlı ilişki göstermiştir (r=0,604). PÇT ve 20m ivmelenme ile sprint testi arasında istatistiksel olarak anlamlı korelasyon bulunmuştur (r=0,513). Derinlik sıçraması herhangi bir çeviklik testiyle anlamlı ilişki göstermemiştir (p>0,05). Ayrıca, FÖRÇT ve zig-zag testte dönme anındaki adım sayısı istatistiksel olarak anlamlı bir ilişki (r=-0,502), (p<0,05) gösterirken FÖRÇT izokinetik değişkenlerin hiçbirisi ile anlamlı bir ilişki göstermemiştir. **Sonuç:** Sonuç olarak; çeviklik testi içerisinde futbola özgü beceriler bulunduğunda performansın teknik becerilerden etkilendiği söylenebilir. Ayrıca koşu tekniği analizleri sonuçları oyuncuların çeviklik performansında daha başarılı olabilmek için yön değiştirme anında yere yaklaşmaktansa karar vermede daha etkili olmaları gerektiğini göstermektedir.

Anahtar Kelimeler: Planlanmış çeviklik; reaktif çeviklik; koşu tekniği; futbol

Agility is an essential component in many team sports such as all codes of soccer. Even though there is no certain definition of agility in the sports science community, recently "a rapid whole body movement with change of direction or velocity in response to a stimulus" has been identified as an agility skill.[1] According to this definition; agility is affected by two main components: 1) perceptual and decision making factors and 2) change of direction speed.[1] Moreover, many other skills such as linear sprinting speed, running technique, anthropometry and leg muscle qualities may also affect different agility tasks. For this reason, it is ideal to evaluate players by using an agility test that includes a stimulus.[1] According to time motion analysis studies, soccer players perform approximately 1350 movements, run 9-12 km and execute strong turning movements to control the ball against defensive pressure[4] during a game.[2-4] In order to have successful performance during a soccer match, it is important for players to be aware of the right stimulus during the game. Players must correctly read the stimulus that is coming from either the ball, opponent, or team-mate. In the very first second of reaching the ball; players must perform high technical skills to control the ball and then decide the best option for the ball to go. To train the players either planned or reactive change of direction activities are effective to develop change of direction speed in sports. However, little research exists that include reaction to a stimulus.[5]

The relationship between speed and change of direction speed among Australian Rules soccer players was investigated and the correlations between sprint and agility tests were very low.[6] In contrast, Draper and Lancaster[7] found statistically significant correlation (r =0.47) between the Illinois test and a 20 m sprint. In addition to these correlations, Buttifant, Graham and Cross compared the change of direction speed involving four direction changes and a 20 m linear sprint performances and found low correlations (r=0.33).[8,9] Moreover, Young et al. found low and non-significant correlations (r = 0.34) between 8 m sprint with directional changes and an isokinetic squat for power set at 40 degrees per second.[10] In contrast to these results, moderate and significant (r =-0.60, p<0.05) relationships between single leg isokinetic squat strength and a complex multidirectional change of direction speed task was reported However, Young et al. found a low (r = 0.36) and non-significant relationship between a drop jump and 20 m sprint with three directional changes.[6,11] Likewise, Young et al. investigated the relationship between a drop jump and sprints with changes of direction.[10] Correlations between these two variables were also non-significant (r=–0,47). There are very few studies in the literature that have investigated the relationship between anthropometric variables and change of direction speed performance. Webb and Lander found that body composition and change of direction speed in rugby players were not strongly correlated (r = 0.21).[1,10] Sayers pointed out that to sprint with high center of gravity needs adjustments for postural structure.[13] Therefore, it is important to have a low center of gravity in order to change direction in a rapid succession. It was also found, one needs to lower their center of gravity by both bending their knees and shortening their stride length.[1]

There are many studies investigating the relationship between agility performance and many of its components.[10,14] Most of these studies used planned change of directions and did not search for the relationship of agility and all its components at the same time. For this reason, the primary purpose of the current study was to determine the relationship between of direction speed components (anthropometric measurements, linear sprint speed, reactive strength, concentric strength and power, running technique) and the three different agility tasks; planned agility test (PAT), unplanned agility test (UNAT) and unplanned soccer specific agility test (USRAT).

