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RELATIONSHIP BETWEEN HIP FLEXION RANGE OF MOTION, LEG STRENGTH, AND SHOOTING SPEED IN YOUNG SOCCER PLAYERS

Gizem Başkaya[1*], Sare Bostancı[2], Kamil Uzgur[1], Bekir Çar[1], Okan Kamiş[3]
[1]Bandırma Onyedi Eylül University, Faculty of Sport Sciences, BALIKESİR
[2]Bandırma Onyedi Eylül University, Manyas Vocational School, BALIKESİR
[3]Aksaray University, Faculty of Sports Sciences, AKSARAY

Abstract: This study aimed to determine the relationship between hip flexion range of motion, leg strength, and shooting speed in young soccer players. Twenty-three volunteer male soccer players actively competing in the Turkish U17 league participated in the study. Leg strength was determined by the Activforce 2 device, hip flexion range of motion by the MyRom application, and shooting velocity by radar device (Stalker Solo 2 Sports Radar). The Pearson Correlation Test was applied to determine the relationship between the parameters. Moderate and high positive correlations were found between 11m, 18m and 25m shooting speeds and right hip flexion ROM at moderate level and between left hip flexion ROM at moderate and high level; moderate and high positive correlations were found between 18m and 25m shooting speeds and non-dominant leg peak force and average force. It can be concluded that the correlations at different levels or no correlations will provide an effective result for coaches to prepare training programmes and will contribute to which parameters should be focused on to improve shooting performance and it can be said that the mobility and strength levels of the hip flexors in both dominant and non-dominant legs should be increased in order to improve the shooting speed performance of young soccer players.

Key Words: Football, hip flexion, shot, strength, range of motion

GENÇ FUTBOLCULARDA KALÇA FLEKSİYON HAREKET AÇIKLIĞI, BACAK KUVVETİ VE ŞUT HIZI ARASINDAKİ İLİŞKİ

Öz: Bu çalışmanın amacı genç futbolcularda kalça fleksiyon hareket açıklığı, bacak kuvveti ve şut hızı arasındaki ilişkiyi belirlemektir. Çalışmaya Türkiye U17 liginde aktif olarak mücadele eden 23 gönüllü erkek futbolcu katılmıştır. Bacak kuvveti Activforce 2 cihazı ile, kalça fleksiyon hareket açıklığı MyRom uygulaması ile ve şut hızı radar cihazı (Stalker Solo 2 Sports Radar) ile belirlenmiştir. Parametreler arasındaki ilişkiyi belirlemek için Pearson Korelasyon Testi uygulanmıştır. 11m, 18m ve 25m şut hızları ile sağ kalça fleksiyon ROM'u arasında orta düzeyde ve sol kalça fleksiyon ROM'u arasında orta ve yüksek düzeyde; 18m ve 25m şut hızları ile dominant olmayan bacak zirve kuvveti ve ortalama kuvveti arasında orta ve yüksek düzeyde pozitif anlamlı korelasyonlar bulunmuştur. Ortaya çıkarılacak farklı düzeylerdeki ilişkilerin ya da ilişkisiz parametrelerin antrenörlerin antrenman programları hazırlamalarında etkili bir sonuç sağlayacağı ve atış performansının artırılması için hangi parametrelere yönelinmesi gerektiğine katkı sağlayacağı sonucuna varılabilir ve genç futbolcuların şut hızı performanslarını geliştirmek için hem dominant hem de dominant olmayan bacaklardaki kalça fleksörlerinin mobilizasyonunun ve kuvvet düzeylerinin artırılması gerektiği söylenebilir.

Anahtar Kelimeler: Futbol, kalça fleksiyon, şut, kuvvet, hareket açıklığı

[*] *Corresponding Author: Gizem Başkaya, Assist. Prof., E-mail: gbaskaya@bandirma.edu.tr*

INTRODUCTION

Soccer is a team sport that requires high levels of aerobic and anaerobic power, endurance, and muscular performance. In football, physical fitness parameters such as strength, speed, and endurance are decisive for technical and tactical efficiency (Aka et al., 2021). In this highly competitive environment, shooting speed is one of the determinants of score and performance. The athletes' dominant and non-dominant leg strength determines the shot's effectiveness and speed (Grouios et al., 2009; Kawamoto et al., 2007). On the other hand, it is accepted that mobilization components are also prioritized as the main element for high-quality performance in football (Yıldız, 2015).

