ORIGINAL ARTICLE

The influence of linear speed on the ability to change the direction of movement in elite female football players

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Abstract

The aim of this study was to show the influence of linear speed on the ability to change the direction of movement. Nineteen football players (16.90±2.28 years old) from the Serbian Super League participated in the research. Tests were performed to estimate speed: the linear speed at 5 m, 10 m, 20 m, and flying start at 10 m, and the 505 test for dominant and non-dominant leg, as well as CODS deficit, were applied to assess the ability to change direction. Using regression analysis, it was shown that linear speed has no statistically significant effect on the ability to change direction with elite female football players ($P<0.05$). In interpreting the results, several factors should be taken into account and the complexity of the linear speed relationship and the ability to change direction should be understood. The findings we gained from this research could influence the modification of training cycles, primarily strength, movement mechanics, and later more specific training episodes of football players.

Keywords speed • female football players • ability to change the direction of movement.

Introduction

Football is a game that is actively played by over 240 million people in more than 200 countries of the world. The continuous growth and popularity of the game itself are reflected in the increasing number of football clubs as well as active players not only in the men's but also in the women's competition. The requirements of today's football, viewed from the point of view of physical qualities, are certainly different compared to the very beginnings of this sport. Fitness aspects, especially those related to high-intensity activities, have changed a lot over the past years (Bradley et al., 2015). Moreover, it was shown that male players had better COD performance and more excellent sprint mechanical properties than female football players (Zhang et al., 2021).

Speed and the ability to change the direction of movement are very important factors in football, their development starts from childhood and determines the performance of football players (Kyranoudis et al., 2021). Accordingly, change of direction (COD) is the ability to change the direction of movement and can be a good predictor of success given a large number of changes of direction of movement (more than 700 in men during a football game) that are performed in one football match (Bloomfield et al., 2007). On the other hand, speed is also important for success in football. Most high-intensity activities (sprints and accelerations) occur during decisive moments, such as scrambles for the ball, offensive and defensive actions, and scoring opportunities (Di Salvo et al., 2009).

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Many identify agility with the ability to COD of movement; however, agility is defined as the ability to quickly change the direction of motion, noting that there is an external stimulus, and changing the direction of movement, or COD, is one of the components of agility, which includes technique, the explosiveness of the lower extremities, as well as the ability to effectively brake and accelerate (Javorac, 2017; Sheppard, & Young, 2006).

Linear accelerations and sprints are the most common actions performed by a football player before the actual act of scoring a goal, and this applies not only to the scorer but also to the assistant (Haugen et al., 2013). The terms acceleration and sprints are used in many speed development programs, but it is necessary to distinguish between these two terms. Acceleration represents the rate of increase in speed, and sprinting is the highest rate of speed an individual reaches (Jeffreys, 2013). Because of this, running at maximum speed at distances of 5 or 10 meters cannot be called sprints because maximum speed is not reached. From that aspect, we can define speed as the ability to accelerate and reach top speed (Haff & Triplett, 2013).

Studies over several decades show that soccer players become faster over time (Haugen et al., 2013; Tønnessen et al., 2013) and it is interesting to see if increasing speed affects the ability to COD movement. The fact that in the English Premier League, in a period of 10 years, the number of high-intensity activities increased by as much as 50 percent (Fransson et al., 2017) tells us how important speed is for football in general. It is clear to us that the ability to COD movement plays a big role in these activities, because football is not only about straight movements.

The topic of this research is precisely two anaerobic components that significantly impact football performance. For running speed, we can say that it represents the ability to accelerate and reach maximum speed (Haff & Triplett, 2013). It is related to the ratio of step length and frequency, which means that by increasing either of these two variables, we also affect the increase in speed itself. The ability to COD movement represents exactly that, the ability to quickly change the direction of movement but without the influence of an external stimulus and during pre-planned activities.

There is a certain amount of research directly or indirectly related to the topic; however, the vast majority only included work with the male population. A small share of research has dealt with this topic among female soccer players. For example, Lockie et al. (2018) conducted research on female players of Division I and Division II of the American National College Association and showed that there is a significant statistical correlation between the linear speed at 10 meters and the ability to COD movement, the parameter of which was taken as test 505. Similar results were shown with soccer players (Loturco et al., 2018). However, there are many studies on soccer players where there is no statistically significant influence of speed on the ability to COD (Freitas et al., 2021; Papla et al., 2020; Sammoud et al., 2021). In other sports, there is a noticeable difference in the results obtained, both for men (Buchheit et al., 2012; Suarez-Arrones et al., 2020) and women (Nimphius et al., 2010).

