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Mustafa SİYAH, PT, MSc[1]
Tuğba ŞANLI, PT, MSc[1]
Elif TURGUT, PT, PhD[2]

EFFECTS OF PHYSICAL AND COGNITIVE FACTORS ON REACTIVE AGILITY IN PROFESSIONAL FOOTBALL PLAYERS

ORIGINAL ARTICLE

ABSTRACT

Purpose: The primary aim of this study is to examine the effects of physical and cognitive factors on reactive agility in football players; the secondary aim is to compare reactive agility parameters in football players with low and high risk of lower extremity injury in football.

Methods: Thirty professional football players were included. All participants underwent physical and cognitive assessments. Reactive Agility Test (RAT), tablet-based right/left discrimination, Vertical Jump Test, T Agility Test (T-Test), Y Balance Test (YBT), 20 m sprint test and hamstring eccentric strength were evaluated. Tuck Jump assesment (TJ) was used for injury risk analysis.

Results: In our study, there was a negative correlation between RCT movement time parameter and Y-Balance test composite, posteromedial and posterolateral reach scores and right/left discrimination accuracy; there was a positive correlation with the T-Test (p<0.05). In addition, there was a negative correlation between the RAT response time parameter and the right/left discrimination test time, and a positive moderate correlation with the T-Test result (p<0.05). In the comparisons between the athletes with low and high risk of injury, there was no difference between the groups in the parameters of RAT movement, reaction and decision-making time (p>0.05).

Conclusion: Reactive agility in football players is associated with physical parameters such as dynamic balance and agility, and cognitive factors such as right/left discrimination. We suggest that sports physiotherapists working with football players should evaluate the reactive agility performance and consider the physical and cognitive factors associated with reactive agility during the rehabilitation.

Keywords: Athletes, Balance, Performance, Physical Fitness, Strength Sport

FİZİKSEL VE BİLİŞSEL FAKTÖRLERİN PROFESYONEL FUTBOL OYUNCULARINDA REAKTİF ÇEVİKLİK ÜZERİNE ETKİLERİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Bu çalışmanın birincil amacı futbolcularda fiziksel ve kognitif faktörlerin reaktif çeviklik üzerine etkisini incelemek; ikincil amacı ise futbolda alt ekstremite yaralanma riski düşük olan ve yüksek olan futbolcularda reaktif çeviklik parametrelerini karşılaştırmaktır.

Yöntem: Çalışmaya 30 profesyonel futbol oyuncusu dahil edildi. Tüm katılımcılara fiziksel ve kognitif değerlendirmeler uygulandı. Reaktif çeviklik değerlendirmesinde görsel uyaran ve fotoselli kapılar içeren Reaktif Çeviklik Testi (RÇT) kullanıldı. Tablet temelli sağ/sol diskriminasyonu, Dikey Sıçrama Testi, T Çeviklik Testi (T-Test), Y Denge Testi (Y-Denge), 20 m Sprint Testi ve Hamstring Eksentrik Kuvveti değerlendirildi. Yaralanma risk analizi için ise Tuck Jump Testi kullanıldı.

Sonuçlar: Çalışmamızda RÇT hareket süresi parametresi ile Y-Denge testi komposit, posteromedial ve posterolateral uzanma skoru ve sağ/sol diskriminasyonu doğruluk oranı arasında negatif yönde; T-Test ile pozitif yönde bir ilişki vardı (p<0,05). Ayrıca, RÇT tepki süresi parametresi ile sağ/sol diskriminasyonu test süresi arasında negatif yönde, T-Test sonucu ile pozitif yönde orta düzeyde ilişki gözlendi (p<0,05). Yaralanma riski düşük olan ve yüksek olan sporcular arasında yapılan karşılaştırmalarda gruplar arasında RÇT hareket, tepki ve karar verme süresi parametrelerinde fark yoktu (p>0,05).

Tartışma: Futbolcularda reaktif çevikliğin dinamik denge ve çeviklik gibi fiziksel parametrelerle ve sağ/sol diskriminasyonu gibi kognitif faktörlerle ilişkili olduğu gözlenmiştir. Bu nedenle özellikle futbolcular ile çalışan spor fizyoterapistlerinin reaktif çeviklik performansını değerlendirmesi ve rehabilitasyon aşamasında reaktif çeviklik ile ilişkili fiziksel ve kognitif faktörleri göz önüne almalarını önermekteyiz.

