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The Relationships among Acceleration, Agility, Sprinting Ability, Speed Dribbling Ability and Vertical Jump Ability in 14-Year-Old Soccer Players

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Abstract: *The aim of this study was to evaluate the relationships among acceleration, agility, sprinting ability, speed dribbling ability and vertical jump ability in 14-year-old soccer players. Twenty-five young soccer players (average age 13.52 ± 0.51 years; height 158.81 ± 5.76 cm; weight 48.92 ± 6.48 kg; training age 3.72 ± 0.64 years) performed a series of physical tests: Yo-Yo Intermittent Recovery Test Level 1 (YYIRT); zigzag agility with the ball (ZAWB); without the ball (ZAWOB); sprinting ability (10-m, 20-m and 30-m); speed dribbling ability (SDA), acceleration ability (FLST) and jumping ability (counter-movement jump (CMJ), squat jump (SJ) and drop jump (DJ). The results showed that 10-m sprint was correlated with 20-m (r = 0.682), 30-m sprint (r = 0.634) and also SDA, FLST and ZAWOB (r = 0.540, r = 0.421; r = 0.533 respectively). Similarly, 20-m sprint was correlated with 30-m sprint (r = 0.491) and ZAWOB (r = 0.631). 30-m sprint was negatively correlated with CMJ (r = -0.435), while strong and moderate correlated with FLST (r = 0.742), ZAWOB (r = 0.657). In addition, CMJ strong correlated with SJ and DJ (r = 0.779, r = 0.824 respectively). CMJ, SJ and DJ were negatively correlated with ZAWOB. Furthermore, SDA strong and moderate correlated with FLST (r = 0.875), ZAWB (r = 0.718) and ZAWOB (r = 0.645). Similarly, a correlation was also found among FLST, ZAWB and ZAWOB (r = 0.421, r = 0.614 respectively). Finally, ZAWOB was strong and moderate correlated with the performance of soccer players in different field tests. In conclusion, the findings of the present study indicated that agility without the ball associated with the all physical fitness components. In addition, agility performance affects acceleration, sprint and jumping performances in young soccer players. Therefore, soccer players should focus on agility exercises in order to improve their acceleration, sprinting and jumping performance.*

Keywords: *soccer, speed, agility, jump, dribbling*

I. Introduction

Soccer is characterized as a high-intensity intermittent team sport requiring jumping, shooting, tackling, turnings, sprinting, controlling the ball under pressure, running at different speeds, and sliding tackles [1,2,3] Many factors such as technical, tactical and physical skills can affect player performance in soccer [4]. Moreover, physical capacities that have the potential to affect performance during a match, speed, peak running speed, and high-intensity intermittent exercise capacity with changes of directions are likely the most determinants [5]. It is generally assumed that through the years, the game has developed to become faster, with more intensity and aggressive play than seen previously [6]. Therefore, players require well-developed aerobic endurance and anaerobic capacity [7].

High-intensity actions can be categorized into actions requiring acceleration, maximum speed, or actions requiring agility during soccer matches [8] Successful performance of high-intensity actions including agility (change-of-direction), sprinting, jumping is really essential in many team sports, particularly soccer. The speed and acceleration over the first few seconds of running are important data for coaches, and the ability to accelerate over a single step is a critical factor in some game situations [9]. In addition, the performance of speed dribbling is characteristic of soccer players [10]. For these reasons, monitoring and assessment of physical capacities, using sport specific field tests, is one of the most important issues for training in professional sports [11]. Therefore, some field tests which requires little equipment and includes common movement skills are used to assess performance and including evaluation of acceleration ability [12], agility [13], sprinting [14], jumping [15] and soccer skill tests [16] in soccer player.

