Educational Administration: Theory and Practice
2024,30(4), 141-151
ISSN:2148-2403
https://kuey.net/

Research Article

Investigation Of The Relationship Between Reactive Strength And Speed, Change Of Direction, Agility And Reaction Time In Rugby Players

Musab ÇAĞIN[1*], Burak DOĞAN[2], Sezen ÇİMEN POLAT[3], Özlem ORHAN[4], Halil SAROL[5], Esin Çağla ÇAĞLAR[6]

[1*]Gazi University, Faculty of Sport Science, Department of Physical Education and Sports Teaching, Ankara, Turkey. https://orcid.org/0000-0001-8882-5506.
[2]Gazi University, Faculty of Sport Science, Department of Coaching Education, Ankara, Turkey. https://orcid.org/0009-0009-3087-7966
[3]Gazi University, Faculty of Sport Science, Department of Coaching Education, Ankara, Turkey. https://orcid.org/0000-0002-2143-8402.
[4]Gazi University, Faculty of Sport Science, Department of Coaching Education, Ankara, Turkey. https://orcid.org/0000-0002-4047-234X
[5]Gazi University, Faculty of Sport Science, Department of Recreation, Ankara, Turkey. https://orcid.org/0000-0002-1678-3244
[6]Hitit University, Faculty of Sport Science, Physıcal Educatıon and Sports Department, Çorum, Turkey. https://orcid.org/0000-0002-2717-0830

Citation: Musab ÇAĞIN et al., Investigation Of The Relationship Between Reactive Strength And Speed, Change Of Direction, Agility And Reaction Time In Rugby Players, *Educational Administration: Theory And Practice*, *30*(4), 141-151, Doi: 10.53555/kuey.v30i4.1414

ARTICLE INFO

ABSTRACT

Rugby is a team sport in which physical competition is dominant and motoric attributes such as speed, agility, strength and reaction as well as movement speed, decision time and reaction accuracy are emphasized. Based on the idea that reactive strength may be important for performance considering the characteristics of rugby, the present study aims to investigate the correlations between reactive strength and speed, change of direction, agility and reaction time. A total of 15 male rugby players with a mean age of 17.07±1.71 years, a mean height of 176.67±7.63 cm, a mean body weight of 76.67±16.22 kg and a mean sports age of 2.86 years participated in the study. Drop jump test (DJ), countermovement jump test (CMJ), 30 m sprint test, 505 test and Illionis test were applied to the subjects. The data obtained were analyzed using SPSS 26.0. The Pearson Product Moment Correlation Test was used to determine the correlations between the variables. The results of the analysis showed that there was a significant relationship between reactive strength and hand simple correct reaction rate, but there was no significant relationship between reactive strength values and values of sprint, change of direction and agility ($p<0.05$).

Keywords: Reactive strength, change of direction, agility, reaction, rugby

INTRODUCTION

The game of rugby is a contact sport that is played over two 30-40 minute halves with a 10-minute rest period and requires players to be at a high performance level both physically and physiologically. Additionally, rugby players repeat many activities during the game such as walking, sprinting, ball carrying and tackling to gain possession and positional advantage (Duthie et al., 2005). Having high levels of technical, tactical, physical and physiological performance is of great importance for rugby players to reach the highest level of efficiency. In addition to this, players are required to develop the two fundamental skills of ball and off-ball skills in order to succeed. During a rugby game, skills such as running, passing, catching, tackling, ruck, and maul are frequently applied. In order for all of these skills to be performed with high efficiency by the athlete, motoric characteristics such as strength, power, speed, reaction time, endurance and coordination are needed (Bompa & Claro, 2015). Previous studies on rugby suggest that rugby is classified as a sport based on speed (Bompa & Claro, 2015). Rugby players increase their speed over short distances due to the nature of the game. Therefore, acceleration and change of direction provide a great advantage for rugby players to change their position relative to their teammate or opponent in order to gain an advantage in the game. The distance and direction of running varies for actions such as protecting the ball from the opponent while running with or without the ball and scoring goals (Duthie et al., 2003). Not only linear sprints but also runs with directional changes come to the forefront in the display of skills such as hiding the ball from the opponent, moving towards the goal, and passing to teammates at different angles. The runs are usually performed with sideways and forward runs, backwards, zigzags and directional changes. Therefore, changing direction is very important in actions such as receiving the ball, keeping the ball under control, and deceiving the opponent. In order to change direction efficiently, the athlete is expected to have a high level of agility capacity. Agility is defined as the ability to slow down, change direction and accelerate efficiently in the shortest time. It is also stated that the ability to change direction is a component of agility (Young & Farrow, 2006; Brewer, 2017; Kara & Özal, 2022). In fact, Meir et al. (1993) emphasized the importance of agility for rugby as a result of their study analyzing rugby competitions. Reducing speed, turning the body in different directions and increasing speed are all part of the game of rugby. Therefore, components such as speed, power, concentric power, eccentric power, balance power, strength, rate of force change and stretching-shortening cycle can be determinants of rugby performance (Farrow et al., 2005).

Reaction time is defined as the time between the perception of a stimulus (movement of an opponent or ball, etc.) and the first muscle movement (Bompa & Claro, 2015). Reaction time, which holds an important place in rugby as in many other branches of sport, is critical in order to respond to the opponent's actions in offensive or defensive situations (Ratamess & Medicine, 2011). Athletic performance in rugby players involves the response to an opponent's movement, and performance can often depend on the reaction time required to initiate the muscle sequence in response to the opponent's movement, as well as the quality of the response (in terms of strength) (Marshall & Moran, 2013; Söyler & Çingöz, 2023).