In soccer, instep kicks are widely used as the main offensive technical actions during the match (Cerrah et al., 2024). The results of studies that have extensively examined the kinematic and electromyographic characteristics of these kicks have reported that the instep kick is the result of the simultaneous activity of many muscles that connect the segments and cause joint movement (Kellis and Katis, 2007; Lees and Nolan, 2002; Shan and Westerhoff, 2005). Kellis and Katis (2007) underlined this performance improvement of the instep kick is due to the developed muscle strength of the players.

In addition to shooting kinematics (Cerrah et al., 2011), there are studies in the literature that evaluate shooting speed based on different criteria, including accuracy and distance (Aslan and Kaya, 2023; Şengür et al., 2019; Topal et al., 2023; Tracey et al., 2012). Some of these studies tried to reveal the relationship between strength and shooting speed; as a result, some of them found significant correlations with shooting speed (Aka et al., 2021; Cerrah, 2009; Cerrah and Ertan, 2015; Cerrah et al., 2011; Maly et al., 2018), while some others failed to reveal this relationship (Chew-Bullock et al., 2012; Kellis and Katis, 2007; Mc Lean and Tumilty, 1993; Narici et al., 1988; Saliba and Hrysomallis, 2001; Yıldız, 2015).

In the literature, no consensus between these studies evaluated strength and shooting speed. On the other hand, considering that the variability in the joint angle of the striking motion will also cause a change in the shooting speed (Şengür et al., 2019), it would not be correct to evaluate the shooting speed only in terms of strength. Therefore, more studies are needed to reveal the factors affecting shooting speed and to determine how important these factors are. In addition, in the existing studies, older age groups and professional soccer players are preferred as the sample group (Aslan and Kaya, 2023; Cerrah, 2009; Cerrah and Ertan, 2015; Şengür et al., 2019; Yıldız, 2015). In light of all of the data mentioned above, variables such as unilateral leg strength, and range of motion (ROM) of the joints involved in the movement, should be also evaluated, rather than just bilateral leg strength, for football players in various age groups. Despite the recent increase in the scientific literature on young soccer players, there is still a lack of studies on the performance evaluation of young players. With the recent development of soccer and the increase in the level of competition, the skill levels of athletes and the physical demands of the competition are also increasing. It has become an important issue to keep up with this increase and enhance young soccer players´ physical and physiological capacity both individually and as a team.

It is thought that the different levels of relationships or unrelated parameters to be revealed will provide an effective result for coaches to prepare training programs and contribute to which parameters should be directed to increase shooting performance. In this context, the study aimed to determine the relationship between hip flexion range of motion, leg strength,

and shooting speed in young soccer players. We hypothesized that hip flexion range of motion and leg strength significantly affect shooting speed.

METHODS

Research Design

The relational survey model was used to examine whether there is a co-variance between the data belonging to the variables of the research and to determine its degree (Karasar, 2011).

Procedures

The athletes and coaches who would take part in the study were informed by the researcher about the purpose, and test procedure of the study one week prior to the study, and the necessary permissions were obtained. General information about the athletes was entered into the data form. Body weight, height, range of motion (hip flexion/right-left), and dominant/non-dominant leg strength measurements were recorded. Then, on the same day, soccer players' shooting speed measurements were taken from 11m, 18m, and 25m distances, and the necessary data were recorded on the data form. All tests were performed between 5:00-7:00 p.m., and the shooting speed measurements were performed on the artificial turf field. Adequate 3 to 5 minutes rest periods were given between the tests to avoid any cumulative fatigue. Before testing, a standardized warm-up protocol of approximately 15 minutes was performed, including running, dynamic flexibility movements for the lower extremities, and various change of direction activities. Each subject was fully informed about the risks associated with study participation and gave written informed consent before the start of the study. This research was approved by the Bandırma Onyedi Eylul University, Health Sciences Non-Interventional Research Ethics Committee with date 18.10.2023 and number 2023/8.

Study Group

A total of 23 football players (age:16.43±0.66 years, height: 178.09±7.41 cm, weight: 69.11±8.02 kg, training experience: 7.11±2.18 years) who took part in Balıkesir Buyuksehir Belediyespor U17 team in the 2022-2023 season volunteered to participate in the present study. They actively played football in the 2022-2023 season, practiced at least five training sessions per week, and did not have any injury or illness that prevented them from participating in the tests performed. Those study participants who did not have these characteristics were excluded from the study.

Data Collection Tools

Body Weight and Height: Height and body weight measurements were obtained using one Seca769 electronic measuring device (Seca Joint Stock Company, Germany). Height and body mass were measured to the nearest 0.1 cm and 0.01 kg, respectively (Bogataj et al., 2020).

