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The Relationship Between Reactive Strength Index and Acceleration, Sprint, Change of Direction Performance and Leg Strength in Football Players: Descriptive Research

Futbolcularda Reaktif Kuvvet İndeksi ile İvmelenme, Sprint, Yön Değiştirme Performansı ve Bacak Kuvveti Arasındaki İlişki: Tanımlayıcı Araştırma

Gizem BAŞKAYA[a], Kamil UZGUR[a], Sare BOSTANCI[b], Okan KAMİŞ[c]

[a]Bandırma Onyedi Eylül University Faculty of Sport Sciences, Department of Coaching Education, Balıkesir, Türkiye
[b]Bandırma Onyedi Eylül University Manyas Vocational School, Department of Property Protection and Security, Balıkesir, Türkiye
[c]Aksaray University Faculty of Sports Sciences, Department of Sports and Health, Aksaray, Türkiye

ABSTRACT Objective: The aim of this study was to determine the relationship between reactive strength index and leg strength, acceleration, sprint, change of direction and eccentric utilisation rate parameters of young football players. **Material and Methods:** A total of 23 football players who competed in the U17 league in the 2022-2023 season voluntarily participated in the study. Height and body weight measurements were used to determine the physical parameters of the footballers and right-left leg strength, drop jump, countermovement jump, squat jump, 10 m acceleration, 40 m sprint and illinois agility tests were used as performance tests. Reactive strength index and eccentric utilisation ratio were calculated with the data obtained from jump tests. The normal distribution of the data was analysed by Shapiro-Wilks test and the relationship between the variables was determined by Pearson correlation test. **Results:** Significant relationships were found between reactive strength index and eccentric utilisation ratio ($r=0.547$; $p<0.05$), right leg average strength ($r=0.451$; $p<0.05$) and left leg average strength ($r=0.436$; $p<0.05$). No significant correlation was found between reactive strength index and acceleration, sprint, change of direction and right-left leg peak strength performances ($p>0.05$). **Conclusion:** In conclusion, it can be suggested that the reactive strength index parameter should be taken into consideration in the evaluation process of strength and eccentric utilisation rate of young football players.

Keywords: Football; reactive strength index; sprint; strength; change of direction

ÖZET Amaç: Bu çalışmanın amacı, genç futbolcuların reaktif kuvvet indeksi ile bacak kuvveti, ivmelenme, sprint, yön değiştirme ve eksantrik kullanım oranı parametreleri arasındaki ilişkiyi belirlemektir. **Gereç ve Yöntemler:** Çalışmaya 2022-2023 sezonunda U17 liginde mücadele eden toplam 23 futbolcu gönüllü olarak katılmıştır. Futbolcuların fiziksel parametrelerini belirlemek için boy ve vücut ağırlığı ölçümleri, performans testleri olarak ise sağ-sol bacak kuvveti, "drop jump, countermovement jump, squat jump", 10 m ivmelenme, 40 m sprint ve illinois çeviklik testleri kullanıldı. Sıçrama testlerinden elde edilen veriler ile reak tif kuvvet indeksi ve eksantrik kullanım oranı hesaplanmıştır. Verilerin normal dağılımı Shapiro-Wilks testi ile analiz edilmiş ve değişkenler arasındaki ilişki Pearson korelasyon testi ile belirlenmiştir. **Bulgular:** Genç futbolcuların reaktif kuvvet indeksi ile eksantrik kullanım oranı ($r=0,547$; $p<0,05$), sağ bacak ortalama kuvveti ($r=0,451$; $p<0,05$) ve sol bacak ortalama kuvveti ($r=0,436$; $p<0,05$) arasında anlamlı ilişkiler bulunmuştur. Reaktif kuvvet indeksi ile ivmelenme, sprint, yön değiştirme ve sağ-sol bacak zirve kuvvet performansları arasında anlamlı bir korelasyon bulunmamıştır ($p>0,05$). **Sonuç:** Sonuç olarak, genç futbolcuların kuvvet ve eksantrik kullanım oranı değerlendirme sürecinde reaktif kuvvet indeksi parametresinin dikkate alınması önerilebilir.