The ability of the neuromuscular system to switch quickly and efficiently from an eccentric contraction to a concentric contraction is defined as reactive strength. Reactive force represents the ability to efficiently utilize the stretch-shortening cycle. This generally occurs when body parts are subjected to forces that activate stretching (Clark et al., 2018). Changes in reactive force may be primarily related to changes in stretch rate (a faster eccentric/concentric muscle movement) or changes in tension load (an increase in the height of the fall in bounce-oriented jumping tasks) (Di Giminiani & Petricola, 2016; Marshall & Moran, 2013). It is suggested that this may be related to skills such as speed, change of direction and jumping (Bobbert & Casius, 2005; McCormick et al., 2014; Sáez de Villarreal et al., 2012). In the study conducted by Hennessy & Kilty (2001), a significant relationship was found between bounce drop jump and countermovement jump and 30 m and 100 m sprints. In another study examining the relationship between reactive strength and change of direction in football, basketball, Australian football and tennis athletes, a relationship was found between change of direction and reactive strength (Young et al., 2002). Another study on athletes engaged in recreational field sports reported a correlation between reactive strength and change of direction (Lockie et al., 2014).

This study was conducted with the idea that the parameters of reactive strength, speed, change of direction, agility and reaction are important for the performance of rugby players.

Method

Study Design

The measurements of the study were carried out in an indoor gymnasium and it was determined that the air temperature during the measurements was between 23-24 degrees. First, demographic measurements of the athletes were taken. Afterwards, the athletes were informed about the tests to be applied and five-minute running and dynamic warm-up exercises were performed prior to the tests (Jones et al., 2016). The Optojump™ (Microgate, Bolzano, Italy) system was used for the counter movement jump (CMJ) and drop jump (DJ) tests (Castagna et al., 2013; Glatthorn et al., 2011). The Optojump system consists of two parallel rods placed on the ground, connected to a computer. The first rod is the transmitter and the second rod is the receiver, recording with a precision of 1 ms according to the principle of light interruption between the two rods. Therefore, the hang time (HT) is calculated according to the interruption of light at the ground contact time (CT). All variables (CT, HT, JH, RSI, RSI_{mod}) were calculated automatically using the Optojump™ device and detected on the connected computer screen through the Optojump™ registered software (OptojumpTM Next software, version 1.9.9.0). Reactive strength index and modified reactive strength index were calculated automatically by the Optojump™ system as the ratio of jump height (JH; in meters) to ground contact time (CT; in seconds) (McMahon et al., 2021).

Study Group

A total of 15 male Rugby athletes with a mean age of 17.07 ± 1.71 years, a mean height of 176.67 ± 7.63 cm, a mean body weight of 76.67 ± 16.22 kg and 2 years of active training participated in the study. The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Gazi University (Code: E-77082166-2023-460) All subjects were informed and signed a consent form before the measurements were taken.

Data Collection Tools

Measurement of height and body weight

The height of the athletes was measured using a wall-mounted stadiometer (Holtain Harpender Stadiometer, UK) with an accuracy of 0.1 cm. Body weight was measured using an electronic scale (Tanita TBF-401A USA) connected to a bioelectrical impedance analyzer with an accuracy of 0.1 kg.

Reactive Strength Index

Drop jump and counter movement jump tests were performed to determine reactive strength (McMahon et al., 2021).

For the DJ test, the subjects were instructed to stand on a frame with a height of 30 cm and then land on the ground on both feet with hands on the waist and elbows outward and jump to the highest height after contacting the ground. A recovery period of 30 seconds was given between each trial. 3 jumps were performed and the best value was recorded (Jones et al., 2016).

The CMJ test was performed to determine the modified reactive strength values. The athletes were allowed to choose the depth of movement. They were instructed to jump as fast and as high as possible with their hands on their waist. All athletes performed 3 jumps and rested for 1 minute between trials (McMahon et al., 2021).

Speed

The athletes' 30m sprint rates (first 20m and 30m) was measured using FitLight trainer sensors (±0.01 s accuracy) on a tartan floor in an indoor track and field arena (Fitlight Sports Corp., Canada). The FitLight trainer sensor was adjusted according to the average hip height of the participants. During the sprint, 3 sensors were placed at the starting line, 20 m line and finish line (30 m). The athletes started the sprint in the high starting position when they felt ready from the line located one meter behind the start sensor. The first 20 m and 30 m sprint values were recorded. The subjects were asked to run at maximum speed and the sprint test was performed three times with 3 minutes of passive rest in between. The results of the sprint test were measured in seconds and split seconds and the best times were recorded (Furlong et al., 2021).

Change of Direction

Change of direction was measured through the 505 test. The test consisted of a 10-meter acceleration run followed by a 5-meter distance to be completed with a turn, for a total length of 20 m (Figure 1). Two Fitlight (Fitlight Sports Corp., Canada) sensors were placed at the 10 m line according to the participants' average hip height. At the start signal, the athlete accelerated, first crossed the 10 m line, quickly turned around the 5 m turn line and returned to the finish line at the 10 m line. After the athletes were informed about the test, they were allowed to perform a number of trials at a slow pace. The athletes were asked to perform warm-up and stretching exercises for 5-6 minutes before starting the test. This test was repeated twice with 3-4 min intervals and the best score was taken into consideration.

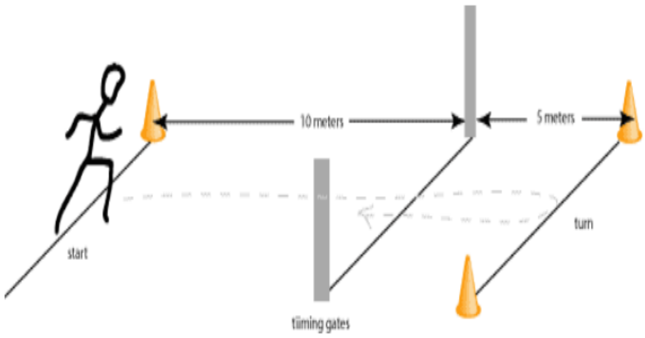

Figure 1. 505 Test (Büyükyazı, 2020; Hazır et al., 2010)

Agility

The agility test track was marked with three cones spaced 3.3 meters apart with a width of 5 meters and a length of 10 meters in the middle of four center cones (Figure 2). The four corner cones were placed 2.5 meters away from the center cones (Figure 2). The course consisted of a 40-meter straight run and a 20-meter slalom run with a 180-degree turn every 10 meters. A FitLight trainer sensor system with an accuracy of 0.01 seconds was placed at the end of the track. Before the test, the subjects were informed about the course, then they were allowed to perform 3-4 trials at a low pace. Then, warm-up and stretching exercises were applied to the subjects at a self-determined low tempo. The subjects took the prone position at the starting line and made their exits. The test was repeated twice with complete rest for each subject and the best grade was recorded (Raya et al., 2013).