Anahtar kelimeler Sporcular, Denge, Performans, Fiziksel Uygunluk, Kuvvet Sporu

1 *Institute of Health Sciences, Hacettepe University, Ankara, Türkiye*
2 *Faculty of Physical Therapy and Rehabilitation, Hacettepe University, Ankara, Türkiye*

Correspondence (İletişim):

Tuğba ŞANLI
Institute of Health Sciences, Hacettepe University, Ankara, Türkiye
tubasanli96@gmail.com
ORCID: 0000-0001-6004-1734

Mustafa SİYAH
E-mail: fztmustafasiyah@gmail.com
ORCID: 0000-0003-1018-8089

Elif TURGUT
E-mail: elif.turgut.pt@gmail.com
RCID: 0000-0002-2006-9617

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INTRODUCTION

Football is accepted as the most popular sport worldwide. Therefore the studies on the importance of athlete health in football players, maintaining health and increasing performance in sports are increasing (1). Physical fitness, which is defined as the ability to perform professional, recreational, and daily activities correctly and successfully without fatigue, plays an important role in increasing the performance of athletes and determining the risk of injury (2). Many prominent physical fitness parameters for football players have been determined in the literature (3). These parameters can be summarized as especially balance, strength, flexibility and agility (4). Reactive agility, one of the physical fitness parameters, is defined as a sudden change in speed or direction that occurs in response to an unplanned stimulus containing a reactive component (5-7). Studies have shown that reactive agility exercises increase on-field performance in football players (8). As a common view, it is recommended to evaluate and develop reactive agility especially in athletes who are interested in football where there are many stimuli.

The importance of deficit in reactive agility or decrease in reactive agility performance as a risk factor for sports injuries is not yet known, but applications on agility in physiotherapy and rehabilitation, prevention of injuries, return to sports after injury, and sports-specific exercise programs are quite common (9). Therefore, knowing the effective factors in reactive agility practices, which are estimated to be associated with many physical and cognitive factors, may be the focus of the rehabilitation program.

Research on injury mechanisms and injury prevention has increased in recent years (10-12). However, there is no study in the literature that states whether reactive agility parameters can be used to determine the risk of injury (13, 14). In the literature, specific reactive agility test protocols have been determined for different sports branches and it is stated that the visual reactive component for football is more suitable for the nature of the sport (15).

Knowing the factors associated with reactive agility will provide basic information for training programs to be applied to increase reactive agility performance and for further studies in this field. Therefore, the primary aim of this study is to examine the effects of physical and cognitive factors on reactive agility in football players. Additionally, the secondary aim is to compare reactive agility parameters in football players with low and high risk of lower extremity injury in football.

METHODS

Participants

The GPower (version 3.1.9.3) program was used in the sample analysis before the study. In the analysis, it was determined that at least 29 analyzable athletes should be included in the study in order to show the relationship between the movement time, one of the reactive agility parameters, and the reaction time of the right/left discrimination test with 80% power. A total of thirty asymptomatic football players from Sebat Gençlikspor, Erdoğduspor, and Uçarsuspor football clubs were included in the study. Volunteer football players between the ages of 18-36, licensed for at least 5 years, continuing active sports life and training in the last 6 months were included in our study. Football players who had a history of visual, mental, or systematic disease, had acute or chronic pain in the last 6 months, goalkeepers, and did not volunteer to participate in the study were excluded. This study was designed as a cross-sectional study design and carried out between October 2019 and August 2021. Ethical approval was obtained from the Hacettepe University, the Non-Interventional Clinical Research Ethics Committee (Approval Date: 22 October 2019 and Approval Number: 2019/25-20) and all volunteers were informed about the study and signed a consent form.

Procedures

This study consisted, of two visits made to each sports club at different times. In the first visit, the athletes were informed about the research, and they were asked to maintain regular sleep patterns before the next visit. Also, demographic information (age, height, weight, sports age, weekly training time) of the participants were recorded. At the second visit, all participants performed the physical fitness tests [Reactive agility test (RAT), Left/Right Discrimination Test, Vertical Jump Test (VJT), Y Balance Test (YBT), 20m Sprint Test, Hamstring Eccentric Test, Tuck Jump Assessment (TJ)] after the standard warm-up procedure (5-minute jogging and standard dynamic lower extremity exercises).

