Original article

Determination of running performance in young soccer players

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Abstract. *Study Objectives:* This study aimed to determine the relationship between running performances in young soccer players and various parameters. *Methods:* The study was conducted with 20 male athletes from the U-14 youth setup soccer team of a sports club playing in the Turkish Football Super League. Various measurements were made to determine athletes' height, body weight, leg, lower leg and upper leg length, leg force, active and squat jump heights, sprint times in 15, 20, 25, 30, 35, and 40 meters. The videos, on which athletes' two full stride lengths where they reached maximal speed were recorded, were analyzed on Ariel Performance Analysis System (APAS) package program the with below-waist analysis method, and their stride lengths on maximal speed were found. Thus, athletes' step frequencies were found by dividing their running times into their stride lengths. Data were evaluated on SPSS 22.0 package program with descriptive statistics and Spearman's rank correlation coefficient to determine the correlation between stride length and step frequency, and other parameters. *Results*: The results of statistical analyses showed that there was a negative medium level correlation between stride length and sprint time in 15m (r = -.484) while there was a negative strong correlation between stride length and step frequency (r = -.880). There was a positive strong correlation between step frequency and sprint time in 15m (r = .751), 20m (r = .691), 25m (r = .632) and 40m (r = .635) while a positive medium level correlation with sprint time in 35m (r = .460). *Conclusion:* Stride length is more determinative than step frequency especially in short distance races in terms of running performance in young soccer players.

Key words: soccer, running performance, stride length, step frequency, sprint

Introduction

Soccer is a universal game loved by people almost everywhere regardless of their sex, age, height, level of skill, race, or beliefs (1). A professional sports branch, soccer became a sector due to its large budget possibilities, and teams make thousands of their fans expect sportive success (2). Developing world conditions require being able to control and manage all possible uncertainty in their favor to be successful in soccer. Therefore, success can be achieved with high-level techniques, tactics, and physical skills (3, 4). Because game performance in soccer is the interaction of different techniques, tactics, mental and physical factors (5), high game speed in modern soccer generally requires soccer players to perceive various situations at the same time, evaluate them quickly, make decisions quickly, and apply them quickly. During a game, players do 2 or 4 seconds long sprints every 90 seconds, thus, they do short-term activities for 1000 or 1400 times in total (6). Previous studies have shown that the number of sprints that players display during a game increased at the rate of 37%. This is a solid proof that soccer requires increased physical performance (7). Speed in general is one of the most important components of soccer-specific efficiency ability. Best soccer players not only display high-level technical-tactical features but also have very advanced speed capabilities. Speed in both offense and defense can mostly be significant for the win (8).

Knowing the physiological needs of young soccer players during the matches will make the training plans to be made more efficient (9). Previous studies have shown that soccer players are exposed to high game intensity during games, therefore, young players should also participate in training processes similar to adult players (10). Studies have shown that the most significant performance-related superiority of professional young setup players aged between 15 and 16 superior over same-aged amateur players appeared in agility and sprint tests (11). Maly, Zahalka, Hrasky, et al. (12) stated that sprint ability develops between the ages of 12 and 18, and sprints trainings conducted during this period are quite significant.

Brown (13) defines speed as the multiplication of stride length with step frequency while defining agility as swing speed. To increase speed, one must improve their stride length and frequency, and to increase agility, they must improve the speed of acceleration, deceleration, and swing. The number of studies on the relationship between athletes' sprint performances and anaerobic power is insufficient, and the acceleration capacities of athletes and covering longer distances in shorter times may be affected by power output (14, 15). Sprint is a type of recurring human movement and composed of running steps at maximum speed. Studies on determining which parameters affect sprint performance have been conducted for years. When evaluated biomechanically, stride length and step frequency of an athlete are the most effective parameters of sprint performance (16). During running, speed is determined by stride length and stride frequency and desired running performance is revealed by the optimal ratio between stride length and stride frequency. (17, 18). Stride length and step frequency increase according to a linear increasing of speed at certain speeds (19). Speed changes in every stage of performance based on the interaction between stride length and step frequency. Because stride length and step frequency are two parameters having a negative correlation in between both parameters are associated with one's morphological features, physiological properties, motor abilities, and energy capacities. Studies have stated that stride length is generally related to the height or leg length of an athlete while step frequency is based primarily on the central nervous system functioning on cortical and subcortical levels (16, 20–22).

Which of stride length and step frequency is more important for reaching maximal running speed and what affects these are discussed (17). The development of these two important parameters of sprint running with different training methods has always been a study subject (16). Knowing which parameter prominent as well as what the two parameters are affected from and related to be important to plan the content of sprint training of sports branches like soccer for which sprint performance is quite effective. Therefore, this study aimed to determine the relationship between running performance in young soccer players, and physical and performance parameters.