According to all the previously mentioned research, we can see that the data are undoubtedly contradictory, considering that a large number of studies prove the influence of linear speed on the ability to change the direction of movement, 'which deny it. This is precisely why the research aims to see how much the linear speed affects COD in these conditions.

Method

This research was carried out on the sports fields in Novi Sad. The testing was carried out under the guidance of professional staff from the Faculty of Sports and Physical Education in Novi Sad. Modern equipment was used, photocells (Microgate, Polifemo Radio Light, Bolzano, Italy), with an accuracy of 0.001 s. In the preparation of the work, the available scientific literature, as well as primary and secondary sources, were used. The conducted study is by the ethical standards of the Declaration of Helsinki.

Nineteen football players of different ages from the women's football club in the Serbian Super League (16.90±2.28 years) participated in the testing. In order to participate in the research, the respondents needed proof of a completed medical examination, where their physical readiness for the efforts required by sports activities was confirmed. In addition, the subjects were informed verbally and in writing about the protocol, potential risks, and benefits of the study. Also, they were required to provide written consent to participate in the research.

To evaluate the speed, the following parameters were taken into consideration:

1) Linear speed at 5 meters
2) Linear speed at 10 meters
3) Linear speed at 20 meters
4) Flying sprint 10 meters

To assess the ability to COD movement, the following was taken into consideration:

1) 505 test for dominant and non-dominant leg
2) COD deficit

The football players were familiar with the complete testing procedure. Their tasks were demonstrated and explained in detail, while the measurers had previous training so that the obtained data would be as valid as possible. Before the tests themselves, the test subjects performed a dynamic warm-up to raise their body temperature and reduce the risk of injury to a minimum. After the dynamic warm-up, a protocol consisted of acceleration, jumping, and braking as adequate preparation for the test. Each linear run was done twice, and a better result was taken for all variables. The 505 test was performed twice per leg. The designed initially 505 test was made so that we could measure "agility" in the horizontal plane (Draper et al., 1985). Considering that the test subject's activity is planned, this test is suitable for assessing the ability to COD movement.

Test 505, they started with maximum acceleration to the line 15 m away, turned 180° so that their right leg is the one that pushes off when changing the direction of movement, and then passed through the gate 5 m away at maximum speed. Female athletes are not allowed to touch the floor with their hands and not to use the hand push-off during the turn. After 3 minutes, the test was repeated with the other leg. Some findings tell us that the 505 test is valid and reliable for evaluating the change in the direction of movement (Stewart et al., 2012).

For the linear speed tests, the gates were placed at 5, 10, and 20 meters from the start and 20 and 30 meters for the 10 m flying sprint. Their task was to run the given distance in the shortest period, and for each test, they had two attempts with a 3-minute break in between. A better result was taken for the analysis.

Testing was done on an open field with an artificial grass surface in the morning hours (9:00-11:00), during favorable weather conditions (no wind or rain). On the first day, the linear speed at 5 and 20 meters as well as the flying sprint at 10 were tested, and the second day was scheduled for the linear speed at 10 meters and the 505 test.

The data were processed using the Statistical Package for Social Science, version 21.0 (SPSS Inc., Chicago, Illinois, USA). Regression analysis was applied in order to see the influence of speed on the ability to change the direction of movement as well as the COD deficit. The level of statistical significance was set as $P<0.05$.

Results

Data processing to determine the influence of linear speed on the ability to change the direction of movement was performed using multiple linear regression. A review of the Normal Probability plot diagram proves that the results do not deviate from normality. Tabachnick and Fidell (2007) define non-peak points as cases with a standardized residual greater than 3.3 or less than -3.3. Tolerance and VIF (Variance inflation factor) values indicate that the assumption of the non-existence of multicollinearity is not violated.

Regression analysis was applied to see the effect of speed on time required to perform the 505 test with the dominant leg. The coefficient of determination is 0.219; based on it, we conclude that our model describes 21.9% of the total variance. The significance of the model is 0.449, which means that the model is not significant. Therefore, based on the previous variables, we cannot predict the time for test 505 with the dominant leg.