The participation of adolescents in competitive sports has increased in recent years, and competitive soccer is one of the most popular sports in this population [17]. Many studies have focused on the relationships between high intensity actions in young soccer players. While, some authors have focused on studying the determinants of rapid movement performance and studying their interrelations, others have determined the relationships between jumping, sprinting, and agility in young soccer player [18,19,14]. For example, [8] found high level correlations between 10-m, 20-m sprint and zigzag performance in soccer players. Similarly, [18] study found high level significant relationship between 10-m, 30-m speed times and zigzag agility performance in young soccer players. In contrast, [20] found no correlation between 9.1-m and 18.3-m sprint and pro-agility tests times of college soccer players. Furthermore, a study found high level significant relationship between counter-movement jump, squat jump and zigzag agility performance in young soccer players [18]. However, results of correlation analyses have been inconsistent. In addition, no study has examined the relationships among acceleration, agility, sprinting ability, speed dribbling ability and vertical jump ability, although these performance determinants contribute directly soccer match performance [10]. Therefore, the purpose of this study was to evaluate the relationships among acceleration, agility, sprinting ability, speed dribbling ability and vertical jump ability in 14-year-old soccer players.

II. Methods

2.1. Participants

Twenty-five young soccer players (average age 13.52 ± 0.51 years; height 158.81 ± 5.76 cm; body mass 48.92 ± 6.48 kg; body fat percentage 14.06 ± 2.02; training age 3.72 ± 0.64 years) voluntarily participated in this study. This study was carried out over a week's pre-season training period in September 2015, during which the soccer players who participated were not involved in any other training or matches. All the players were members of the same youth team competing in an elite academy league and they generally trained four days per week for two hours. Written informed consent was obtained from all the participants and their parents. All players and parents were notified of the research procedures, requirements, benefits, and risks before giving informed consent. The study was approved by the local Ethics Committee, and was conducted in a manner consistent with the institutional ethical requirements for human experimentation in accordance with the Declaration of Helsinki.

2.2. Procedures

Yo-Yo Intermittent Recovery Test 1

Yo-Yo Intermittent Recovery Test 1 (YYIRT) was performed according to the procedures suggested by Bangsbo, Iaia, & Krustrup, (2008). Test reliability was established in a previous study [22]. Each player's HR was measured at 1-second intervals throughout the test and stored using HR monitors (Polar V800, Polar Inc, Denmark). Stored data were transferred to the computer and filtered by dedicated software (Polar Precision Performance SoftwareTM, Finland). The highest HR measurement during the test was recorded as HR_{max} [22]. After the test, estimated maximum oxygen uptake (VO_{2max}) was calculated by using the following formula [21].
VO_{2max} = 36.4 + (0.0084 x covered distance in YYIRT)

Zigzag Agility Tests With And Without The Ball

The zigzag agility test was used for the purposes of assessment of running agility from changes in direction. A zigzag course consisted of 4 5-m sections set out at 100° angles. The selection of this test was based on rapid acceleration, deceleration, and balance control required for short running time, which represented the result of the test [8, 13, and 18]. The players performed zigzag agility tests with and without the ball 3 times on a synthetic grass pitch. There was a recovery period of 3 minutes between trials. The shortest time was recorded as zigzag agility tests with and without the ball performance. There is no specific rule such as number of the ball touches during the zigzag agility with ball test. Time was assessed using a portable wireless photocell system (Witty, Microgate, Bolzano, Italy).

10-M, 20-M And 30-M Sprint Tests

Before sprint tests, each player performed warm up consisting of 10 minutes of jogging and then 5 minutes of exercise involving skipping and 3-5 single short distances sprints on a synthetic grass pitch. The players were asked to run 3 maximal 30-m sprints interspersed with 3 minutes of passive recovery, and the fastest time was recorded. Sprint performance was assessed using a portable wireless photocell system (Witty, Microgate, Bolzano, Italy).

Speed Dribbling Ability

This test was used for the purposes of assessment of coordinated speed dribbling under time pressure and speed. The player starts with the ball from behind the line. After 5-m, player dribbles to the right, around the first post of a triangle. Following the set order, player dribbles around the other posts. After 10-m, player dribbles around a block. Then, after 8-m, player plays the ball around one side of a square and runs around the other side to collect it. Then player sprints through a gate and puts his foot on the ball [23,12]. The time between the starting command and crossing the finish line was measured by a portable photocell system (Witty, Microgate, Bolzano, Italy) and was recorded as the score of the players in units of 0.1 seconds.