Material and Methods

Participants

The study was conducted with 20 voluntary male athletes (age: 13.75 ± 0.44 years, height: 159.92 ± 10.60 cm, body mass: 47.94 ± 9.55 kg) from U-14 youth setup soccer team of a sports club playing in the Turkish Football Super League. Measurements were made at the same training day and time for all athletes.

Anthropometric Measurements

Necessary calculations were made by measuring height, body weight, lower and upper leg lengths, and whole leg length. Measurements were taken place in the dressing room at the sports facilities of the team before the training. Athletes were asked to take off their shoes and shirts and only wear shorts for the measurements. Athletes' height was measured using a stadiometer with ±0.1 mm precision. For measuring body weight, Japanese-brand Tanita TBF 401 A weighing machine was used. For leg length measurements, the length between an athlete's hip joint and floor while standing was measured with a tape. The upper leg length was measured as the length between the proximal patella and midpoint of the inguinal ligament while in sitting position. Lastly, the lower leg length was measured as the length between tibial point and medial malleolus point while in cross legged position.

Leg force measurements were made with ±1 pound error using a Lafayette brand strain gauge, and a leg dynamometer consisting of a dynamometer with crystal and sitting panel. Video recordings were made using the Panasonic NV-MS2B camera that can shoot 50 fields per second. The videos were analyzed using the APAS package program. Jumping tests were conducted with a Bosco test device consisting of a microprocessor with a data bank that can measure with a 1 cm error margin and a line connected to it. Sprint times were recorded using a seven-door telemetric timer and a scoreboard system (Prosport, Ankara, Turkey) located at the start, 15m, 20m, 25m, 30m, 35m, and finish (40m) lines.

Testing Procedures

Measurements were conducted on two days. On the first day, height, leg force, jumps, and anthropometric measurements were made, and familiarization practices were conducted. On the second day, sprint measurements were made, and running videos during sprint were recorded. Forty-meters speed test was carried out with the athletes as a pre-study and the photocell doors were placed at the start, 15m, 20m, 25m, 30m, 35m, and finish lines (40m) to determine the five-meters long gap where they reach maximum speed. The sprint values of the athletes were recorded, the periods athletes finished 5-meter long distances after the 15th meter were analyzed, and these periods were checked to determine which gap they reached maximum speed. This process was carried out for every athlete and the gap to reach maximal speed was found. The study found that athletes reached maximal speed between 20 and 25 meters. The athletes one again undergone 40m speed test on another day. The researchers placed the Panasonic NV-MS2B camera that can shoot 50 fields per second between the 20th and 25th meters to record the five-meter gap where they reach maximal speed during this run. The athletes' two full stride lengths where they reached maximal speed were analyzed on the APAS package program with the below-waist analysis method, and their stride lengths on maximal speed were found. Thus, athletes' step frequencies were found by dividing their running times into their stride lengths.

Leg Force Measurements

These measurements were made using 1-sec preparation and 3-sec test method at 90^0 with Strain Gauge leg dynamometer, and the athletes' relative force indexes were calculated by converting pound values into kilograms and dividing to body weights.

Leg Force Index = (Measured Value * 0,454) / Body Weight

Jump tests

Countermovement jump (CMJ): The athletes were made to perform CMJ by making a quick downward movement starting from an upright hands-at-waist standing position, then immediately jumping vertically with maximum force.

Squat jump (SJ): The athletes' stood hands at the waist, the knees at an angle of 90 degrees and without any downward movement, then they jumped upward with maximum force.

Statistical analysis

The data were analyzed on the IBM SPSS 22 package program using descriptive statistics and Spearman's rank correlation coefficient. The study used mean and standard deviation among descriptive statistics because all of the variables were continuous. Since the sample size was smaller than 30, the researchers used Spearman's rank correlation coefficient which is a nonparametric analysis method to determine the correlation between variables. The correlation coefficient (r) can be between −1 and +1, and the minus sign (–) shows a negative correlation while plus sign (+) shows a positive correlation. The correlation coefficient between variables was regarded as very weak when lower than 0.20, as weak when between 0.20 and 0.39, as medium level when between 0.40 and 0.59, as strong when between 0.60 and 0.79, and as very strong when at and above 0.80. The statistical significance level was $p<0.05$.

Table 1. Descriptive Statistics Results of the Participants from the Measurements.