Table 1. Presentation of the linear speed regression analysis for the 505 test with the dominant leg

Variable	B	Standard Error	Standardized Beta	Sig.
5 meters speed	-0.243	1.059	-0.108	0.822
10 meters speed	0.184	0.657	0.122	0.784
20 meters speed	-0.092	0.838	-0.097	0.914
Flying sprint 10 meters	1.007	1.152	0.519	0.397

Note: R^2=0.21

Although the highest correlation was obtained between the speed of the flying sprint at 10m and the ability to COD movement measured by the 505 test for the dominant leg (Table 1), no variable has a significant contribution to the obtained model, that is, no variable influences the ability to COD movement measured by the 505 test for the dominant leg foot.

Regression analysis was also applied to see the effect of speed on time required to perform the 505 test with the non-dominant leg. The coefficient of determination is 0.180, and based on it, and we conclude that our model describes 18% of the total variance. Therefore, the significance of the model is 0.563, which means that the model is not significant; that is, we cannot predict the time for test 505 with the non-dominant leg based on the previous variables.

Table 2. Presentation of the linear speed regression analysis for the 505 test with the non-dominant leg

Variable	B	Standard Error	Standardized Beta	Sig.
5 meters speed	-1.098	0.908	-0.585	0.246
10 meters speed	0.176	0.563	0.140	0.759
20 meters speed	0.401	0.718	0.506	0.585
Flying sprint 10 meters	0.148	0.987	0.091	0.883

Note: R^2=0.180

Although the highest correlation was obtained between the speed at 5m and the ability to COD movement measured by the test 505 for the non-dominant leg (Table 2), none of the variables has a significant contribution to the obtained model that is, none of the variables influences the ability to COD movement measured by the test 505 with the non-dominant leg.

Regression analysis was applied a third time to see speed's influence on the COD deficit. The coefficient of determination is 0.213, and based on it, and we conclude that our model describes 21.3% of the total variance. The significance of the model is 0.466, which means that the model is not significant; that is, we cannot predict the time for test 505 with the non-dominant leg based on the previous variables.

Table 3. Presentation of the linear speed regression analysis for the COD deficit test

Variable	B	Standard Error	Standardized Beta	Sig.
5 meters speed	-0.243	1.059	-0.109	0.822
10 meters speed	-0.816	0.657	-0.546	0.234
20 meters speed	-0.092	0.838	-0.098	0.914
Flying sprint 10 meters	1.007	1.152	0.521	0.397

Note: R^2=0.213

Although the highest correlation was obtained between the speed at 10m and the COD deficit, (Table 3), none of the variables has a statistically significant contribution to the obtained model; that is, none of the variables has an impact on the COD deficit.

Discussion

The research aimed to determine the influence of linear speed on the ability to change the direction of movement.

For linear speed parameters, four variables were taken into account: the linear speed at 5 meters, the linear speed at 10 meters, the linear speed at 20 meters, and the flying sprint at 10 meters. For the parameters of the ability to change the direction of movement, three variables obtained based on the performance of test 505 were taken into consideration, namely: the time required to perform the test with the dominant leg, the time required to perform the test with the non-dominant leg and the COD deficit (parameter obtained by from the time required to perform the 505 test subtract the time required to perform the linear velocity test at 10 meters).

Based on the data obtained using regression analysis, it was determined that linear speed has no statistically significant influence on the ability to change the direction of movement and the COD deficit.

The results of this study confirm the earlier conclusion that linear speed and the ability to change the direction of movement are two separate physical components (Javorac, 2017; Sheppard & Young, 2006; Suarez-Arrones et al., 2020). Therefore, we define the ability to change the direction of movement as the physical capacity of an athlete to change the direction of movement while simultaneously slowing down and immediately after that accelerating movement using different forms of movement. In contrast, we define speed as the ability to accelerate and reach maximum speed.

The reason for the fact that these are two different components could lie in the fact that at high speeds, we need much more significant force to decelerate, i.e., to freeze effectively (Buccheit et al., 2012). Therefore, we conclude that a person who can achieve a higher speed must also exert a tremendous effort to achieve an efficient change of direction. COD is a very complex ability, and it depends on many factors such as power, movement mechanics, braking and acceleration, and the entire kinematic component.

Locke et al. (2018) conducted a study that supports these findings in football players with similar tests. A study from last year with pre-adolescent football players that took into account the 505 test as well as tests for the assessment of linear speed at 5, 10, and 20 meters also did not show a significant effect of speed on the change of direction of movement but also on the COD deficit (Sammoud et al., 2021), as well as a very similar study from the same year (Freitas et al., 2021). Research conducted on professional football players of the Polish second league showed no statistically significant relationship between the linear speed at 20 meters and COD deficit for both legs (Papla et al., 2020).