Hip Flexion Range of Motion: Athletes´ hip flexion ROM was measured with the MyROM application included in the MyJump Lab application. The validity and reliability of the application have been demonstrated in different studies (Balsalobre-Fernandez et al., 2018; Mason-Mackay et al., 2017; Mosler et al., 2015). The athletes' hip flexors of the right and left legs were evaluated. During the measurement, the iPad 9th generation tablet (Apple Inc., USA) was placed on the limb whose ROM was to be measured, and the participant was asked to slowly bring the limb to the last opening and wait 1-2 seconds. The value obtained at the end of the measurement was recorded in degrees.

Leg Strength: Lower extremity strength was measured with a dynamometer Activforce 2 (San Diego, CA, USA). Before testing, athletes received theoretical and practical explanations about the application of the test. Before testing, a short dynamic warm-up was performed, and the results were recorded on the measuring device. After adjusting the seat and dynamometer, the test protocol was applied. The athletes performed three repetitions before starting the strength test (Karagiannopoulos et al., 2022). The measurement was taken separately for the athlete's legs with one minute of rest, and the test was performed with a 90° leg flexion.

Shooting Speed: A Stalker Solo 2 Sports Radar Gun (Stalker Sport II Radar Gun (Applied Concepts Inc., Plano, Texas, USA) brand pistol radar device was used to measure the shooting speed. Athletes were provided information about the test´s purpose and the requested shooting style. The athletes were asked to use an on-foot shooting style for shooting speed. They were asked to shoot two shots from 11m, 18m, and 25m to measure the shooting speed. Only the best attempt was recorded.

Statistical Analysis

Statistical analysis was performed with the SPSS 26 package program (Version 26 for Windows; IBM, Armonk, NY, USA). Data is presented as mean and standard deviation. Shapiro-Wilks test was applied to determine whether the measurement values of the athletes had a normal distribution. Since the data showed normal distribution, The Pearson Correlation Test was used to estimate the relationships between different parameters. The level of significance was set at $p<0.05$. The Pearson correlation coefficients obtained were interpreted as follows: $r<0.09$ insignificant; $0.1<r<0.29$ small; $0.3<r<0.49$ moderate; $0.5<r<0.69$ high; $0.7<r<0.89$ very high; $r>0.9$ excellent (Hopkins et al., 2009).

RESULTS

In this section, statistical analyses are interpreted and presented in tables. Table 1 shows the performance parameters of young soccer players.

Table 1. Performance parameters of soccer players

Parameters	N	Mean ± sd.
Hip Flexion Range of Motion (right) (°)	23	77.72 ± 8.44
Hip Flexion Range of Motion (left) (°)		79.56 ± 7.53
Dominant Leg Peak Strength		39.51 ± 13.57
Dominant Leg Average Strength		35.73 ± 11.02
Non-dominant Leg Peak Strength		37.54 ± 11.86
No-dominant Leg Average Strength		26.62 ± 9.30
Shooting Speed (11 m)		110.39 ± 5.61
Shooting Speed (18 m)		110.13 ± 5.72
Shooting Speed (25 m)		110.43 ± 5.62

According to the results of the analyses, the hip flexion range of motion (right) is 77.72 ± 8.44°; hip flexion range of motion (left) is 79.56 ± 7.53°; the dominant leg peak strength 39.51 ± 13.57 kg; dominant leg average strength 35.73 ± 11.02 kg; non-dominant leg peak strength 37.54 ± 11.86 kg; non-dominant leg average strength 26.62 ± 9.30 kg; shooting speed

of 11m is 110.39 ± 5.61 km/h; shooting speed of 18m 110.13 ± 5.72 km/h; shooting speed of 25m was 110.43 ± 5.62 km/h (Table 1).

Table 2. The relationship between shooting speed with hip flexion ROM and leg strength performance of young soccer players

Parameters		Hip Flexion ROM (right)	Hip Flexion ROM (left)	Dominant Leg Peak Strength	Dominant Leg Average Strength	Non-dominant Leg Peak Strength	Non-dominant Leg Average Strength
Shooting Speed (11 m)	r	**.456**	**.431**	.142	.061	.138	.255
	p	**.029***	**.040***	.517	.782	.531	.239
Shooting Speed (18 m)	r	**.489**	**.536**	.267	.142	**.429**	**.417***
	p	**.018***	**.008****	.218	.518	**.041***	**.048**
Shooting Speed (25 m)	r	**.491**	**.513**	.325	.170	**.585**	**.528***
	p	**.017***	**.012***	.130	.439	**.003****	**.003**

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

A positive moderate correlation between the hip flexion ROM (right) and 11m shooting speed, 18m shooting speed, and 25m shooting speed, respectively (r=.456, p=.029; r=.489, p=.018; r=.491, p=.017; p<0.05) was found.