Vertical Jump Measurements

Jumping performances were assessed using a portable force plate (Optojump, Microgate, Bolzano, Italy). Players performed countermovement jump (CMJ) squat jump (SJ) and drop jump (DJ) with hands kept on the hips to minimize the contribution of the upper limbs. CMJ starting from a standing position, squatting down and then extending the knee in one continuous movement; SJ starting from a static semi squatting position (~90° of flexion) maintained for ~1 second and without any preliminary movement; DJ starting from a standing position on a 30-cm height, dipping, and then extending the knee in one continuous movement. Before tests, following the soccer-specific warm-up, participants performed 3 times CMJ, SJ and DJ as a practice. During the tests, the players were instructed to keep their legs straight throughout the tests. Each player was asked to 3 jumps interspersed with 45 seconds of passive recovery and the highest jump was recorded in centimetres.

Four-Line Sprint Test

The ability of sprinting and acceleration in athletes was assessed by four-line sprint test (FLST). A starting line (A) was determined on a football field. Line B and C were marked behind and in front of the starting line. There was distance 10-m from line A to line B and line C. The finishing line (D) was 20-m away from line C. The player lay on the ground behind the line A. When the starting command was given, the player ran to line B and touched the line with foot. Then he turned back and ran from line B to line C. Later, after player touched line C with foot, he turned back again, ran from line C to line A and touched line A. Finally, player turned back again and ran to line the finishing line (D) between 2 flag posts. The time between the starting command and crossing the finish line was measured by a portable photocell system (Witty, Microgate, Bolzano, Italy) and was recorded as the score of the subject in units of 0.1 seconds [23,12].

2.3. Statistical Analyses

The mean and standard deviation values for each test were calculated for all players. The relationships among acceleration, agility, sprinting ability, speed dribbling ability and vertical jump ability were analyzed using the Pearson product moment correlation coefficient. The reliabilities of all tests – zigzag agility with the ball; without the ball; sprinting ability (10-m, 20-m and 30-m); speed dribbling ability, acceleration ability and jumping ability (counter-movement jump, squat jump and drop jump – were assessed using intraclass correlation coefficients (ICCs) between test–retest and confidence interval (CI). Statistical analyses were performed using SPSS software statistical package (SPSS Inc., Chicago, IL, USA, 16.0), and statistical significance was set at $p<0.05$.

III. Results

Test–retest reliability analysis of all physical performance tests in the present study shows ICCs of: 0.942 (CI 95% = 0.868–0.974) for the CMJ; 0.947 (CI 95% = 0.613–0.984) for the SJ; 0.926 (CI 95% = 0.834–0.967) for the DJ; 0.880 (CI 95% = 0.730–0.947) for the 10-m sprint; 0.971 (CI 95% = 0.706–0.992) for the 20-m sprint; 0.945 (CI 95% = 0.876–0.976) for the 30-m sprint; 0.841 (CI 95% = 0.644–0.930) for the ZAWB; 0.875 (CI 95% = 0.715–0.945) for the ZAWOB; 0.887 (CI 95% = 0.748–0.950) for the SDA and 0.927 (CI 95% = 0.835–0.968) for the FLST. The players' test performances are shown in Table I.

Table I: Descriptive statistics of test performances in soccer players (mean ± SD).