Reactive agility was measured with the Reactive Agility Test system, which was created using a visual stimulus (16). Microgate Witty Photocell (Microgate, Bolzano, Italy) system with photocell and stimulating monitor was used for measurements. For measurement, 3 different balls were placed at a distance of 150 cm from the photocell door at 45° angles. From left to right, the balls were given the codes 'A', 'B', and 'C'. In addition, the measurement was recorded using a camera (iPhone 7; Apple Incorporated, CA, USA; 12 megapixels [f/1.8]) mounted on a tripod positioned to view the test area. During the test, the athletes were given standard commands; first, the athlete was asked to look at the monitor placed in front of him while in an upright position. When the players saw the first warning on the monitor, they were asked to switch to the 'Ready!' position. When the countdown from three was finished on the monitor, one of the names of the balls 'A', 'B', or 'C' flashed randomly. The football player started running towards the ball indicated by the lit letter. The football player, who came out of the photocell door, was asked to touch the ball with his foot and go back again and pass through the door.

Tablet-based right/left discrimination test was used to evaluate right/left discrimination (17). In this evaluation, the Noi Recognize App (Neuro-Orthopedic Institute, Australasia) used on the mobile device was used. Before starting the test, the test was explained to the participants. It was tried once for practice.

Jumping performance was evaluated using the VJT. Athletes were asked to jump as far as they could where they were. The test was repeated 3 times. The test was repeated separately on the right, left, and bilateral lower extremities, and the average result of each test was recorded (18). The test was recorded with a camera (iPhone 7; Apple Incorporated, CA, USA; 12-megapixel [f/1.8]) placed so that the athletes could see their contact with the ground. The recorded video was watched with the Kinovea (version: 0.8.15) program. With the slowed display, the time between the athlete's last contact with the ground before jumping and the first contact with the ground at the time of fall was determined. The jump height was determined by the formula: Jump height=9.81 x (flight time) ^{2}

Change of direction speed was evaluated with the T-test, which is a standard field test (19). For evaluation, 4 T-shaped cones were lined up on the track. The athlete was asked to touch the cones with the 'Start' command and return to the starting point. The total time was recorded with a stopwatch. The average result after 3 repetitions was accepted as the agility score of the athlete.

Dynamic balance was evaluated with the YBT (20). For the evaluation, the test setup was prepared by using a standard "Y" shaped tape measure with 120° angle between them. The athlete was asked to stand on one foot at the midpoint and maintain his balance with the other foot in the anterior, posteromedial and posterolateral directions. Atlethes were asked to reach as far as they could reach. The test was performed bilaterally. The reaching distances of the athletes were measured by doing 3 repetitions for each direction. The average of the 3 measurements obtained was divided by the leg length and multiplied by 100 to obtain the participant's normalized score. While determining the composite score, the amount of reach towards the anterior, posteromedial, and posterolateral directions on the side being evaluated was added, divided by 3 times the leg length, and multiplied by 100, and the participant's normalized composite score was recorded.

The 20 m Sprint Test was used to measure the sprint performance of the athletes (21). Marks were placed at the start (0 m) and finish (20 m) points for the measurement. The athlete was asked to run the entire distance in the shortest time, starting from 1 m behind the starting line. The athlete started running with the 'Start' command. The running time was recorded via the stopwatch. In the sprint performance with three repetitions, 2-minute rest intervals were given between runs. The best results in performances were included in the analysis.

Eccentric hamstring muscle strength was evaluated using the Hamstring Eccentric Strength Test (Nordic Hamstring Test) (22). In this test, the athlete was placed in the "Nordic Hamstring Exercise" standing position on the knees to the starting position. The athlete was asked to cross his hands in front of his chest and to move forward in a controlled manner without disturbing the body alignment as far as he could maintain this position. Meanwhile, the recording was taken with a camera placed perpendicular to the participant. The degree to which the athlete lost control and exceeded 10°/s speed was determined on the videotape and the angle between him and the starting position was taken. After 3 repetitions, the best score was recorded as the athlete's score.