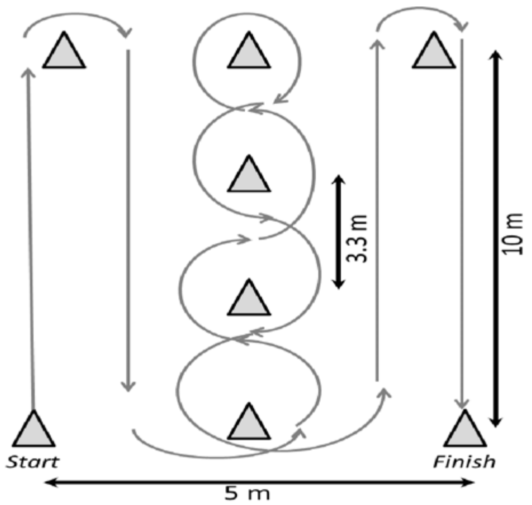

Figure 2. Agility Test (Raya et al., 2013)

Reaction Tests

ÇAĞIN Hand and Foot Reaction Tests

The ÇAĞIN Hand and Foot Reaction Test is a test battery applied with FitLight Trainer or BlazePod devices to determine the subjects' simple, selective and discriminative reaction performance. It is a reaction test battery with very high reliability and validity (r= 0.70-0.90) (Çağın et al., 2024). In the present study, the tests were performed using the FitLight Trainer device.

ÇAĞIN Color Blindness Test

Prior to both the hand and foot reaction tests, the ÇAĞIN Color Blindness Test was administered to determine whether the subject is fit to take the test. The subject is randomly shown the colors yellow, red, blue and green and asked which color they are. The person who gives 2 correct answers for each color is included in the test. If the subject gives more than 1 wrong answer, they are not included in the test.

ÇAĞIN Hand Simple Reaction Test

Sensors and a blue cup are placed on the table according to the measurements based on protocol. The subject is asked to turn off the blue lights that will be turned on randomly for 20 seconds. After each light is turned off, they are asked to switch hands and touch the glass to the half area that is close to the subject. Lights extinguished without switching hands or without touching the half-area close to oneself are evaluated as error points (1 point for each error). At the end of 20 seconds, the reaction time, the number of lights extinguished and the number of errors made are recorded and analyzed. The test is administered twice and the best score is taken into account.

ÇAĞIN Hand Selective Reaction Test

Sensors and blue, red, yellow and green-colored glasses are placed on the table as per the measurements in accordance with the protocol. The subject is asked to take the cup and turn it off according to the color of the lights that will be turned on randomly for 20 seconds. After each light is turned off, the subject is asked to switch hands and touch the glass to the half-area closest to themselves. Failure to switch hands, not touching the half-area close to oneself or turning off the lights with a glass of the wrong color is considered as an error score (1 point for each error). At the end of 20 seconds, the reaction time, the number of lights extinguished and the number of errors made are recorded and analyzed. The test is administered twice and the best score is taken into account.

ÇAĞIN Hand Discriminative Reaction Test

Sensors and a red cup are placed on the table in accordance with the measurements of the protocol. The subject is asked to turn off only the red color among the blue, red, green and yellow colors that will randomly light up at the same time for 20 seconds. After each light is turned off, the subject is asked to switch hands and touch the glass to the half-area closest to themselves. Failure to switch hands, failure to touch the cup to the half-area close to oneself or turning off the wrong light is evaluated as an error score (1 point for each error). At the end of 20 seconds, the reaction time, the number of lights turned off and the number of errors made by the subject are recorded and analyzed. The test is administered twice and the best score is taken into account.

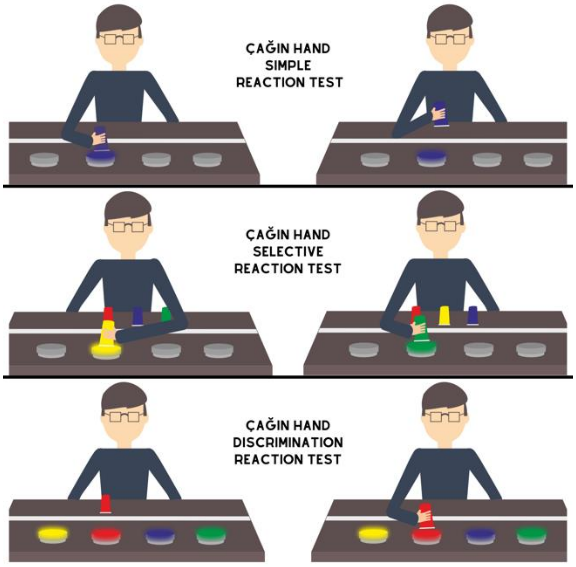

Figure 3. ÇAĞIN Hand Reaction Tests

ÇAĞIN Foot Simple Reaction Test

Sensors and a blue rectangular sheet of paper are placed on the floor as per the measurements in accordance with the protocol. The subject is asked to turn off the blue lights that will be turned on randomly for 20 seconds. After each light is turned off, it is asked to switch the foot on the paper and the foot that turns off the light. Lights turned off without switching feet are evaluated as error points (1 point for each error). At the end of 20 seconds, the reaction time, the number of lights turned off and the number of errors made by the subject are recorded and analyzed. The test is administered twice and the best score is taken into account.