MATERIAL AND METHODS

Eighteen sub-elite male soccer players (age 18±1.28 years; body height 1.75±0.04 cm; body weight 63.66±8.56 kg; BMI 20.44±2.33 kg/m^2, training age 7.06±2.93 years) from Eskisehir Anatolian University (3 times training and a match per week) under nineteen (U19) team participated in the current study. None of the subjects had any previous injury. All parents provided written permission and all subjects provided assent before the start of the study. The investigation was approved by the local University Ethics Committee (Approve number: 36/30.01.2013).

TESTING

Agility tests were conducted using Smartspeed (Fusion Sport, Australia) photoelectrical timing gates to provide a flashing light as a generic stimulus for the reactive tests.[9] Subjects completed two repetitions of all tests and the best score was recorded for statistical analysis. Subjects performed all tests in a random order. A standardized warm-up, consisting of jogging (5 to 10 minutes), multi directional movements, sprinting, dynamic stretching and drilling with balls was used before the agility tests, linear sprint tests, reactive strength tests and running technique tests. Besides agility tests; anthropometric, isokinetic strength, and running technique measurements were also performed. All of the testing procedures are defined in the following sections and testing days are summarized in Table 1. Subjects refrained from intensive exercise in 24 hours before each testing session and they stopped drinking and eating 3 hours before the test. The subjects were given courage to perform well in the tests.

ANTHROPOMETRIC MEASUREMENTS

Body height measurements were done by using a stadiometer (Holtain Stadiometer, Crosswell, Wales, UK) accurate to within 0.1 cm.[15] To prevent any possible miscalculations subjects were informed not to wear thick clothes and socks. Electronic scales Tanita MC 180 MA (Tanita Co., Ltd, Tokyo -Japan) accurate to within 0.1 kg were used to measure body weight, body mass index, and body fat percentage (BFP).

AGILITY TESTS

Agility tests consisted of three different agility protocols; (a) unplanned soccer specific reactive agility test (USRAT), (b) planned agility test (PAT) and (c) unplanned agility test (UNAT). Time for each interval was recorded to the nearest 0.001 seconds.

TABLE 1: Tests and days.

Tests	1st Day	2nd Day	3rd Day	4th Day
Agility Tests				
USRAT		√		
PAT		√		
UNAT		√		
Anthropometric Measurements				
Tanita Measurements	√			
Height Measurements	√			
Linear Sprint Speed Tests				
Static 10m Sprint Test		√		
20m Flying Sprint Test		√		
Reactive Strength Tests – 40 cm Drop Jump				
Both Legs Drop Jump		√		
Dominant Leg Drop Jump		√		
Non-Dominant Leg Drop Jump		√		
Concentric Strength and Power Tests				
Isokinetic Leg Strength Measurements – Concentric /				
Concentric – $60°.sec^{1}$ and $300°.sec^{-1}$			√	
Running Technique Tests				
Zig-Zag Test				√

UNPLANNED SOCCER SPECIFIC REACTIVE AGILITY TEST (USRAT)

USRAT was designed by researchers to evaluate unplanned change of direction speed of subjects related to soccer specific movement (Figure 1). Subjects began on the marked line, 30 cm behind the first timing gate as explained by Oliver and Meyers.[9] The test started when the green light stimulus from gates automatically appeared. Subjects reacted to the stimulus and sprinted 5 m forward. During the subject's forward sprint, a second light stimulus automatically appeared either from right or left randomly. According to this stimulus, subjects ran through the gate that was to their left or right. After passing through the second timing gate subjects sprinted 7 m forward then dribbled a ball through 5 cones that were placed 1 m apart. To reach the last gate and finish the trial, subjects sprinted with ball a final 2 m. The USRAT was used to measure (a) reaction time at the first gate (b) reactive agility at the second gate (c) soccer specific technique ability at the third gate. Total time was measured as seconds and used for the statistical analysis.

PLANNED AGILITY TEST (PAT)

PAT was designed as The Pro Agility drill (also known as the 5-10-5 shuttle). This drill is a popular test of planned agility used in many sports.[16] Before the test started, subjects were informed about the direction which they would run at the first place (either right or left). As shown in figure 2, the protocol required one gate per track. Subjects started at the gate, ran around a cone (3 m), came back through the gate, and ran around another cone (3 m), and back through the gate to finish the trial (Figure 2).