Anahtar Kelimeler: Futbol; reaktif kuvvet indeksi; sprint; kuvvet; yön değiştirme

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Correspondence: Gizem BAŞKAYA
Department of Sports Coaching Education, Bandırma Onyedi Eylül University Faculty of Sport Sciences, Balıkesir, Türkiye
E-mail: gbaskaya@bandirma.edu.tr

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Football is a multifaceted sport and requires high-level performance components to be successful. While the outcome of a successful match is largely determined by the technical and tactical level, high intensity athletic performance also contributes to elite level performance.[1] Explosive endeavours during sprints, one-on-one challenges, jumps and changes of direction also involve important performance factors such as maximum power of the neuromuscular system and anaerobic power.[2] Team sports athletes, especially those involving such explosive activities, are expected to reach high levels of physical performance at elite levels.[3]

Athletes have different muscle activations at different intensities and durations while performing. One of these actions is the stretch-shortening cycle (SSC). The SSC is an important component of the ability to produce force in a minimum time. At the same time, the SSC is an important parameter in many sports activities such as the ground contact time of the leg extensor muscles in jumping, leaping and running.[3,4] The underlying mechanism of SSC is the transition to the shortening phase after the stretching phase that occurs in muscles.[4] However, the concept of reactive strength index (RSI) is used in the literature to measure the functionality of the SSC.[5] RSI is the athlete's ability to rapidly transition from eccentric to concentric contraction.[5-7] RSI is currently one of the most widely reported performance markers in the literature and is a reliable scientific method as a diagnostic test of functional competence to assess the training quality of athletes.[8-10] On the other hand, the use of RSI is vital for high-performance sport professionals. Because coaches can use this value as a motivational tool that they can give instant feedback to improve the physical performance of their athletes according to their RSI values.[9]

Since football is a high-level performance sport, which includes physical performance qualities such as agility, speed, strength and power by its nature and is affected by all these performance qualities, considering the definition of RSI and the characteristics of these parameters, it is thought that RSI may affect these performances or there may be a relationship between them.[11,12] In addition, due to the recent importance of the RSI in terms of athlete performance, the number of studies on this parameter in the literature is increasing.[8,13-20] However, despite all these studies, the number of studies investigating the relationship between performance tests and performance tests, especially on young football players, is almost negligible.[21] Therefore, it is seen that there is very little information about the possible links between these performances in the scientific literature.

Despite the recent increase in the scientific literature on young footballers, studies on performance testing on young players are still lacking. With the development of football and the increase in the level of competition, the skill levels of athletes and the physical demands of competition are also increasing. It has become an important issue to keep up with this increase and to increase the physical and physiological capacity of young footballers both individually and as a team. It is thought that the different levels of relationships or unrelated parameters to be revealed with the parameters to be analysed in this study will give effective results to coaches in terms of test applications and training programmes, and will also contribute to the widespread use of branch-specific and competition performance or tests similar to the nature of the competition. In this direction, the aim of this study was to determine the relationship between RSI and leg strength, acceleration, sprint, change of direction (COD) performance and eccentric utilisation rate (EUR) of young football players.

MATERIAL AND METHODS

PARTICIPANTS

A total of 23 football players with an average training age of 7.11±2.184 years, an average body weight of 69.11±8.027 kg, and an average height of 178.09±7.410 cm, who took part in "Balıkesir Büyükşehir Belediyespor U17" team in the 2022-2023 season, participated in the study voluntarily. Athletes with any injury or disease that prevented their participation in the tests were not included in the study.