ÇAĞIN Foot Selective Reaction Test

Sensors and blue, red, yellow and green rectangular papers are placed on the floor according to the protocol. The subject is asked to turn off the lights that will be turned on randomly for 20 seconds with one foot on the rectangular paper according to its color. After each light is turned off, the subject is asked to switch the foot on the paper and the foot that turns off the light. Failure to switch feet or turning off the lights by stepping on the wrong colored paper is considered as an error score (1 point for each error). At the end of 20 seconds, the reaction time, the number of lights turned off and the number of errors made by the subject are recorded and analyzed. The test is administered twice and the best score is taken into account.

ÇAĞIN Foot Discriminative Reaction Test

Sensors and a red rectangle are placed on the floor in accordance with the protocol measurements. The subject is asked to turn off only the red color among the blue, red, green and yellow colors that will light up at the same time in a randomized manner for 20 seconds. After each light is turned off, it is asked to switch the foot on the paper and the foot that turns off the light. Failure to switch feet or turning off the wrong light is assessed as an error score (1 point for each error). At the end of 20 seconds, the reaction time, the number of lights turned off and the number of errors made by the subject are recorded and analyzed. The test is administered twice and the best score is taken into account.

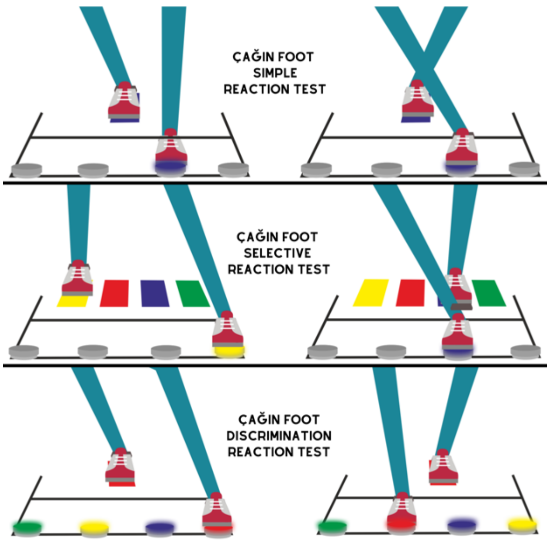

Figure 4. ÇAĞIN Foot Reaction Tests

Statistical Analysis of ÇAĞIN Hand and Foot Reaction Tests

ÇAĞIN Hand and Foot Reaction Tests can determine the subjects' average reaction time, total number of touches and number of errors. With these data, the average reaction time as well as the correct and incorrect reaction rate of the subject can be determined.

Average Reaction Time: Automatically determined by the FitLight Trainer after 20 seconds of testing (e.g. 0.444 ms).

Correct and Incorrect Reaction Rate: The ratio between the total number of touches and the number of errors is taken into account. For example, if the subject touched 20 times and made 5 errors, the correct reaction rate of the subject is determined as 75% and the incorrect reaction rate is determined as 25%.

Statistical Analysis

The data were analyzed using the SPSS 26.0 package program. Following the descriptive statistics, the Pearson Product Moment Correlation Test was applied for the relationship between the parameters. Statistical significance level was accepted as $p<0.05$.

FINDINGS

The findings obtained in the study showed that there was a statistically significant difference between the speed values of the subjects (20m-30m) and DJ and CMJ values. When the agility and change of direction findings of the subjects were analyzed, a significant relationship was found between the 505 test (10m) and the Illinois test and DJ and CMJ values. There was a significant relationship between the selective reaction test, which was examined within the scope of the hand reaction test, and DJ and CMJ values. Moreover, a significant relationship was found between the discriminative foot reaction test and the DJ test.

Table 1. Demographic features of the subjects

Variables	$\bar{x}$ ±Sd	Min.	Max.
Age (years)	17.07±1.71	15	22
Height (cm)	176.67±7.63	160.00	186.00
Weight (kg)	76.67±16.22	51.00	117.00
Sports Age (years)	2.87±3.83	1	16

Table 2. The subjects' values related to the speed, change of direction, agility, DJ and CMJ tests

	$\bar{x}$ ±Sd	Min.	Max.
20m (sec)	3.36 ± 0.24	3.02	3.89
30m (sec)	4.73 ±0.34	4.30	5.56
505 $test_{15m}$ (sec)	3.77 ± 0.22	3.44	4.40
505 $test_{10m}$ (sec)	2.14±0.19	1.93	2.54
Illinois test (sec)	17.14 ±1.27	15.43	17.14
DJ_{jh} (cm)	24.447±5.804	12.80	32.40
DJ_{ct} (ms)	0.403±0.077	0.283	0.519
DJ_{ht} (ms)	0.443±0.055	0.323	0.514
RSI	0.620 ±0.166	0.29	0.95
CMJ_{jh} (cm)	26.467±6.356	14.5	37.8
CMJ_{ht} (ms)	0.461±0.058	0.344	0.555
RSI_{mod}	56.55±7.14	42.15	68.11

DJ_{jh}: Drop Jump jump height; **DJ_{ct}**: Drop jump ground contact time; **DJ_{ht}**: Drop jump hang time; **RSI**: Reactive strength index; **CMJ_{jh}**: Countermovement jump jump height; **CMJ_{ht}**: Countermovement jump hang time; **RSI_{mod}:** Modified reactive strength index.