Tests	Mean ± SD
Yo-Yo Intermittent recovery test level 1	
Maximal running velocity (m/s)	4.29 ± 0.11
Total distance covered (m)	1238.40 ± 174.54
Estimated maximal oxygen uptake (ml/kg/min)	46.80 ± 1.47
Maximal heart rate (bpm)	202.48 ± 5.33
Sprint tests	
10-m sprint (s)	2.10 ± 0.10
20-m sprint (s)	3.64 ± 0.24
30-m sprint (s)	5.06 ± 0.35
Acceleration test	
Four-line sprint test	14.81 ± 0.92
Vertical jump tests	
Counter-movement jump (cm)	27.94 ± 2.88
Squat jump (cm)	30.50 ± 2.33
Drop jump (cm)	27.68 ± 2.04
Soccer skill test	
Speed dribbling ability (s)	25.34 ± 1.86
Agility tests	
Zigzag agility without the ball (s)	7.06 ± 0.26
Zigzag agility with the ball (s)	8.62 ± 0.48

The results of the study showed that 10-m sprint was correlated with 20-m sprint (r = 0.682), 30-m sprint (r = 0.634) and also SDA and ZAWOB (r = 0.540, r = 0.533 respectively). Similarly, 20-m sprint was correlated with 30-m sprint (r = 0.491) and ZAWOB (r = 0.631). 30-m sprint was negatively correlated with CMJ (r = -0.435), while strong and moderate correlated with FLST (r = 0.742), ZAWOB (r = 0.657). In addition, CMJ strong correlated with SJ and DJ (r = 0.779, r = 0.824 respectively). CMJ, SJ and DJ were negatively correlated with ZAWOB (r = -0.583, r = -0.602, r = -0.597 respectively. Furthermore, SDA strong and moderate correlated with FLST (r = 0.875), ZAWB (r = 0.718) and ZAWOB (r = 0.645). Similarly, a correlation was also found among FLST, ZAWB and ZAWOB (r = 0.421, r = 0.614 respectively). Finally, ZAWOB was strong and moderate correlated with the performance of soccer players in different field tests (Table II).

Table II: Correlations among acceleration, agility, sprinting ability, speed dribbling ability and vertical jump ability.

	10-m	**20-m**	**30-m**	**CMJ**	**SJ**	**DJ**	**SDA**	**FLST**	**ZAWB**	**ZAWOB**
10-m	**1**									
20-m	0.682**	**1**								
30-m	0.634*	0.491*	**1**							
CMJ	NS	NS	-0.435*	**1**						
SJ	NS	NS	NS	0.779*	**1**					
DJ	NS	NS	NS	0.824*	NS	**1**				
SDA	0.540*	NS	NS	NS	NS	NS	**1**			
FLST	0.421*	NS	0.742**	NS	NS	NS	0.875**	**1**		
ZAWB	NS	NS	NS	NS	NS	NS	0.718**	0.421*	**1**	
ZAWOB	0.533*	0.631*	0.657*	-0.583*	-0.602*	-0.597*	0.645**	0.614*	0.617*	**1**

CMJ: Countermovement Jump; SJ: Squat Jump; DJ: Drop Jump; SDA: Speed Dribbling Ability; FLST: Four-Line Sprint Test; ZAWB: Zigzag Agility With The Ball; ZAWOB: Zigzag Agility Without The Ball
Data are reported as Pearson product moment correlation coefficients, r.
* Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level
NS Not significant

IV. Discussion

The purpose of the present study was to evaluate the relationships among acceleration, agility, sprinting ability, speed dribbling ability and vertical jump ability in 14-year-old soccer players. To the best of our knowledge, the present study is the first to undertake such a thorough examination of these relationships in young soccer players.

The main findings of the present study show different levels correlations among acceleration, agility, sprinting ability and speed dribbling ability in 14-year-old soccer players. While no previous study has correlated speed dribbling ability and performance characteristic of soccer, the speed dribbling ability test is similar to the Hoff dribble test in that they both have a similar test design and the results of previous studies examining the relationship between Hoff dribble test and performance characteristic of soccer suggest that the speed dribbling ability provides a valid prediction of speed dribbling time [15]. In a similar study, moderate correlations were found hexagon test for agility, the 40-yards test for maximum speed, T test for acceleration and vertical jump performances in college-aged men [24]. Study showed correlations between acceleration, maximum speed, and agility without the ball in young soccer players (r = 0.567 and 0.714 respectively) [18]. In addition, [8] found that 10-m test for acceleration, the flying 20-m test for maximum speed, and the zigzag test for agility were all correlated at high levels of statistical significance ($p < 0.0005$). The present study also shows moderate to strong correlation between straight-line sprint and agility (r-values from 0.533 and 0.657) in 14-year-old soccer players [19]. Reported high correlation between 10-m, 20-m sprint and agility tests performance in 13-14 years old soccer players (r = 0.68 and 0.69 respectively). In addition, 10-m and 20-m sprint performances correlated with agility in 11-12 years old soccer players (r = 0.68 and 0.75 respectively) [25].