Injury risk analysis was performed using the Tuck Jump Lower Extremity Injury Risk Analysis (23). For risk analysis, the athlete was asked to jump within an area marked on the floor, 41 cm long and 35 cm wide, for 10 seconds by pulling his knees as far as possible to his stomach. Before starting the assessment, the athletes were explained the test verbally and were told to jump for 10 seconds with only their knees drawn to their stomachs. The test was repeated 1 time. Jump performance was recorded with anterior and lateral view cameras (iPhone 7; Apple Incorporated, CA, USA; 12-megapixel [f/1.8]). Records of knee, foot, hip, and jump biomechanics were checked and injury risk analysis was performed according to these parameters.

Statistical Analyses

The data of all analyzed variables were evaluated with the Shapiro-Wilk Test and it was determined that all variables showed normal distribution ($p>0.05$). Pearson correlation analysis was used in statistical analysis. The correlation coefficient (r) between the variables was evaluated. Regression analysis was performed to examine the effect of independent variables on reactive agility. Student-t Test was used in independent groups in order to compare reactive agility parameters between groups of football players with low and high risk of injury. Demographic information and descriptive information about performance tests were presented as mean (X) and standard deviation (SD). SPSS 24.0 (IBM, USA) program was used for statistical analysis of the data. The statistical significance level was accepted as $p<0.05$ for all analyses (24).

RESULTS

This study was conducted with 30 football players between the ages of 18-28 (mean age 20.13 ± 0.5). The sports age of these football players was between 5 and 15 years (mean sports age 8.2± 2.32) (Table 1).

According to the results of the correlation analysis, a moderate correlation found between the duration of movement, and the posteromedial reach score obtained from the dominant and non-dominant side in the YBT composite score ($p<0.05$; respectively $r=-0.533$, $r=-0.591$). Additionally, a moderate negative correlation was found between the duration of movement, and the accuracy rate recorded in the right/left discrimination test ($p<0.05$, $r=-0.411$) (Table 2). According to the results of the regression analysis performed for further analysis, the YBT dominant and non-dominant side composite score obtained by the evaluation of the dynamic balance explains 28% to 34% of the RAT movement time.

On the other hand, a correlation was found between the movement time and the posterolateral

Table 1. Demographic Characteristics

	(n=30) X ± SD	Minimum – Maximum
Age (years)	20.13 ± 0.5	18-28
Height (cm)	177.4 ± 0.7	169-187
Weight (kg)	69.63 ± 1.29	52-88
BMI (kg/m²)	22.1 ± 1.92	17.2-26.6
Sports Age (years)	8.2 ± 2.32	5-15
Weekly Training Time (min)	503 ± 60	450-600

X: Mean, SD: Standart Deviation, BMI: Body Mass Index, cm: centimeter, kg: kilogram, m²: meter square, min: minute.

Table 2. The Relationship between Reactive Agility Parameters and Physical and Cognitive Factors