Table 3. The relationship between the speed, change of direction and agility test values of the subjects and the DJ and CMJ tests

	DJ_{jh}	DJ_{ct}	DJ_{ht}	RSI	CMJ_{jh}	CMJ_{ht}	RSI_{mod}
20 m	**-0.57*** **(0.03)**	-0.11 (0.69)	**-0.58*** **(0.02)**	-0.40 (0.14)	**-0.71**** **(0.00)**	**-0.72**** **(0.00)**	-0.10 (0.73)
30 m	**-0.62*** **(0.01)**	-0.20 (0.48)	**-0.56*** **(0.01)**	-0.38 (0.17)	**-0.79**** **(0.00)**	**-0.81**** **(0.00)**	0.31 (0.27)
505 test (10m)	**-0.60*** **(0.02)**	-0.20 (0.49)	**-0.60*** **(0.02)**	-0.29 (0.30)	**-0.71**** **(0.00)**	**-0.71**** **(0.00)**	-0.05 (0.86)
505 test (15m)	-0.10 (0.72)	0.17 (0.56)	-0.10 (0.72)	-0.15 (0.61)	-0.39 (0.15)	-0.39 (0.15)	0.22 (0.43)

Illinois test	**-0.59*** **(0.02)**	-0.08 0.77	**-0.61*** **(0.02)**	-0.42 (0.12)	**-0.78**** **(0.00)**	**-0.80**** **(0.00)**	0.20 (0.48)

* $p<0.005$ **$p<0.01$

Table 4. Descriptive statistics of the subjects for the hand reaction test

	Variables	$\bar{x}$ ±Sd	min.	max.
Reaction Time	Hand Simple (ms)	0.651±0.062	0.542	0.774
	Hand Selective (ms)	1.010±0.251	0.157	1.266
	Hand Discriminative (ms)	0.690±0.124	0.520	0.984
Reaction Accuracy Rate	Hand Simple (%)	91.95±14.72	50	100
	Hand Selective (%)	89.65±11.05	53.33	100
	Hand Discriminative (%)	98.84±3.19	88.89	100

Table 5. The relationship between the hand reaction test values, DJ values and RSI of the subjects

Variables			DJ_{jh}	DJ_{ct}	DJ_{ht}	RSI
Reaction Time	Hand Simple (ms)	r	-0.18	0.09	-0.19	-0.16
		p	0.52	0.75	0.49	0.58
	Hand Selective (ms)	r	-0.63	-0.34	-0.63	-0.31
		p	**0.01***	0.21	**0.01***	0.27
	Hand Discriminative (ms)	r	-0.34	-0.01	-0.34	-0.31
		p	0.21	0.96	0.21	0.26
Reaction Accuracy Rate	Hand Simple (%)	**r**	-0.34	0.24	-0.34	-0.53
		p	0.21	0.38	0.21	**0.04***
	Hand Selective (%)	**r**	-0.08	0.24	-0.08	-0.22
		p	0.79	0.39	0.79	0.44
	Hand Discriminative (%)	**r**	-0.16	0.27	-0.16	-0.39
		p	0.58	0.34	0.58	0.15

* $p<0.005$ **$p<0.01$

Table 6. The relationship between the subjects' hand reaction test values, CMJ values and RSI_{mod}

Variables			CMJ_{jh}	CMJ_{ht}	RSI_{mod}
Reaction Time	Hand Simple (ms)	r	-0.35	-0.37	-0.06
		p	0.20	0.18	0.83
	Hand Selective (ms)	r	-0.57	-0.57	-0.00
		p	**0.03***	**0.03***	0.99
	Hand Discriminative (ms)	r	-0.22	-0.23	0.30
		p	0.43	0.41	0.27
Reaction Accuracy Rate	Hand Simple (%)	**r**	-0.47	-0.47	-0.13
		p	0.08	0.08	0.66
	Hand Selective (%)	**r**	-0.47	-0.47	0.12
		p	0.08	0.08	0.67
	Hand Discriminative (%)	**r**	-0.33	-0.33	0.05
		p	0.23	0.23	0.87

* $p<0.005$ **$p<0,01$

Table 7. Descriptive statistics of the subjects for the foot reaction test

	Variables	$\bar{x}$ ±Sd	min.	max.
Reaction Time	Foot Simple (ms)	0.648±0.101	0.515	0.858
	Foot Selective (ms)	1.078±0.183	0.698	1.404
	Foot Discriminative (ms)	0.597±0.093	0.440	0.823
Reaction Accuracy Rate	Foot Simple (%)	97.10±4.90	84.38	100
	Foot Selective (%)	89.71±10.53	68	100
	Foot Discriminative (%)	98.56±2.689	92.59	100

Table 8. The relationship between the foot reaction test values, DJ values and RSI of the subjects

Variables			DJ_{jh}	DJ_{ct}	DJ_{ht}	RSI
Reaction Time	Foot Simple (ms)	r	-0.04	-0.02	-0.09	-0.07
		p	0.88	0.98	0.76	0.82
	Foot Selective (ms)	r	-0.26	0.05	-0.23	-0.32
		p	0.35	0.87	0.40	0.25
	Foot Discriminative (ms)	r	-0.35	0.21	-0.38	-0.48
		p	0.20	0.45	0.16	0.07
Reaction Accuracy Rate	Foot Simple (%)	**r**	-0.14	-0.04	-0.14	-0.13
		p	0.62	0.90	0.62	0.65
	Foot Selective (%)	**r**	-0.02	-0.06	-0.02	0.09
		p	0.94	0.83	0.94	0.74
	Foot Discriminative (%)	**r**	-0.04	-0.53	-0.04	0.34
		p	0.90	**0.04***	0.90	0.22

* p<0.005 **p<0.01

Table 9. The relationship between the subjects' foot reaction test values, CMJ values and RSI_{mod}