Similarity in relationships of the our study results may be not explained with physiological and biomechanical determinants of the soccer. Many studies showed that these determinants have previously been indicated to be more closely related to the stretch-shortening-cycle abilities [26,27]. In contrast, [20] showed weak correlation between 9.1-m sprint and the performance of two different agility tests high school soccer players (r = 0.473 and 0.297). Moreover, no significant correlations were found between 20-m sprinting and 20-m agility performances in soccer players [28]. The differences in relationship between these studies may be explained with many factors that affects the players' performance results. One of the possible factors is all of these players are playing soccer at different levels and it affects their aerobic and anaerobic performance responses [29, 30, 31]. Another possible factor could be the distance used in the sprint and agility tests [20].

Another finding of the present study also shows that vertical jumping ability significantly negatively correlated with 30-m sprint times (r = -0.435) in young soccer players. It can therefore be seen that our findings are similar to those of previous studies [18, 32, 33, 34, 35]. In contrast, some study found weak correlation between vertical jumping performance and various sprint distances [20, 36], while other studies reported no correlation between these performance indicators [18, 37]. These differences might be explained with participants' age and training age.

The present study agreed with the previous study, which found no correlations among maximum speed, acceleration, vertical jump performance and agility with the ball in young soccer players [18, 38]. However, we find that zigzag agility without the ball performances were moderately correlated with not only maximum speed, but also vertical jump performance. This result also supported by previous similar study [18, 38]. Both zigzag agility with and without ball tests, which are short-time and high intensity, have similar energy demands and it is generally provided same energy system. However, we found only moderate correlation between zigzag agility with and without ball tests (r = 0.617). Players' technical capacity or skills of agility are probably the reason for the differences in the tests. In the light of these result, it can be said that coaches should use both tests in order to determine performance level of soccer players. In addition, coaches should not only use agility without ball training, but also they should use agility with ball training in order to improve agility with ball performance of their players.

The speed dribbling test was used to measure the technical abilities of both elite and non-elite soccer players [39]. In addition, the capability for acceleration is an important factor in the success of soccer players in game situations, where the need to reach the ball first or to be in place for the development of a play is essential [40]. It can therefore be seen that our findings are similar to those of previous studies [13, 18, and 23]. The present study also shows moderate to strong correlation both speed dribbling test and four-line sprint test and zigzag agility with and without ball. To the best of our knowledge, there is no previous study has correlated speed dribbling ability with acceleration and agility test results in young soccer players. Therefore, we think that soccer players have similar activity pattern in soccer is better replicated by a short time and anaerobic energy system play a major role in the performance of these tests.

V. Conclusion

In conclusion, this is the first study that systematically examined the relationships among acceleration, agility, sprinting ability, speed dribbling ability and vertical jump ability in 14-year-old soccer players. The findings of the present study show a significant correlation between acceleration, sprinting ability, speed dribbling ability, vertical jump performance and zigzag agility without the ball. Taken together, these results suggest that agility is a key factor for young football players not only for improving sprinting, jumping, as previous studies have concluded, but also for performing football-specific skills, such as acceleration and speed dribbling ability. From a practical perspective, the field test results are a reliable and time-efficient measuring style to assess physical performance in youth. In addition, we recommend that future research is performed on larger sample sizes to validate the findings of the current study to wider populations.

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