Statistically significant positive moderate to high correlations were observed between the hip flexion ROM (left) and 11m shooting speed, 18m shooting speed, and 25m shooting speed, respectively (r=.431, p=.040; r=.536, p=.008; r=.513, p=.012; p<0.05). There were also positive moderate and high correlations between the non-dominant leg peak force and 18m shooting speed, and 25m shooting speed, respectively. (r=.429, p=.041; r=.585, p=.003; p=.040; p<0.05). Additionally, there were positive, moderate and high correlations between the non-dominant leg average force and 18m shooting speed, and 25m shooting speed, respectively (r=.417; p=.048; r=.528, p=.003; p<0.05) (Table 2).

DISCUSSION

In this study, which was conducted to determine the relationship between shooting speed and right-left hip flexion ROM and right-left average and peak force of young soccer players, significant positive correlations were found between 11m, 18m, and 25m shooting speed and right hip flexion ROM (r=.456, p=.029; r=.489, p=.018; r=.491, p=.017; p<0.05) at medium level and between left hip flexion ROM (r=.431, p=.040; r=.536, p=.008; r=.513, p=.012; p<0.05) at medium and high level respectively. In addition, moderate and high positive significant relationships were found between non-dominant leg peak power and 18m and 25m shooting speed (r=.429, p=.041; r=.585, p=.003; p=.040) and between non-dominant leg average peak force (r=.417; p=.048; r=.528, p=.003; p<0.05) respectively. There was no significant correlation between the dominant leg peak and average peak force and shooting speed performances (p>0.05).

Maly et al. (2018) showed that concentric knee extensor and flexor muscle strength at different angles is directly related to ball speed. Cerrah and Ertan (2015) reported that there were significant correlations between concentric peri-knee muscle strength at different angular velocities and shooting speed in amateur soccer players. However, the researchers could not detect this correlation, although the concentric strength of the peri-knee muscles of professional soccer players was higher than that of amateur soccer players. The study

confirmed that strength was more effective in the shooting speed performance of amateur soccer players, while technique was more effective in professional soccer players. The researchers attributed this to the fact that amateur soccer players have less training age and fewer training sessions per week compared to professional soccer players, so the technical skills of amateur soccer players are more limited compared to professional soccer players. The results of the aforementioned study are partially in line with the findings of our study. The fact that the strength parameter is related to the shooting speed as the distance increases, even if the leg is not dominant, reveals the effect of strength on the shooting speed.

Aka et al. (2021) evaluated not only the concentric phase of the muscle but also the eccentric phase; they reported that shooting speed was affected by hamstring (H) and quadriceps (Q) muscle strengths. The authors claim that even if the kicking techniques are different, the explosive execution of the movement will increase kicking performance, and the increase in strength, particularly in the H and Q muscle groups, will increase the contraction velocity. As a result, the authors suppose that knee extension and flexion during kicking may be the determinants of the increase in ball velocity. According to these results, the researchers suggested that exercises to increase Q and H concentric-eccentric muscle strength should be included in the training programs to improve the shooting speed of soccer players. In addition to the suggestion of the current study, the same suggestion can be given for the strength of the non-dominant leg according to our research results. In summary, it can be said that it would be important for coaches to include exercises that will increase dominant and non-dominant leg muscle strength in their training programs.

Manolopoulos et al. (2004) found significant differences in the pre and post-test values of the 30 m shooting test after strength training. They attributed this improvement in ball striking speed to changes in kinematic parameters such as body position and linear velocity of the distal segments during the shot. Similarly, Manolopoulos et al. (2006) reported that strength development affects shooting speed. Wong et al. (2010) reported a statistically significant relationship between shooting speed and knee extension strength at high angular velocity at a high level and low angular velocities at a moderate level. Sedano et al. (2009) observed an improvement in shooting speed after a 12-week plyometric training program. Kellis et al. (2001) reported that muscles contract both concentrically and eccentrically in all kick phases during soccer kicking. On the other hand, De Proft et al. (2001) and Kaya (2003) reported that the quadriceps femoris muscle is the primary contracting muscle in kicking motion and movements such as jumping and balance in soccer. Vural (2013) also stated that the contraction of the knee extensor and hip flexor muscles are among the determining factors of shooting speed. Luhtanen (1988) stated that foot speed during shooting is determined by the range of motion in the hip ankle, and pelvis joints. Therefore, the range of motion in the dominant leg is a determining factor in the speed of the shot (Young et al., 2004). In this context, the reason why we only determined the strength of the quadriceps muscle and did not determine the hip flexion angle at the point of determining the leg strength of the athletes in our study can be explained by this information. This study found a significant correlation between hip flexion values in both dominant and non-dominant legs and shooting speed. In a study conducted by Çakıroğlu (2001) on soccer players, hip joint flexion was compared in the dominant and non-dominant leg. ROM values in the dominant leg were significantly higher than in the non-dominant leg. Although no such comparison was made in our study, these results suggest that hip joint flexion is an important parameter during shooting. The findings obtained at the end of our study also support the literature.