		Movement Time		Reaction Time		Decision Making Time	
	X ± SD	r	P value	r	P value	r	P value
Right/Left Discrimination Test, DOM Time	1.71 ± 0.44	-0.094	0.61	-0.061	0.74	-0.274	0.14
Right/Left Discrimination Test, DOM Accuracy Rate	70 ± 15.53	-0.206	0.27	0.106	0.57	-0.126	0.50
Right/Left Discrimination Test, Non-DOM Time	1.78 ± 0.54	-0.332	0.07	-0.492	**0.006***	-0.037	0.84
Right/Left discrimination Test, Non-DOM Accuracy Rate	68.33 ± 19.84	-0.411	**0.02***	-0.152	0.42	-0,080	0.67
VJT, DOM Score	6.61 ± 0.27	-0.136	0.47	-0.058	0.75	-0.11	0.56
VJT, Non-DOM Score	6.77 ± 0.28	-0.123	0.51	0.031	0.87	-0.039	0.83
VJT, Bilateral Score	11.93 ± 0.40	0.066	0.72	-0.155	0.41	-0.046	0.81
T-Test	9.70 ± 0.11	0.425	**0.01***	0.415	**0.02***	-0.01	0.95
YBT, Anterior, DOM Score	82.03 ± 1.42	-0.046	0.80	-0.082	0.66	0.137	0.47
YBT, Posteromedial, DOM Score	103.98 ± 1.62	-0.442	**0.01***	-0.063	0.74	-0.03	0.87
YBT, Posterolateral, DOM Score	93.07 ± 1.96	-0.677	**<0.001***	-0.201	0.28	-0.298	0.11
YBT, DOM Composite Score	93.12 ± 1.32	-0.533	**0.002***	-0.155	0.41	-0.111	0.55
YBT, Anterior, Non-DOM Score	81.52 ± 1.61	-0.183	0.33	-0.157	0.40	0.067	0.72
YBT, Posteromedial, Non-DOM Score	103.67 ± 1.74	-0.506	**0.004***	-0.2	0.28	-0.099	0.60
YBT, Posterolateral, Non-DOM Score	92.18 ± 1.97	-0.7	**<0.001***	-0.2	0.28	-0.334	0.07
YBT, Non-DOM Composite Score	92.46 ± 1.44	-0.591	**0.001***	-0.231	0.22	-0.167	0.37
Sprint 20 m	3.31 ± 0.04	0.24	0.20	0.319	0.08	-0.065	0.73
Hamstring Eccentric Strength	22 ± 1	0.083	0.66	-0.182	0.33	0.264	0.15

X: Mean, SD: Standart Deviation, p: statistical significance level, *p <0.05, sec: second, cm: centimeter. r: Pearson Corelation Coefficient VJT: Vertical Jump Test, T-Test: T Agility Test, YBT: Y Balance Test, DOM: Dominant side, Non-DOM: Nondominant side.

reach score of the YBT for both dominant and non-dominant sides respectively (p<0.01, r=-0.677, r=-0.700). In addition, there was a moderate correlation between the movement time and the T-Test score (p<0.05, r=0.425). There was a moderately positive correlation between response time and T-Test (p<0.05, r=0.415). In addition, a moderately significant correlation was found between the reaction time and the test time recorded with the right/left discrimination test (p<0.0, r=-0.492). According to the results of the regression analysis, the non-dominant side time score obtained by the right/left discrimination evaluation explains 24% of the RAT response time. There was no correlation between the decision-making time, another sub-parameter of RAT, and the physical and cognitive factors (p>0.05) (Table 2).

TJ risk analysis revealed n = 13 players with a high risk of injury (TJ score ≥ 6) and n = 17 players with a low risk of injury (TJ score <6). According to the Student's t-test results, there was no difference between the groups with low and high risk of injury in all RAT parameters (p>0.05) (Table 3).

DISCUSSION

According to the results of the study, it was found that reactive agility parameters were related to both physical and cognitive factors. On the other

Table 3. Comparison of Reactive Agility Parameters between Groups

	High Injury Risk (n=13) X ± SD	Low Injury Risk (n=17) X ± SD	P value
RAT - Movement Time (sec)	2.4 ± 0.16	2.3 ± 0.17	0.06
RAT - Reaction Time (sec)	0.28 ± 0.07	0.26 ± 0.05	0.45
RAT - Decision Time (sec)	0.56 ± 0.13	0.54 ± 0.16	0.70

X: Mean, SD: Standart Deviation, p: statistical significance level, sec: second, RAT: Reactive Agility Test

hand, the results of this study showed that there was no difference in any of the reactive agility parameters between the athletes at low and high risk of injury.

According to the study in which dynamic balance is associated with RAT movement time, football players with high dynamic balance performance show reactive agility performance, while better controlling body oscillations and dynamic balance components during direction change, allowing the athlete to achieve more stable ground contact (25). In addition, Dolan et al. (26) investigated the relationship between the balance test performed by the Balance Error Score System on 14 female football players and reactive agility. In this study, it has been shown that the move made towards the right side of the athlete is related to the balance on the left foot, and the move made towards the left side is related to the balance on the right foot, according to the stimulus while performing the task in reactive agility assessments. These results also show that there is a relationship between peripheral joint stability and the ability to change direction abruptly. Considering this relationship, dynamic balance exercises can be use to improve reactive agility. For this, agility skills exercises that include stability and change of direction can be included in training programs.