PROCEDURES

The athletes and coaches who would participate in the study were informed by the researcher about the purpose, importance and test procedure of the study

one week before the study and necessary permissions were obtained from the athletes. Then, the athletes who would participate in the study were brought to the club facilities for test measurements. In the laboratory of the facility, firstly, the general information of the athletes was entered into the data form, then a measurement track was created and body weight and height measurements were taken and recorded in the data form. Then, right-left leg strength, countermovement jump (CMJ), squat jump (SJ) and drop jump (DJ) performance measurements were measured on the same day. At least 48 hours after the first test day, 10 m acceleration, 40 m sprint and COD test performances were measured and the necessary data were recorded on the data form. All performance tests were performed on an artificial turf field between 17:00-19:00 in the afternoon and adequate rest periods of 3 to 5 minutes were given between the tests to avoid any cumulative fatigue. Prior to the tests, a standardised warm-up protocol of approximately 15 minutes including running, dynamic flexibility movements for the lower extremities and various directional change activities with increasing intensity was applied. The RSI and eccentric use ratio of the athletes were determined by formulations after the relevant tests were performed. The study was conducted in accordance with the principles of the Declaration of Helsinki. Morover, ethics committee approval for this study was obtained at the meeting of Bandırma Onyedi Eylül University Health Sciences Non-Interventional Research Ethics Committee dated June 21, 2023 and numbered 2023-6 with decision number 2023-111.

DATA COLLECTION TOOLS

Anthropometric Measurements: Height and body weight measurements were obtained using Seca769 electronic measuring device (Seca Joint Stock Company, Germany).[22] The device measures height with an accuracy of 0.1 cm and body weight with an accuracy of 0.01 kg.

Leg Strength: The lower extremity strength of the athletes was measured with a dynamometer (Activforce 2). Before the test, the athletes were verbally and practically explained about the content and application of the test. A short dynamic warm-up was performed before the test and the results were recorded on the measuring device. After the seat and dynamometer were adjusted, the test protocol was applied to the athletes in order. Before starting the strength test, the athletes performed 3 repetitions.[23] The measurement was made separately for both legs of the athlete and the test was performed with the leg in 90° flexion.

Reactive Strength Index (RSI): The "My Jump 2" application, whose validity and reliability have been previously tested, was used in the studies conducted to determine the RSI with DJ. The DJ performance of each footballer was recorded with the 240 Hz high-speed video capture feature of the iPad. The evaluations for the DJ test were performed with iPad (Apple Inc., USA) brand and model tablet. Before the start of the test, the footballers were given instructions and were instructed to jump to the highest height with ground contact as soon as possible after falling to the ground. Since 40 cm vertical jump frame height is preferred as the most reliable measurement in studies, all football players performed the jump exercise by falling from a 40 cm high platform and were asked to put their hands on their waist during all jumps. For the result of these measurements, the drop jumping "time in the air/ground contact time" formula was used with the "My Jump 2" application.[19,21]

Eccentric Utilise Rate (EUR): The measurement was performed using the MyJump 2 application (intraclass correlation=0.997), whose validity and reliability have been established by various researchers.[24,25] For the CMJ, athletes were instructed to perform a rapid downward movement from the starting position (approximately 90° knee flexion) followed by a rapid upward movement to jump as high as possible. For SJ, athletes were instructed to perform a quick upward movement from the starting position (approximately 90° knee flexion), wait 2s, and then perform a quick upward movement to jump as high as possible. To determine the effect of the stress shortening cycle, the EUR was calculated with the following equation:

EUR=CMJ Jump Height/SJ Jump Height[26]

10 m Acceleration ve 40 m Sprint: It will be carried out in 40 m long areas to be determined in advance, with starting and ending lines of 10 and 40 m.

A photocell (Newtest Powertimer) with an accuracy of 0.01 was placed at the start and end points of the test.[27] Measurements were made by taking the best of 2 trials with rest intervals. All players performed a 5-minute dynamic warm-up before the test, followed by a 5-metre low-intensity sprint.