On the other hand, one study investigated a similar topic by measuring the effect of flying sprints on COD ability as measured by the zig-zag test, and the results obtained also show a statistically significant association between flying sprints at 20 and 10 meters and change of direction in youth soccer players (Loturco et al., 2018).

In addition to these, some studies were conducted on something other than football players. First, the research on netball players did not show a statistically significant correlation between the speed at 10 meters and the time obtained on the 505 test for both the dominant and the non-dominant leg. In the same research, data showed a statistically significant inverse relationship between 10-meter linear sprint and COD deficit, which further implies that faster athletes have a more significant COD deficit (Dos'Santos et al., 2019).

One study on non-athletes found a significant association between the change of direction and linear sprints of 10 and 20 meters. This study explains the high correlation with the fact that the tests for changing the direction of movement were more extended than 20m (30-40m). They believe that the distance run and the number of turns the individual needs to make significantly influence the correlation results (Suarez-Arrones et al., 2020). Research on 12 individuals coming from team sports showed a considerable statistically significant influence of linear speed on the ability to change the direction of movement at an angle of 45°. This research also points out that by increasing the angle of change of direction of movement, linear speed has less and less influence, and this is supported by the opinion that when changing direction at an angle of 45°, much less propulsive force is needed for a turn compared to a turn of 180° (Buchheit et al., 2012).

A study on female softball players showed no statistically significant effect of speed on the 505 test performed with the dominant leg. However, it shows a significant statistical effect of speed measured at 35.8m on the 505 test performed with the non-dominant leg (Nimphius et al., 2010).

Numerous studies give recommendations on how to develop explosive power, primarily of the legs (de Hoyo et al., 2016; Javorac, 2012; Keller et al., 2020), which can improve results in the speed of changing

direction but also some specific football training for COD (Beato et al., 2018; Young & Rogers, 2014).

It should be noted that there is a much higher correlation between speed on COD when it comes to distances longer than 30 meters (Suarez-Arrones et al., 2020). Research on this topic is mainly contradictory because the results are interpreted differently. Some research involves using other tests (e.g., the zig-zag test for the ability to change the direction of movement); therefore, it is not surprising that the data obtained are different. Nevertheless, a large number of studies have been able to confirm the effect of speed on COD, and a large number of those have not. These different data tell us exactly how many factors influence the ability to change the direction of movement and how complex it is.

In order to more precisely determine the influence of speed on the ability to change the direction of movement, in future research, we would have to pay attention to all the previously mentioned components that affect COD, as well as to define more precisely at which angles the subjects should change the direction of movement so that the results are as authoritative as possible.

Conclusion

Speed and the ability to change direction are critical factors in football. The research was conducted on 19 elite female football players, and the goal was to determine the influence of linear speed on COD.

This leads us to the conclusion that the influence of linear speed on the ability to change the direction of movement could be influenced by the following:

• Distance run - the more significant the distance, the greater the influence of linear speed.

• The angle at which the turn is performed - the smaller the rise, the less force the athlete needs to generate to freeze and then accelerate again, and the influence of eccentric power and the rate of force production is significantly reduced, while the impact of speed increases.

• Number of turns - the greater the number of turns or changes of direction, the greater the role played by abilities that are key to an efficient transition of leadership (technique, explosiveness of the lower extremities, and the ability to brake and accelerate effectively), and the lower the linear speed.

• Movement mechanics.

This research was conducted to provide future coaches and sports experts with information on the connection between linear running and abilities that are key to the success and efficiency of women's football. The knowledge we gained through this research could influence the modification of training cycles in terms of designing more specific training episodes for female football players. In training programming, fitness and soccer coaches should be aware that increasing speed does not necessarily mean improving COD and should treat linear acceleration and the ability to COD as two separate components. Eccentric training is one of the tools that could help develop COD, considering that when stopping at high speeds, the unnatural strength of the muscles of the lower extremities plays a considerable role. Acceleration-deceleration exercises and the change of direction technique improve the COD ability. When developing speed, coaches must be aware that they influence only that component and that for the overall performance on the field, they must integrate several physical features to obtain a harmonious and efficient implementation of technical and tactical elements.

Precisely because of this, the education of football and fitness coaches is of crucial importance so that we can create versatile athletes who are abundant with quality physical attributes produced at the expense of the quality work of the entire professional staff and the profession. Knowing the field of conditioning greatly facilitates creating a quality athlete. This is precisely the importance of well-programmed training, which is preceded by a lot of time and effort required to learn the basics of conditioning as strength training.

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