	Descriptive Statistics			
	Minimum	Maximum	Mean	SD
Age (year)	13,00	14,00	13,75	0,44
Height (cm)	138,20	177,90	159,92	10,60
Body Weight(kg)	31,00	62,40	47,94	9,55
15m Sprint (s)	2.31	2.83	2.51	0.14
20m Sprint (s)	2.97	3.53	3.22	0.16
25m Sprint (s)	3.56	4.23	3.89	0.20
30m Sprint (s)	4.19	5.04	4.66	0.26
35m Sprint (s)	5.06	5.82	5.45	0.22
40m Sprint (s)	5.76	6.64	6.21	0.27
Leg Force Index	1.14	2.21	1.66	0.25
Counter Movement Jump (cm)	24.10	42.80	33.97	4.51
Squat Jump (cm)	20.60	37.40	31.30	4.39
Leg Length (cm)	72.25	95.75	85.60	5.89
Lower Leg Length (cm)	36.50	48.25	41.53	2.93
Upper Leg Length (cm)	35.00	46.50	41.18	2.73
Stride Length (m)	1.29	1.73	1.53	0.12
Step Frequency (freq/sec)	3.33	4.84	4.08	0.41

Results

The means and standard deviations of athletes' age, height, body weight, sprint times, leg force index, jumps, leg, lower and upper leg, stride length and step frequency values are shown in the Table 1.

The results of Spearman's correlation analysis between athletes' stride length and other parameters showed a positive strong correlation between stride length and height ($r=.644$) and leg length ($r=.613$), a positive medium level correlation between stride length and body weight ($r=.592$), lower leg length ($r=.569$), and upper leg length ($r=.532$). There was a negative medium level correlation between stride length and sprint time in 15m ($r=-.484$) while there was a negative strong correlation between stride length and step frequency ($r=-.880$). No significant correlation was found between stride length and other parameters (Table 2).

The results of Spearman's correlational analysis between athletes' step frequency and other parameters showed a negative strong correlation between step

Table 2. Spearman's correlation results for the participants' stride lengths and other parameters

Variables	Stride Length	
	Correlation Coefficient	p
Height (cm)	**.644****	**.002**
Body Weight (kg)	**.502***	**.024**
15m Sprint (sec)	**−.484***	**.031**
20m Sprint (sec)	−.386	.093
25m Sprint (sec)	−.324	.163
30m Sprint (sec)	−.064	.790
35m Sprint (sec)	−.118	.619
40m Sprint (sec)	−.255	.278
Leg Force Index (BW/kg)	−.171	.471
Counter Movement Jump (cm)	−.044	.852
Squat Jump(cm)	.017	.942
Leg Length(cm)	**.613****	**.004**
Lower Leg Length (cm)	**.569****	**.009**
Upper Leg Length (cm)	**.532***	**.016**
Step Frequency (freq/sec)	**−.880****	**.000**

*p < 0.05; **p < 0.01

Table 3. Spearman's correlation results for the participants' step frequency and other parameters

Variables	Step Frequency (freq/sec)	
	Correlation Coefficient	p
Height (cm)	**−.749****	**.000**
Body Weight (kg)	**−.597****	**.005**
15m Sprint (sec)	**.751****	**.000**
20m Sprint (sec)	**.691****	**.001**
25m Sprint (sec)	**.632****	**.003**
30m Sprint (sec)	.357	.122
35m Sprint (sec)	**.460***	**.041**
40m Sprint (sec)	**.635****	**.003**
Leg Force Index (BW/kg)	.149	.531
Counter Movement Jump (cm)	−.211	.371
Squat Jump (cm)	−.151	.525
Leg Length (cm)	**−.658****	**.002**
Lower Leg Length (cm)	**−.658****	**.002**
Upper Leg Length (cm)	**−.575****	**.008**
Stride Length (m)	**−.880****	**.000**

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

frequency and height (r = −.749), leg length (r = −.658) and lower leg length (r = −.658), and a negative medium level correlation between step frequency and body weight (r = −.597) and upper leg length (r = −.575). There was a positive strong correlation between step frequency and sprint time in 15m (r = .751), 20m (r = .691), 25m(r = .632) and 40m (r = .635) while a positive medium level correlation with sprint time in 35m (r = .460). No significant correlation was found between step frequency and other parameters (Table 3).