Change of Direction (COD): The Illinois Agility Test was used to measure the participants' direction change performance. For the test, a test track consisting of 3 cones arranged at 3 m intervals on a straight line, with a width of 10 m, a length of 10 m and a centre section of 3.3 m was set up. The test consists of a slalom run with 180-degree turns every 10 metres, a 40-metre straight course and a 20-metre cone course. After the test track was prepared, a two-door photocell electronic stopwatch system (Newtest Powertimer) with an accuracy of 0.01 seconds was placed at the start and end points. Volunteers stepped out from the starting line of the test track in contact with the ground. The time to finish the course was recorded in seconds. The test was repeated 2 times and the best result was recorded.[11]

STATISTICAL ANALYSIS

It was evaluated in SPSS 26.0 (SPSS, Inc., Chicago, II., USA) package programme. Shapiro-Wilks test was applied to determine whether the measurement values of the athletes had normal distribution. Since the data showed normal distribution, Pearson correlation test was applied at α=0.05 significance level to reveal the relationships between the parameters. Statistical results were evaluated at $p<0.05$ significance level. Reference intervals based on magnitude ($r<0.09$ insignificant; $0.1<r<0.29$ small; $0.3<r<0.49$ medium; $0.5<r<0.69$ high; $0.7<r<0.89$ very high; $r>9$ excellent) will be used to define the level of relationship between the data.[28]

TABLE 1: Mean performance parameters of footballers.

Parameters	n	X̄±SD
Right leg average strength (kg)		25.12±9.844
Right leg peak strength (kg)		38.97±13.340
Left leg average strength (kg)		25.47±9.964
Left leg peak strength (kg)		38.42±11.681
Reactive strength index (m/s)	23	1.68±0.460
Acceleration (0-10 m) (s)		1.83±0.160
Sprint (0-40 m) (s)		5.44±0.179
Change of direction (s)		15.37±0.501
Eccentric utilisation rate		1.14±0.102

SD: Standard deviation.

RESULTS

In this section, statistical analyses are interpreted and presented in tables. The mean values of the performance parameters of the footballers are shown in Table 1.

According to the results of the analyses, significant positive relationships were found between RSI and EUR ($r=0.547$; $p<0.05$) at high level, and significant positive relationships were found between right leg mean strength ($r=0.451$; $p<0.05$) and left leg mean strength ($r=0.436$; $p<0.05$) at moderate level (Table 2).

DISCUSSION

In professional football, the ability to accelerate and change direction in goal situations is the most common action.[29] Accelerations in the game are mainly performed in response to external stimuli (movement of the ball, opponent, team-mate) and are usually preceded by a COD of movement. In this way, the described basic football ability actually represents reactive strength.[21]

TABLE 2: The relationship between RSI and performance parameters of football players.

Parameters		Right leg peak strength	Right leg average strength	Left leg peak strength	Left leg average strength	EUR	0-10 m	0-40 m	COD
RSI	r value	0.162	0.451*	0.336	0.436*	0.547**	-0.036	-0.150	0.024
	p value	0.460	0.031	0.117	0.038	0.007	0.870	0.494	0.913

**p<0.01; *p<0.05; RSI: Reactive strength index; EUR: Eccentric utilisation rate; COD: Change of direction.

In this study, which was conducted to determine the relationship between RSI and right-left leg strength, acceleration, sprint, COD and EUR of young footballers, high level positive significant relationships were found between RSI and EUR ($r=0.547$; $p<0.05$) and moderate level positive significant relationships were found between right leg ($r=0.451$; $p<0.05$) and left leg average strength ($r=0.436$; $p<0.05$). No significant difference was found between right and left leg peak power, acceleration, sprint and COD performances.

In the literature, studies on athletes in different branches and age groups have revealed different values of RSI values.[8,14-19,21,30-32] While these values are similar to the results of our study, it has also been determined that there are differences. It is thought that this difference may be due to factors such as branch, age, training level, as well as the fact that the jump test was performed at different frame heights.

When the literature was examined, a limited number of studies were found to reveal the relationship between RSI and performance parameters such as sprint, COD and jumping. In a study parallel to the results of our study Kahraman and Özkan investigated the relationship between RSI and agility performance in young male and volleyball players and found no significant relationship between these parameters in both sample groups.[31] In another study, Healy et al. found no relationship between isometric peak power and RSI values in 28 sprinters.[15] Healy et al. did not find any correlation between reactive and maximal strength values and sprint measurements in their study in which they aimed to determine the relationship between reactive and maximal strength with 40 m sprint performance and mechanical properties. The researchers reported that there is a need for various methods to assess reactive strength that can better represent the demands of different phases of sprinting such as acceleration and maximal speed.[32]