Variables			CMJ_{jh}	CMJ_{ht}	RSI_{mod}
Reaction Time	Foot Simple (ms)	r	-0.25	-0.28	0.49
		p	0.36	0.31	0.07
	Foot Selective (ms)	r	-0.16	-0.14	-0.19
		p	0.58	0.62	0.50
	Foot Discriminative (ms)	r	-0.49	-0.49	0.03
		p	0.07	0.06	0.91
Reaction Accuracy Rate	Foot Simple (%)	**r**	-0.12	-0.12	0.01
		p	0.68	0.68	0.97
	Foot Selective (%)	**r**	-0.29	-0.29	0.17
		p	0.30	0.30	0.55
	Foot Discriminative (%)	**r**	0.06	-0.06	0.23
		p	0.84	0.84	0.42

* p<0.005 **p<0.01

Table 10. The relationship between DJ_{jh}, DJ_{ct}, DJ_{ht} RSI and CMJ_{jh}, CMJ_{ht}, RSI_{mod}

Variables	CMJ_{jh}	CMJ_{ht}	RSI_{mod}
DJ_{jh}	**0.78** (0.00)**	**0.78** (0.00)**	**0.78**(0.00)**
DJ_{ct}	0.16 (0.56)	0.14 (0.61)	0.15 (0.61)
DJ_{ht}	**0.78* (0.00)**	**0.78** (0.00)**	**0.78** (0.00)**
RSI	**0.55* (0.03)**	**0.57* (0.03)**	**0.57* (0.03)**

* p<0.005 **p<0.01

DISCUSSION AND CONCLUSION

In the present study, it was aimed to reveal the correlations between reactive force and speed, change of direction, agility and reaction time of rugby players. Significant differences were found in speed, agility, change of direction and certain reaction parameters of the players.

The findings on sprint and jumping showed that there were significant negative relationships between 20m and 30m sprint values and DJ_{jh}, DJ_{ht} and CMJ_{ht}, CMJ_{jh} values. The game of rugby is physically demanding, requiring players to participate in a large number of physical collisions and tackles. Therefore, short duration and high intensity sprints can be important for game performance. Players are required to have well-developed physical conditioning (speed, agility, strength) and the skill level to tolerate the physiological demands, as well as the wide range of attacking and offensive skills required by the competition. In the study conducted by Zabaloy et al. (2022) on elite male rugby players, a relationship between speed and jumping was found and differences were also noted across positions (Zabaloy et al., 2022). Tillin et al. (2013) found that short sprint performance (5m) and isometric squat were most strongly associated with the strength ratio obtained at the baseline in rugby players, and there was also a relationship between jump height and sprint. In another study, it was reported that there was a significant relationship between power, agility and speed in rugby players (Wang et al., 2016). Moreover, there are studies in the literature reporting no relationship between speed and jumping (Jiménez et al., 2018; McBride et al., 2009). Considering the results of the study, the relationship between speed and reactive strength values is thought to be due to the fact that the players are in an effort characterized by a large number of high-intensity actions due to the structure of the game of rugby.

In another finding of the study, it was determined that there was a significant relationship between DJ and CMJ and change of direction. It is emphasized that directional change performance is important in the game of rugby. Players may frequently change movement speed and direction during the match to avoid contact with opposing players or to gain positional advantages (Freitas et al., 2022). In a study comparing different team sports (football, rugby, handball), it was reported that rugby players performed better in terms of changing direction (Loturco et al., 2020). Although these three sports have similar game characteristics, the authors stated that this difference may be due to the training history and professional careers of the athletes. In the study conducted by Delaney et al. (2015), negative correlations were found between the reactive strength obtained from the 30 cm drop jump test and the change of direction test in the dominant leg and non-dominant leg direction in rugby athletes. This finding suggests that the dominant leg may play a determinant role on the mechanisms used during the change of direction and in this context, it has a complex interaction with reactive force. On the other hand, in a study conducted by Lockie et al. (2014) on recreational field sports athletes, negative correlations were found between the CODAT change of direction test and reactive strength obtained from the 40 cm drop jump test. However, in the study conducted by Maloney et al. (2017) in male athletes engaged in recreational sports, no significant relationship was found between change of direction and reactive strength. Similarly, in a study conducted by Young et al. (2002) on athletes participating in football, basketball, Australian football, and tennis, it was found that reactive strength differed depending on the type of direction change. These different results suggest that the relationship between the ability to change direction and reactive strength may vary depending on specific factors and sport.

Furthermore, another finding of the study was the significant difference between agility and jumping values. Agility involves the ability to effectively take off, change direction and re-accelerate while maintaining body control and minimizing loss of speed. Since rugby is a game of both offense and defense, agility is one of the most important factors for a satisfactory performance (Lepciuc et al., 2021). Agility in rugby is also important in terms of improving the efficiency of game performance (Rajput, Uppal & Chitkara, 2016). Moreover, vertical jumping can also be effective, especially in line-out situations for backs. At the same time, the power of the jump can contribute to leg movement and consequently ball speed during tackles (Gabbett et al., 2008). There are different findings in the literature on the relationship between agility and reactive strength. In the study conducted by Jones et al. (2016) on female rugby athletes, a negative relationship was found between agility and reactive strength obtained from the drop jump test performed from a height of 30 cm. Singa et al., on the other hand, reported a relationship between speed, agility and jump values in a study on elite rugby players (Singa et al., 2020).

Rugby players are required to react efficiently and adequately in a changing and unpredictable environment. For this, attention and reaction are crucial; the adequacy of these elements requires effective decision-making (Pesce et al., 2007). In the present study, the hand and foot reactions of the players were evaluated as simple, selective and discriminative. When the hand reaction values were analyzed, a significant relationship was found between simple reaction and RSI, and between discriminative reaction and DJ/DJ_{ht} and CMJ/CMJ_{ht} values. In foot reaction, a relationship was found between discriminative reaction and DJ. In the study conducted by Gabbet et al. on rugby players, it was stated that effective performance may be related to both physical (speed, strength, agility) and other factors such as quick decision-making, reaction and visual scanning. In particular, it was emphasized that reaction is important for parameters such as agility and change of direction (Gabbett et al., 2008). Reactive strength is defined as the ability to complete a fast stretch-shortening cycle (SSC) action, i.e. the ability to perform a fast eccentric (braking) phase and then quickly switch to a fast concentric (propulsive) phase (Struzik et al., 2016). In their study with rugby players, McMahon et al. measured reactive power with DJ and CMJ and emphasized that reaction, jumping power, agility, and change of direction should be considered holistically.