Although significant relationships were found between leg strength and shooting speed at different distances, these relationships were found between non-dominant leg strength and shooting speed. It can be explained by the information stated by Barone et al. (2011) that using the non-dominant leg as a pivot leg for support in drills and activities that soccer players repeat a lot can lead to the development of proprioception sensation around the joints and tendons of that leg, neuromuscular control as well as strength development. However, unlike the findings of our study, some studies in the literature reported that the dominant leg determined shooting speed. Vural (2013) compared the dominant leg and non-dominant leg strength and stated that the ball speed increased during the shot thanks to the movement speed made by the dominant leg, and speed transfer from the foot to the ball was provided. Dörge et al. (2002) reported that the reason for fast shooting with the dominant leg is angular velocity. Considering all this information, although the results obtained from our study are different from the literature, it is thought to give important clues in terms of its effect on shooting speed and what to do for its development.

Young and Rath (2011) reviewed research on the factors affecting shooting performance and resistance training designed to increase stroke velocity during shooting. In conclusion, the study reporting correlations between strength and shooting performance supported the importance of hip flexor and quadriceps muscle strength. There is some evidence that adequate strength of the supporting leg and the trunk muscles, hip adductors, and muscles controlling pelvic rotations are important. De Proft et al. (2001) found that the agonist and antagonist muscles contracted by 70% and 90%, respectively, during the backward swing phase of the leg and 80% and 30%, during the forward swing phase of the leg and that the muscles did not maintain the same contraction rate. The studies show that the transitions between segments during shooting are very sensitive and that many joints and muscle groups work synergistically with each other. This situation indicates that focusing on specific muscle groups during the shooting throw would be misleading and that a single muscle group and joint movement alone cannot reflect the shooting throw alone.

Based on all these findings, force evaluated at specific angular velocities of isokinetic dynamometers does not reflect the leg swing velocity during shooting, and it would be misleading to focus specifically on a single muscle group due to the complex kinematics of shooting. During an effective shooting, many muscle groups, especially hip flexors and extensors, should work synergistically from proximal to distal. However, isokinetic dynamometers reflect muscle groups' strength specific to the joint angle. Therefore, obtaining different results regarding shooting speed can be explained by this information. In addition, the fact that the sample group of most of the studies above consisted of older age groups and professional players and that leg strength was measured at different angles with isokinetic devices are the main differences between these studies and our study. In addition, it can be suggested that in future studies on the subject, H and Q muscle strength, dominant and non-dominant leg balance, shooting speed, and accuracy should be determined together with these parameters, comparisons should be made, and relationships should be examined.

The study results have implications for coaches to improve shooting speed in soccer players. Our results suggest that it would be beneficial to include exercises targeting hip flexion range of motion and leg strength in the non-dominant leg in training programs. In addition, individual differences in leg strength and hip flexion range of motion should be considered when designing training programs.

CONCLUSIONS

Considering the recent developments and competition in soccer, teams compete head-to-head and frequently practice the skill of shooting, which is one of the most important parameters to get ahead. Football is a sport in which transition games are commonly exhibited. For this reason, athletes' kicking/shooting technique during shooting should be at an optimal level despite fatigue. Considering this situation and the results of the studies, the strength performance of the athletes should be at an optimal level and the hip flexion range of motion, which is another factor affecting the shooting success, should be at an adequate level. As a result, in order to achieve the desired shooting success in young soccer players, the strength and range of motion values of the limbs involved in the movement should be at an optimal level. For this purpose, coaches can determine the current performances of their players' parameters such as strength, shooting speed, range of motion and according to the results, they can develop more effective and individualized training programs that meet the specific needs of their players.

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