One of the results of our study is that there is a significant relationship between RSI and EUR. EUR is affected by CMJ and SJ jump heights. In a similarly designed study to our study, Barker et al. reported at the end of their study on 26 footballers that researchers and practitioners should include RSI, jump duration and height to improve the assessment of jump performance.[13]

There are also studies in the literature that reveal findings different from the results of our study. In one of them Kayhan et al. found a positive relationship between RSI and COD ability of elite youth football players at $p<0.05$ level; the same relationship was not found between EUR, 0-10 m, 0-20 m and 0-40 m sprint parameters.[21] While the findings of the study related to sprint parameters are similar to the findings of our study, there are differences in the results obtained for other parameters. The reason for this difference may be that the agility test protocol applied by the researchers to the athletes was different from the protocol in our study. In another study conducted in the literature on RSI and sprint performance, results supporting the findings of our study were found. Young and James found no correlation between RSI data obtained from 25 m and 50 m sprint times and DJ in male and female sprinters. It is thought that the reason why the findings related to speed and agility are different is that both parameters are different physical qualities.[33]

In a study conducted on a different sample group, a significant difference was found between the reactive power of young tennis players and their ability to change direction. However, the researchers could not determine this result in terms of sprint performance.[34] In another study İnce, in his research on young volleyball players, found that there was a relationship between RSI and T test ($r=0.440$), 5 m sprint ($r=0.490$), 20 m sprint ($r=0.660$) and spike jump ($r=0.774$) performances.[16] In a study in which the relationship between RSI and maximal strength was investigated on a different sample group, the researchers did not find a significant relationship between these two parameters.[17] The findings of these studies differ from the findings of our study. It is thought that the difference is due to the fact that the branches have different requirements.

CONCLUSION

In conclusion, the findings of this study show that there is a relationship at different levels between reactive strength feature and right and left leg average strength and EUR in young football players. Accord-

ing to these results, RSI can be taken into consideration when planning strength training programmes in young football players and the development of these parameters can be focused in the programmes.

RECOMMENDATIONS

The athlete's ability to accelerate, decelerate, stop and change direction effectively is crucial for success in team sports in general.[35] Considering that in a 90-minute football match, athletes perform more than 600 changes of direction and linear sprints at a large number of different distances, it can be said that these high-intensity activities are crucial for the outcome of the game and ultimately the success of the team.[35] Considering all these, it is thought that it is very important to plan the developmental processes of young athletes and that evaluating the RSI, which is one of the important parameters for this planning and which has become more popular recently, will help to meet the needs of football.

When the literature was examined, only one study was found in which athletes had similar characteristics to the athletes in the present study. On the other hand, there are limited number of studies investigating the relationship between some performance parameters and RSI. It has been observed that the results obtained in the existing studies are inconsistent and there may be various reasons for this inconsistency. In this direction, it can be said that more studies are needed, and it can also be said that in future studies, factors such as branch and age should be taken into consideration and the tests to be selected should reflect the character of the branch. In addition, it is also thought that the preferred frame heights for determining RSI should be standardised depending on factors such as sample group or branch. Considering the studies in the literature, it was determined that this height varied between 30 and 50 cm and different results were obtained depending on these heights. In this direction, researchers can act by taking this factor into consideration in their studies.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Gizem Başkaya;* ***Design:*** *Gizem Başkaya;* ***Control/Supervision:*** *Gizem Başkaya;* ***Data Collection and/or Processing:*** *Gizem Başkaya, Kamil Uzgur, Sare Bostancı;* ***Analysis and/or Interpretation:*** *Gizem Başkaya;* ***Literature Review:*** *Gizem Başkaya, Kamil Uzgur, Sare Bostancı, Okan Kamiş;* ***Writing the Article:*** *Gizem Başkaya, Kamil Uzgur, Sare Bostancı, Okan Kamiş;* ***Critical Review:*** *Gizem Başkaya;* ***References and Fundings:*** *Gizem Başkaya.*

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