In conclusion, it can be said that rugby is a physically and mentally demanding sport. Many physical contacts and interventions that occur in the game may require players to have a well-developed physical condition and skill level. Quick decision-making and the ability to act quickly as a result of this decision-making are crucial. Although speed, change of direction, mobility, agility, and reactive strength have been examined in previous studies on rugby players in the literature, there is no study on simple, selective and discriminative reaction. In this context, it is suggested for future studies to include the parameters that are thought to affect rugby performance in training by increasing the awareness of both players and coaches.

REFERENCES

1. Bobbert, M. F., & Casius, L. J. R. (2005). Is the effect of a countermovement on jump height due to active state development?. *Medicine and Science in Sports and Exercise*, 208, 440-6. https://doi.org/10.1249/01.MSS.0000155389.34538.97
2. Bompa, T., & Claro, F. (2015). *Periodization in rugby*. Meyer & Meyer Verlag.
3. Brewer, C. (2017). *Athletic Movement Skills: training for sports performance*. Human Kinetics.
4. Büyükyazı, G. (2020). *İnsan Performansının Ölçülmesi ve Değerlendirilmesi*. Gazi Kitabevi.
5. Castagna, C., Ganzetti, M., Ditroilo, M., Giovannelli, M., Rocchetti, A., & Manzi, V. (2013). Concurrent validity of vertical jump performance assessment systems. *The Journal of Strength & Conditioning Research*, 27(3), 761-768.
6. Clark, M., McGill, E. A., Lucett, S., & National Academy of Sports Medicine. (2018). *NASM essentials of personal fitness training (Sixth edition. ed.)*. Jones & Bartlett Learning.
7. Çağın, M., Polat, S. Ç., Orhan, Ö., Çetin, E., Abdioğlu, M., Yarım, İ., & Cicioğlu, H. İ. (2024). Reliability and Validity of ÇAĞIN Hand and Foot Reaction Tests Protocol. *Journal of Education and Future*, (25), 59-74. https://doi.org/10.30786/jef.1386526
8. Delaney, J. A., Scott, T. J., Ballard, D. A., Duthie, G. M., Hickmans, J. A., Lockie, R. G., & Dascombe, B. J. (2015). Contributing factors to change-of-direction ability in professional rugby league players. *The Journal of Strength & Conditioning Research*, 29(10), 2688-2696.
9. Di Giminiani, R., & Petricola, S. (2016). The power output-drop height relationship to determine the optimal dropping intensity and to monitor the training intervention. *The Journal of Strength & Conditioning Research*, 30(1), 117-125.
10. Duthie, G., Pyne, D., & Hooper, S. (2003). Applied physiology and game analysis of rugby union. *Sports Medicine*, 33, 973-991.
11. Duthie, G., Pyne, D., & Hooper, S. (2005). Time motion analysis of 2001 and 2002 super 12 rugby. *Journal of Sports Sciences*, 23(5), 523-530.
12. Farrow, D., Young, W., & Bruce, L. (2005). The development of a test of reactive agility for netball: a new methodology. *Journal of Science and Medicine in Sport*, 8(1), 52-60.
13. Freitas, T. T., Pereira, L. A., Alcaraz, P. E., Comyns, T. M., Azevedo, P. H., & Loturco, I. (2022). Change-of-direction ability, linear sprint speed, and sprint momentum in elite female athletes: differences between three different team sports. *Journal of Strength and Conditioning Research*, 36(1), 262-267.
14. Furlong, L.-A. M., Harrison, A. J., & Jensen, R. L. (2021). Measures of strength and jump performance can predict 30-m sprint time in rugby union players. *The Journal of Strength & Conditioning Research*, 35(9), 2579-2583.
15. Gabbett, T. I. M., Kelly, J., & Pezet, T. (2007). Relationship between physical fitness and playing ability in rugby league players. *The Journal of Strength & Conditioning Research*, 21(4), 1126-1133.
16. Gabbett, T. J., Johns, J., & Riemann, M. (2008). Performance changes following training in junior rugby league players. *The Journal of Strength & Conditioning Research*, 22(3), 910-917.
17. Glatthorn, J. F., Gouge, S., Nussbaumer, S., Stauffacher, S., Impellizzeri, F. M., & Maffiuletti, N. A. (2011). Validity and reliability of Optojump photoelectric cells for estimating vertical jump height. *The Journal of Strength & Conditioning Research*, 25(2), 556-560.
18. Hazır, T., Mahir, Ö. F., & Açıkada, C. (2010). Genç Futbolcularda Çeviklik ile Vücut Kompozisyonu ve Anaerobik Güç Arasındaki İlişki. *Spor Bilimleri Dergisi*, 21(4), 146-153.
19. Hennessy, L., & Kilty, J. (2001). Relationship of the Stretch-Shortening Cycle to Sprint Performance in Trained Female Athletes. *The Journal of Strength and Conditioning Research*, 15, 326-331. https://doi.org/10.1519/00124278-200108000-00011
20. Jiménez-Reyes, P., Samozino, P., García-Ramos, A., Cuadrado-Peñafiel, V., Brughelli, M., & Morin, J. B. (2018). Relationship between vertical and horizontal force-velocity-power profiles in various sports and levels of practice. *PeerJ*, 6, e5937.
21. Jones, B., Emmonds, S., Hind, K., Nicholson, G., Rutherford, Z., & Till, K. (2016). Physical qualities of international female rugby league players by playing position. *The Journal of Strength & Conditioning Research*, 30(5), 1333-1340.
22. Kara, S., & Özal, M. (2022). Güreşçilerin Maksimal Ve Reaktif Kuvvet İndeksi Özelliklerinin İncelenmesi ve Yorumlanması. *ROL Spor Bilimleri Dergisi, 3*(1), 165-178.