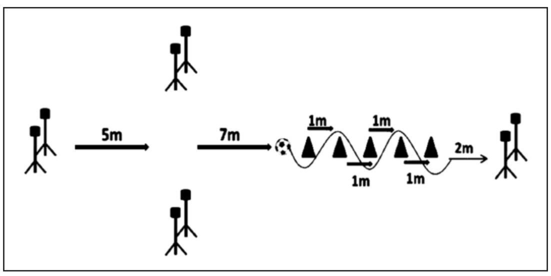

FIGURE 1: Description of USRAT

UNPLANNED AGILITY TEST (UNAT)

Subjects started UNAT (included one change in direction) 30 cm behind the first timing gate. When subjects entered the first gate, timing started and they ran 5 m forward towards the second gate. As subjects passed second gate, players had to react to a light stimulus, which appeared randomly from either the 3rd or 4th gate. The test was finished when players ran through the correct unplanned gate which light stimulus appeared (Figure 3).

LINEAR SPRINT TESTS

Subjects were tested by two different linear sprint tests.

10 M STATIC SPRINT TEST (10M SS)

Subjects started the 10 m static sprint test behind the first timing gate ready to sprint. They were told to put preferred foot forward. The 10m SS trial started at the subject's own discretion. Time was started when they broke the beam of the first timing gate. The test was completed when the subject ran through the second gate.

FLYING 20 M SPRINT TEST

Flying 20 m Sprint test was designed according to the protocol suggested by Little and Williams.[17]

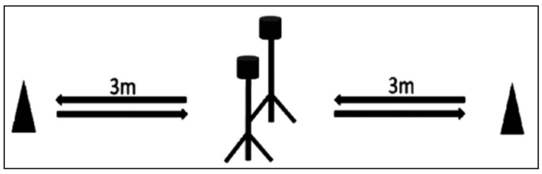

FIGURE 2: Description of PAT.

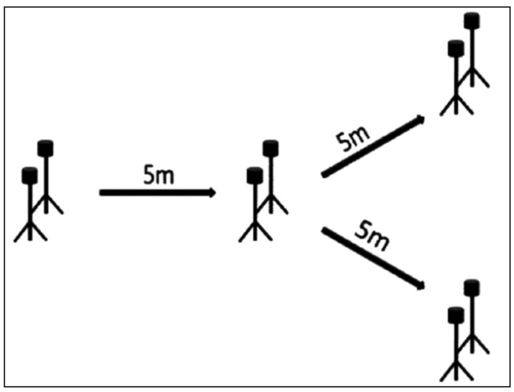

FIGURE 3: Description of UNAT.

Subjects started the trial at their own discretion. Subjects ran 40 m with a maximal velocity. The first 20 m sprint time (seconds) was used for further analysis. Cutting time of second gate at 20 m was measured to identify acceleration of the subjects.

LEG MUSCLE QUALITIES TESTS

To evaluate leg muscle strength, a Cybex isokinetic dynamometer (model 770, Humac Norm Testing and Rehabilitation System, USA) was used.

CONCENTRIC STRENGTH AND POWER TESTS-ISOKINETIC LEG STRENGTH MEASUREMENTS

Subjects performed warm-up exercises on a Monark stationary bike (Monark Exercise AB, Sweden) at a self-selected moderate intensity for 5 minutes. Cybex isokinetic dynamometer (Cybex 770-NORM, Cybex International, Medway, MA, USA) was used to evaluate bilateral concentric isokinetic strength of the knee extensors and flexors. Two different angular velocities (60°.sn^{-1} and 300°) were used for isokinetic leg strength measurements, randomly. Three submaximal efforts were performed for familiarization before maximal tests. A 30 second rest period was given between submaximal and maximal tests. Five trials at each velocity were performed and the maximal peak torque for knee extension and flexion was registered by the Humac (2004) via computer (4.5.5 version, CSMI, USA) and the best value was used as the outcome measure.[18]

REACTIVE STRENGTH TESTS

Reactive strength of subjects was calculated by performing drop jump from a 40 cm height. Three different drop jumps (both legs, dominant leg, non-dominant leg) were performed by each subject. Subjects were informed about tests and they were not allowed to jump before landing to the mat from 40 cm height. Upon landing, subjects were instructed to immediately jump for maximal height, arms akimbo. Take-off and landing was standardized to full knee and ankle extension on the same spot. The subjects were instructed to maximize jump height and minimize ground contact time during the 40 cm drop box. Vertical jump height and contact time were measured. The best score of 2 trials was recorded and the best value was used as the outcome measure.