In cases of chronic pain and injury, the body parts lose the ability (speed and accuracy) to identify left or right images and this skill is also relevant to sports because it concerns complex motor laterity profiles and spatial orientation of the body for athletes beyond right/left preference (27). Our study is the first to compare left/right discrimination with reactive agility parameters. In our study, right/left discrimination was found to be associated with movement time and reaction time, which are sub-parameters of RAT. Although the right/left discrimination test also evaluated the decision-making time, no relationship was found with the RAT decision-making time. This result showed that even if they measure similar parameters in football players, computer-based decision-making tests can produce different results from evaluation tests suitable for sports on the field. Wilkerson et al. (28) reported that there was a difference between the tasks performed to the right and left in the reactive agility performance of the athletes in his study on 35 elite athletes who had concussions. Our results are in agreement with this study. However, it should be considered that there is no difference in reactive agility sub-parameters between players with low and high injury risk. Although it is known that reactive agility has an important place in football, it may be recommended to add right/left discrimination skills, which are not included in rehabilitation after injuries and routine sportive evaluations, to the tests. In addition, for the purpose of increasing reactive agility performance based on the relationship between reactive agility and right/left discrimination, training and practices to improve right/left discrimination skills can be given importance in training programs.

A moderate correlation was observed in terms of RAT movement time and reaction time parameters, but this relationship was not between decision making time and T-test. This shows that reactive agility assessments can also produce similar results with tests that evaluate agility performance due to changes in the direction of agility. However, there are also studies in the literature stating that agility tests involving changing direction on agility are not associated with reactive agility (29, 30). The most important reason for this situation is that RAT protocols can be very different from each other. If the RAT protocols selected for evaluation and the agility test, which includes a to change direction on agility, do not contain similar movement patterns, a statistically significant relationship may not be found between the two tests. This result shows the importance of choosing a sport-specific test design, especially in RATs.

There was no relationship between reactive agility and 20 m sprint performance. The reason for this situation is that the fast running within the RAT takes place in a short distance; it includes acceleration, deceleration, and change direction in agility. On the other hand, 20 m sprint running involves linear acceleration. It has been observed that studies on this subject offer conflicting results (29-31). Based on our results, it can be suggested that RATs in football should be evaluated independently of speed and handled separately in programs.

Vertical jumping ability, which is one of the most basic sportive skills in football, no correlation was shown between reactive agility parameters. These results are in agreement with the results of many studies in the literature (32-34).

It is known that hamstring eccentric muscle strength is effective in the performance of athletes. (35-37). The hamstring eccentric strength test was preferred because it allows an objective evaluation of the athlete without tiring the field without a device (16). According to the results, hamstring eccentric strength was not related with RAT subparameters. This result may be due to the indirect hamstring eccentric strength evaluation with field test and bilateral function evaluation.

In this study, no relationship was found between reactive agility parameters and lower extremity injury risk in football players. However, it has been suggested that rugby players with good decision-making skills can avoid situations that may cause potential injury relatively more easily, thus the risk of injury will be less. There is also evidence that agility training can prevent injuries (13,14).

There are some limitations of this study. All measurements made in this study were made on different pitches of different football teams. These different teams could not be visited in the same weather conditions, at the same times, and in the same environmental conditions. Another limitation of our study can be shown as testing cognitive factors in a limited framework. In addition, the injury risk analysis applied was evaluated with the TJ injury assessment. This analysis grouped football players for anterior cruciate ligament injuries and non-contact injuries. It did not have a classification feature for contact injury or overuse injury.

In conclusion, it was determined that reactive agility parameters in football players were related to both physical and cognitive factors. This study showed that reactive agility parameters are associated with right/left discrimination, agility including change direction in agility, and dynamic balance. On the other hand, the results of this study showed that there was no difference in any of the reactive agility parameters between the athletes with low and high injury risk.

According to these results, right/left separation skills should be evaluated by physiotherapists, especially after injuries. In cases where there are limitations for the development of reactive agility, dynamic balance training can be added to the program and an improvement in reactive agility performance can be achieved. Sports physiotherapists should consider reactive agility performance during injury prevention, performance evaluations, rehabilitation programs, and return to sports; and it is important for athletes to consider the physical and cognitive factors related to reactive agility in improving their performance.

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