Discussion

This study aimed to determine the running performance in young soccer players. Accordingly, the study examined the correlation between print performance and physical parameters, and stride length and step frequency which are determinants of running performance. The main result of this study showed that there is a significant correlation between stride length and step frequency, and sprint performance. There is a medium level negative correlation between stride length and sprint times. The longer the step length becomes, the shorter the sprint times become. This is an intended situation. On the other hand, there is a statistically significant correlation which is sometimes medium level or strong between step frequency and sprint times but this correlation is positive in this one. In other words, when the step frequency increases, the sprint times also increase. This means longer ground contact times. Çetin, (16) has stated that the ground contact time increased as the step frequency increased. This is not an intended situation. There is a very strong negative correlation between stride length and step frequency. One increases while the other decreases. Salo, Bezodis, Batterham, et al. (23) mentioned that the correlation between step frequency and stride length is generally inversely correlated, and an increase on one of them will probably cause a decrease on the other one because of the negative interaction encountered during the generation of these variables

Written resources on sprint measurements and races show that there is no certainty in terms of the correlation between step frequency and stride length and that some athletes prioritize stride length while some other athletes prioritize step frequency. Biomechanical analysis studies have emphasized that the significance between stride length and step frequency differs. For this reason, more information can be obtained if the same level elite athletes get to be analyzed during a several runs (23). Kuitunen and Komi (24) have shown that the step frequency becomes the dominant factor when the running speed increases from 70% to 100%. Higher step frequency was reported as the biggest difference between three 200 m Olympic finalists. Bezodis, Salo and Kerwin (25) claim that there is a strong correlation between step frequency and running speed while there is a relatively weak correlation between stride length and running speed. On the other hand, Gajer, Thépaut-Mathieu, and Lehénaff (26) have found that better sprinters have longer stride length than slower athletes, and that stride length is significantly correlated to the practicing speed at group level while step frequency is not. Omelko, Fostiak, and Mackala (27) have examined the studies in the literature about sprint times and found that better sprint times show up with the increase in stride length. Additionally, they have reported about 60 meters sprint times that sprinters increased their stride lengths even between 40th and 60th meters. On the other hand, they have stated that changes in step frequency are less and relatively similar. Hunter, Marshall and McNair (21) have found a strong correlation between sprint speed and stride length and a weak correlation between sprint speed and step frequency. Mackala and Mero (28) have examined whether an increase in step frequency or stride length increases running speed, and found that stride length had a stronger correlation with stride length than step frequency. Tottori, Wakamiya, Shinohara, et al. (29) have determined that step frequency is important for the initial three steps during acceleration for shorter 100 meter sprint times while stride length is important between the 4th and -21st steps. This study found negative correlations between stride length and sprint times in young soccer players. In other words, their sprint times decreased while their stride lengths increased. The athletes' step frequency increased in line with their sprint times, thus, a positive correlation exists between these variables. The study found that short sprint times are related to stride length more than it is related to step frequency. The results of this study are compatible with the related literature to a large extend.

Based on animal studies, Heglund and Taylor (30) have found that increased stride length on various animals refers to the correlation between muscular force and stride length, and that it requires a higher generation of mean muscular force. Weyand et al. (31) have examined sprint performances of humans and found that higher operating speeds were achieved with higher vertical ground reaction forces rather than faster leg movements. Higher mean force generation during contact resulted in quite high stride lengths. The regression analysis has shown that 1.8 fold increase occurred on the highest operating speed with 1.69 fold longer steps (and 0.5 fold bigger mean vertical force generation than body weight) (23). Çetin (16) has stated that training consisting of hill climbing exercises increase the amount of load on the hip extensor muscles to increase the stride length of an athlete and that this increased the impulse of the athlete during the sprint performance conducted on the horizontal ground and was ultimately effective in increasing the stride length. A study performing a combined training (hill climbing and hill descending) using 4° slope determined that 100 meter sprint performance increased based on stride length. This effect of combined training management on maximal speed was because of the positive changes on stride length, in other words, the positive effect of 4° hill climbing training on hip extensor muscles (32) Acceleration increased in direct proportion to the force of muscles which move the hip, knee, and ankle. It should be remembered that reaching high running speeds is possible when the contact time is as short as possible and the maximal impulse is performed in this minimal duration (33, 36).

Being able to sprint and dribble (sprinting with ball) is regarded as critical for the success in the game, and sprinting and dribbling are important components of soccer abilities (37). Various studies (11,38,39) have revealed that the speed of running with a ball determines the best players. Huijgen et al (40) have found that professional young talented players are 0.3 seconds faster than amateur players in 30 meters dribbling performance. It is concluded that dribbling performance during adolescence with the improvement in physical features can help determine the best players for the future.

Conclusion

Stride length is more determinative than step frequency especially in short distance races in terms of running performance in young soccer players. Trainers can concentrate on trainings that develop stride length in sprint practices to improve sprint performance which has an important role in swinging the balance. It should be remembered that stride length is also directly related to force improvement, thus, training on improving muscle force as well as sprint practices should be carried out.

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