RUNNING TECHNIQUE TESTS

The Zig-zag test was used for an agility running technique test because it has the important aspects of agility such as acceleration, deceleration, change direction and balance; moreover zig-zag tests classically have been used to evaluate agility performance.[1,19] Subjects completed trials both with and without a ball. The zig-zag test involved three turning points spaced 5 m apart. Two high speed motion analysis cameras (Mikroton Cube 7, Germany) were set at 90° angle to record the motion at the turning points and to perform 2D motion analysis. The cameras placed towards first and last turning points to capture movements of the players. The motion data was recorded at 400 MHz. To collect the kinematic data, 6 reflective markers were placed on the following landmarks; acromion, greater trochanter, femoral epicondyle, lateral malleolus, calcaneus, and fifth metatarsal bilaterally.[20] All data was analyzed using the WinAnalyze program. Three different kinematic 2D motion analysis were performed for following movements; (1) number of steps during the pushing movement (NOSPM), (2) knee angle at the pushing movement (KAPM) were calculated separately while pushing from dominant and non-dominant leg-with ball and without ball. All movements described above were divided into 10% segments according to (a) the moment when the heel of first leg touched the ground, (b) the moment when the fingertip of the first leg left the ground.[20] Those 10% segments were then cut into 11 phases to specify pushing movement parts. While 1st, 2nd, 3rd and 4th phases explained the first parts of the movement; 5th, 6th, 7th, 8th phases showed the moment of changing direction. Final 3 frames (9th, 10th and 11th) were to see the change at the last part of the movement.

STATISTICAL ANALYSIS

Descriptive statistics were applied to identify the characteristics of subjects. The relationship between anthropometric, linear sprint speed, leg muscle qualities and running technique components which were independent variables and three different agility tasks (PAT, UNAT, USRAT) as dependent variables were evaluated using Pearson and Spearman correlation analysis, depending on normality of the data. We did not correlate zig-zag test knee angle variables (with ball) with PAT, UNAT. The level of significance was set at $p<0.05$. All analysis was executed in Statistical Package for the Social Science (SPSS), version 22.0.

RESULTS

Results of the current study are explained in the following sections.

ANTHROPOMETRIC COMPONENTS

None of the anthropometric components showed any statistical relationship between agility tests. Only age was significantly (negatively) correlated with agility tasks that did not include any soccer specific skill PAT and UNAT. On the other hand, there was no significant correlation between age and USRAT (Table 2).

LINEAR SPRINT AND LEG MUSCLE QUALITIES RESULTS

There was a statistically positive significant correlation between static 10 m sprint and PAT. Moreover, flying 20 m test was significantly correlated to UNAT. None of the drop jump components was significantly correlated with any of agility tests. For isokinetic strength components, correlation occurred statistically significant and positive with PAT and dominant leg extension ($60^0.sn^{-1}$)/flexion ($60^0.sn^{-1}$) and dominant leg extension ($300^0.sn^{-1}$)/flexion ($300^0.sn^{-1}$). In addition to these corre lations UNAT showed statistically negative significant relationship with dominant leg flexion and non-dominant leg extension angular velocity at $60^0.sn^{-1}$ (Table 3).

RUNNING TECHNIQUE RESULTS

The number of steps taken during turn movement of zig-zag test (pushing from dominant leg) was found to be significantly correlated with PAT while USRAT was correlated to pushing from non-dominant leg (without ball). Planned agility test (PAT) showed statistically significant relationship with knee angles (phase 4th, 5th, 6th) at the turn movement of zig-zag test. USRAT showed statistically significant and negative correlations with knee angles (phase 3rd, 4th, 5th, 6th, 7th, and 8th) at the turn movement of zig-zag test (Table 4).

DISCUSSION

The focus of the present study was to determine the relationship between anthropometric, physical, technic components and three different agility tasks. According to studies that examined the relationship between change of direction speed and body fat percentage, players who showed better results in change of direction speed performance had low body fat percentage.[21,22] It was reported that increased fat, decreases agility performance[1]. Moreover, Chaouachi et al. found statistically significant correlation between weight and body fat percentage (r = 0.58, r = 0.80) with basketball players.[23] In contrast to these significant correlations, Hazır et al. found non-significant correlations between Illinois agility test and anthropometric components.[24] Particularly, none of the studies included unplanned agility task. In the current study, the relationship between three different agility tests; (a) PAT, (b) UNAT, (c) USRAT and anthropometric components (weight, height, BMI, BFP) was investigated. Statistically significant correlations were only found between age and both PAT ($r=-0.621$, $p<0.05$) and UNAT ($r=-0.521$, $p<0.05$) However, USRAT showed no significant correlations between age and any other anthropometric components. According to these results, it is obvious that if an agility task is planned or has no soccer specific task; age may affect agility performance negatively. In such case, it can be reported that in accordance with players' age, agility performance may show