23. Lepciuc, G., Dorgan, V., & Popescu, V. (2021). Effects of the plyometric training programme on the sprint and the agility of rugby 7 feminine players. *Analele Universităţii Ovidius, Seria: Educatţie fizică şi sport*, 2(21), 331-336.
24. Lockie, R. G., Schultz, A. B., Callaghan, S. J., Jeffriess, M. D., & Luczo, T. M. (2014). Contribution of leg power to multidirectional speed in field sport athletes. *J. Aust. Strength Cond*, 22, 16-24.
25. Loturco, I., Pereira, L. A., Reis, V. P., Abad, C. C., Freitas, T. T., Azevedo, P. H., & Nimphius, S. (2022). Change of direction performance in elite players from different team sports. *The Journal of Strength & Conditioning Research*, 36(3), 862-866.
26. Maloney, S. J., Richards, J., Nixon, D. G. D., Harvey, L. J., & Fletcher, I. M. (2017). Do stiffness and asymmetries predict change of direction performance? *Journal of Sports Sciences*, 35(6), 547-556. https://doi.org/10.1080/02640414.2016.1179775
27. Marshall, B., & Moran, K. (2013). Which drop jump technique is most effective at enhancing countermovement jump ability, "countermovement" drop jump or"bounce" drop jump? *Journal of Sports Sciences*, 31. https://doi.org/10.1080/02640414.2013.789921
28. McBride, J. M., Blow, D., Kirby, T. J., Haines, T. L., Dayne, A. M., & Triplett, N. T. (2009). Relationship between maximal squat strength and five, ten, and forty yard sprint times. *The Journal of Strength & Conditioning Research*, 23(6), 1633-1636.
29. McCormick, B., Hannon, J., Newton, M., Shultz, B., Detling, N., & Young, W. (2014). The Relationship between Change of Direction Speed in the Frontal Plane, Power, Reactive Strength, and Strength. *International Journal of Exercise Science*, 7, 260-270.
30. McMahon, J. J., Suchomel, T. J., Lake, J. P., & Comfort, P. (2021). Relationship between reactive strength index variants in rugby league players. *The Journal of Strength & Conditioning Research*, 35(1), 280-285.
31. Meir, R. A., Arthur, D., & Forrest, M. (1993). Time and motion analysis of professional rugby league: A case study. *Strength and Conditioning Coach*, 1(3), 24-29.
32. Pesce, C., Tessitore, A., Casella, R., Pirritano, M., & Capranica, L. (2007). Focusing of visual attention at rest and during physical exercise in soccer players. *Journal of Sports Sciences*, 25(11), 1259-1270.
33. Rajput, A. K, Uppall, S. & Chitkara, A. (2016). *Health and Physical Education*. National Council of Educational Research and Training. ISBN: 978-93-5007-819-8
34. Ratamess, N. A., & Medicine, A. C. o. S. (2011). *ACSM's Foundations of Strength Training and Conditioning*. Wolters Kluwer Health/Lippincott Williams & Wilkins.
35. Raya, M. A., Gailey, R. S., Gaunaurd, I. A., Jayne, D. M., Campbell, S. M., Gagne, E., Manrique, P. G., Muller, D. G., & Tucker, C. (2013). Comparison of three agility tests with male servicemembers: Edgren Side Step Test, T-Test, and Illinois Agility Test. *J Rehabil Res Dev*, 50(7), 951-960. https://doi.org/10.1682/jrrd.2012.05.0096
36. Sáez de Villarreal, E., Requena, B., & Cronin, J. (2012). The Effects of Plyometric Training on Sprint Performance: A Meta-Analysis. *The Journal of Strength and Conditioning Research*, 26, 575-584. https://doi.org/10.1519/JSC.0b013e318220fd03
37. Singa, J. H., Pitil, P. P., & Wahed, W. J. E. (2020). Player positions: Anthropometric and physical fitness in elite rugby. *J Phys Educ Sport*.
38. Söyler, M., & Çingözi Y. E. (2023). Balance Control, Agility, Eye-Hand Coordination For The Sportive Performance Of Amateur Tennis Players: Apilot Study. *ROL Spor Bilimleri Dergisi, 4*(2), 729-745.
39. Struzik, A., Juras, G., Pietraszewski, B., & Rokita, A. (2016). Effect of drop jump technique on the reactive strength index. *Journal of Human Kinetics*, 52(1), 157-164.
40. Tillin, N. A., Pain, M. T. G., & Folland, J. (2013). Explosive force production during isometric squats correlates with athletic performance in rugby union players. *Journal of Sports Sciences*, 31(1), 66-76.
41. Wang, R., Hoffman, J. R., Tanigawa, S., Miramonti, A. A., La Monica, M. B., Beyer, K. S., ... & Stout, J. R. (2016). Isometric mid-thigh pull correlates with strength, sprint, and agility performance in collegiate rugby union players. *The Journal of Strength & Conditioning Research*, 30(11), 3051-3056.
42. Young, W., & Farrow, D. (2006). A Review of Agility: Practical Applications for Strength and Conditioning. *Strength & Conditioning Journal*, 28(5), 24-29.
43. Young, W., James, R., & Montgomery, I. (2002). Is muscle power related to running speed with changes of direction? *Journal of Sports Medicine and Physical Fitness*, 42(3), 282-288.
44. Zabaloy, S., Giráldez, J., Fink, B., Alcaraz, P. E., Pereira, L. A., Freitas, T. T., Loturco, I. (2022). Strength deficit in elite young rugby players: Differences between playing positions and associations with sprint and jump performance. *Journal of Strength and Conditioning Research*, 36(4), 920-926.