TABLE 2: Correlations between anthropometric components and PAT, UNAT, USRAT

Age	PAT r	UNAT r	USRAT r
	-0.621**	**-0.521***	-0.340
Weight	0.139	-0.261	-0.064
Height	-0.161	-0.227	0.002
BMI	0.143	-0.217	-0.077
BFP	0.402	-0.081	0.098

* p<0.05;** p<0.01

TABLE 3: Correlations between linear sprint and leg muscle qualities components and PAT, UNAT, and USRAT.

			PAT	UNAT	USRAT
			r	r	r
Sprint		Static.10m	**0.604****	-0.304	0.249
		Flying.20m	0.228	**0.513***	0.258
		Height	-0.358	0.080	-0.059
	Both Legs	Contact Time	0.351	-0.314	0.167
		Flight Time	-0.365	0.086	-0.059
Drop Jump		Height	-0.271	-0.069	0.167
	Dominant Leg	Contact Time	0.15	-0.174	-0.059
		Flight Time	-0.281	-0.057	-0.321
	Non-Dominant Leg	Height	-0.261	0.075	0.064
		Contact Time	0.273	0.351	-0.321
		Flight Time	-0.276	0.092	-0.066
Isokinetic Strength	Dominant Leg	Ext.60^0.sec-1	**0.487***	-0.432	0.289
		Flex 60^0.sec-1	**0.512***	**-0.497***	0.049
	Non-Dominant Leg	Ext. 60^0.sec-1	0.424	**-0.470***	0.231
		Flex 60^0.sec-1	0.336	-0.356	0.121
	Dominant Leg	Ext.300^0.sec-1	**0.494***	-0.367	0.099
		Flex 300^0.sec-1	**0.533***	-0.227	0.363
	Non-Dominant Leg	Ext. 300^0.sec-1	0.451	-0.451	0.276
		Flex 300^0.sec-1	0.198	-0.307	0.156

** $p<0.01$; * $p<0.05$

changes. Moreover; if a soccer-specific task is involved in an agility test, it may be reported that the performance is most likely to be affected by player's technical skill rather than anthropometric components. For this reason, it can be reported that a younger player may have worse agility performance because of his technical skill. In contrast, an older player may be better at performing agility tasks due to his technical skills.

Although it is believed that there is a strong relationship between linear sprint and agility performance, most of the studies showed contrast results to this hypothesis. In the study where researchers investigated the relationship between Illinois agility test and 20 m sprint test; authors reported statistically significant and low correlations (r = 0.472).[14] Young et al. reported that sprinting and sprinting while bouncing a ball and sprinting while changing direction were different abilities.[6] Tsitskarsis et al. pointed out that if a task involves complex skills such as running with a ball, dribbling, etc., it increases the complexity level of the task.[25] As a result, this complexity affects the performance. In the current study, 10 m SS was significantly correlated with PAT (r = 0.604, p<0.05), and flying 20 m sprint test was only correlated with UNAT (r = 0.513, p<0.05). USRAT showed no significant correlations between any of linear sprint tests. The differences between the correlation results may be due to the contents of three agility tasks. PAT involved planned change of directions and subjects had to run on a linear line, the contracture of the test may explain the significant relation with 10 m SS. UNAT consisted of one unplanned change in direction with a stimulus and the length of the test was more than PAT which may explain the significant relation between flying 20 m test. In contrast to these two agility tests, USRAT involved stimulus, unplanned change in direction and soccer specific skill so that it showed no significant correlation with any of linear sprint tests (p>0.05). Results of the current study support the findings that linear sprint and agility performances are different tasks.

TABLE 4: The relationship between running technique components and PAT, UNAT, and USRAT.

			PAT	UNAT	USRAT
			r	r	r
Step	Dominant Leg	With Ball			-0.104
		Without Ball	**-0.503***	0.095	-0.415
	Non-Dominant Leg	With Ball			0.109
		Without Ball	-0.159	-0.189	**-0.502***
Phase 1	Dominant Leg	With Ball			0.076
		Without Ball	0.082	0.123	-0.051
	Non-Dominant Leg	With Ball			0.091
		Without Ball	0.284	-0.309	-0.179
Phase 2	Dominant Leg	With Ball			-0.404
		Without Ball	0.101	-0.033	-0.260
	Non-Dominant Leg	With Ball			0.051
		Without Ball	0.194	-0.236	-0.105
Phase 3	Dominant Leg	With Ball			**-0.564***
		Without Ball	0.397	0.060	0.154
	Non-Dominant Leg	With Ball			0.196
		Without Ball	0.296	-0.118	0.088
Phase 4	Dominant Leg	With Ball			**-0.571***
		Without Ball	**0.623****	0.023	0.252
	Non-Dominant Leg	With Ball			0.091
		Without Ball	0.435	-0.178	0.047
Phase 5	Dominant Leg	With Ball			**-0.576***
		Without Ball	**0.520***	-0.129	0.277
	Non-Dominant Leg	With Ball			0.154
		Without Ball	0.351	-0.197	0.110
Phase 6	Dominant Leg	With Ball			**-0.593***
		Without Ball	0.574*	-0.070	0.419
	Non-Dominant Leg	With Ball			0.010
		Without Ball	0.397	-0.128	0.270
Phase 7	Dominant Leg	With Ball			**-0.615****
		Without Ball	0.456	-0.067	0.392
	Non-Dominant Leg	With Ball			-0.086
		Without Ball	0.365	-0.161	0.167
Phase 8	Dominant Leg	With Ball			**-0.569***
		Without Ball	0.295	-0.021	0.250
	Non-Dominant Leg	With Ball			-0.032
		Without Ball	0.142	-0.057	-0.015
Phase 9	Dominant Leg	With Ball			-0.353
		Without Ball	0.108	0.067	0.262
	Non-Dominant Leg	With Ball			-0.108
		Without Ball	-0.066	0.027	-0.179
Phase 10	Dominant Leg	With Ball			-0.174
		Without Ball	0.036	0.082	0.083
	Non-Dominant Leg	With Ball			-0.194
		Without Ball	-0.156	0.175	-0.159
Phase 11	Dominant Leg	With Ball			-0.181
		Without Ball	-0.067	0.172	0.076
	Non-Dominant Leg	With Ball			-0.199
		Without Ball	-0.311	0.448	-0.145

** p<0.01; * p<0.05

Even though the correlations between leg strength qualities and agility are moderate, it is believed that strength measures and sprinting performance are more likely to affect each other.[14] Young et al.[6] analyzed the relationship between 20 m sprint with three changes in direction and a countermovement jump as strength measurements. Correlations were found to be low (r=0.01) and non-significant.[14] Moreover, Young et al. investigated if muscle power was related to sprint with changing direction.[10] They used eight different sprint (8 m) tests with angles from 20° to 60°, they also measured concentric leg extension power and leg reactive strength. Results of the study showed that concentric leg extension power was not significantly related to sprints with changing direction ($p>0.05$). In contrast to these findings, some significant correlations ($r = 0.34$, $p<0.05$) were found between reactive strength and sprints with changing directions. According to these results it appears that strength and power measures may have an effect on short distance sprints with changes in directions.[14] In the present study we investigated the relationship between leg muscle qualities and three different agility tests. To measure reactive strength we used drop jump as suggested in the literature and none of the reactive strength variables were significantly correlated with any of the agility tests.[10] Moreover, isokinetic dynamometer measurements were used to investigate the relationship between concentric leg muscle qualities and agility tests. Statistical analysis showed that dominant leg extension and flexion ($60°.sn^{-1}$) were significantly correlated with PAT. Dominant leg flexion ($60°.sn^{-1}$) and non-dominant leg extension ($60°.sn^{-1}$) was also found to be significantly correlated in a negative way with UNAT. Moreover, PAT showed significant correlations with dominant leg extension and flexion ($300°.sn^{-1}$), ($p<0.05$). Similar to previous correlations USRAT again showed no significant correlations with any of the leg muscle qualities components ($p>0.05$). This difference between three agility tests may be due to the structures of the tests. When a player needs to change direction in response to a stimulus (reactive agility) the performance may be affected by leg muscle strength. However, perfor mance is not directly correlated to leg muscle qualities; because one has to read the stimulus, decide where to change direction, and act. So, in such a case better performance may be linked to player's read and act ability more than the leg muscle strength. However; to change direction in rapid succession, players still has to apply forces to the ground and change direction. To perform this kind of unplanned agility, leg muscle strength is also beneficial. In contrast to unplanned agility, players first had to run to the direction (specified before trial started) while performing PAT, lower their center of gravity, push the ground, and change direction. In such task, players do not need to decide, but have to be quick. As a result of these findings, it can be reported that leg muscle qualities have more effect on planned agility than unplanned agility. Considering in soccer game agility performance also depends on players' technical skill, USRAT was used to determine unplanned soccer specific agility performance and it had no significant correlations with leg muscle strength variables ($p>0.05$). While performing USRAT, players had to change direction in response to a stimulus, and then, run with dribbling ability. For these reasons, USRAT performance was presented by not only players' muscle qualities, but also their technical skill and reaction time.

The other important determinant of agility performance in the literature is running technique. To change direction rapidly players first have to decelerate, lean forward and lower their center of gravity. Moreover, if athletes need to change directions very often, they also have to run with lower center of gravity and shorten their stride lengths.[1] Even though it is believed that running technique has an important part on agility performance, there are few studies investigated the relationship between agility performance and running technique.[1] Suziki et al. investigated differences in support leg joint moment and moment power between the side -step (SS) and cross-step (CS) cutting techniques.[26] Results of the study showed that knee extensors had larger negative work in the deceleration phase for SS cutting.

Also, for acceleration phase the center of mass showed no significant differences in the horizontal velocity. Furthermore, according to the Neptune et al. and Rand and Ohtsuki, to decelerate in the braking phase of cutting motion knee extensors have to undergo eccentric contraction.[27,28] In our study, we aimed to investigate the relationship between three different agility tests and running technique. Results of the correlation analysis showed significant relationship between PAT and step number in the turning movement by pushing from dominant leg without ball ($r = -0.503$, $p<0.05$). To be better at PAT performance, players had to run quickly and change direction by applying force to the ground. To perform rapid change direction movement whom had fewer steps during the push movement also aimed to be better in PAT performance and in contrast, players with more steps spent more time to finish the agility task. Also, step number in the turning movement by pushing from non-dominant leg without ball showed statistically significant correlation ($r = -0.502$, $p<0.05$) with USRAT. The correlations between knee angles and agility performances were as follows; USRAT had significant negative correlations with pushing from dominant leg with ball knee angles at phases 3rd, 4th, 5th, 6th, 7th and 8th ($p<0.05$). In contrast to literature, these significant correlations show that if players lower their center of gravity to change direction, the total time to finish the trial gets longer and performance becomes worse. Moreover, PAT showed significant and positive correlations with pushing from dominant leg without ball knee angles at phases 4th ($r=0.623$), 5th ($r=0.520$) and 6th ($r=0.574$), ($p<0.05$). According to these significant correlations, when a player has less knee angle in the turning movement, PAT performance becomes better inversely; if a player's knee angle in the turning movement is larger, the PAT performance is longer. In contrast to previous negative correlations between USRAT and knee angles, significant correlations between PAT and knee angles support the literature. These differences may be explained as follows: USRAT included one change in direction and dribbling ability and showed negative significant correlations with pushing from dominant leg knee angles with ball because; while dribbling, it is hard for players to become closer to the ground by bending knees (lowering the knee angle) as they also have to control the ball. If players bend knees more than necessary, they may lose control of the ball. In such case agility performance may be affected negatively. However; to finish PAT, players did not have to perform any technical skill and they were free to become as close to ground as possible by bending knees (lowering the knee angle). For this reason, to change direction quickly in PAT, players had lower center of gravity and had better agility performances. On the other hand, UNAT had no significant correlations with any of the running technique components ($p>0.05$). UNAT included one change in direction which was dictated by a stimulus. As a result, to decide and change direction quickly, players had to be better at making decisions instead of getting closer to the ground.

CONCLUSION

In the current study, three different agility tests were used to evaluate the relationship between anthropometric, physical, technical components, and three different agility tasks in soccer players. Results of the study demonstrate the importance of an agility task including stimulus, reaction, and technical skill and suggest that specific agility tasks should be included as a part of the physical training program. In conclusion, agility performance differs according to context of the task. This investigation may create an impetus for future researches including kinematic analysis and variations of this study may also allow for a broader application to other sports.

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Conflict of Interest

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