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Investigation of the Relationship Between Dynamic Leg Force and Change of Direction Running in Youth Football Players

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Abstract: Dynamic lower limb force, characterized by explosiveness, speed, and muscular strength of the lower extremities, plays a significant role in the athletic performance of soccer players. However, previous studies have reported inconsistent findings regarding the relationship between agility and dynamic leg force. When agility is defined specifically as running involving changes of direction, the likelihood of a correlation with physical capacities such as speed and dynamic leg power increases. The present study aimed to examine the relationship between dynamic lower limb force and change of direction (CoD) performance. Specifically, we investigated how these two physical qualities relate in youth athletes aged 10 to 13 years participating in individualized training programs. Dynamic leg power was assessed using the standing broad jump test, while change of direction speed was evaluated with the T-test. The results revealed significant improvements in both measured capacities following training. However, no statistically significant correlation was found between dynamic leg force and change of direction performance. Although a weak relationship was observed, it did not reach statistical significance.

Keywords: dynamic lower limb force, agility, change of direction performance, football

Introduction

Numerous studies have investigated the role and significance of dynamic lower limb force in football, confirming that this capacity, encompassing explosiveness, speed, and muscular strength of the lower extremities, plays a key role in football performance. The research of Czimbalmos et al. (2020) highlighted that the development of dynamic leg force significantly enhances on-field performance in youth football players.

Dynamic leg power plays a crucial role in sprinting speed, as it directly influences rapid accelerations and quick changes of direction (Smirniotou et al., 2008; Alemdaroğlu, 2012; Bret et al., 2002). It is also a determining factor in change of direction (CoD) speed (Matlák et al., 2014), which is a component of agility. Within agility, researchers differentiate between perceptual and decision-making factors and the physical ability to perform rapid directional changes. The latter refers to high-speed running with directional changes not necessarily triggered by external stimuli, commonly referred to as change of direction running. Research findings on the relationship between agility (both cognitive-perceptual and physical aspects) and dynamic lower limb force are inconsistent (Young et al., 2002; Peterson et al., 2006; Barnes et al., 2007). According to Sheppard and Young (2006), a stronger association exists between these abilities during short-distance tasks involving multiple changes of direction. Bloomfield et al. (2007) emphasized that both speed and dynamic lower limb power contribute substantially to agility. As these are trainable qualities, they were given considerable emphasis in training routines, and the development of either or both has been shown to improve athletic performance (Bloomfield et al., 2007).

Regarding the relationship between dynamic leg power and agility, when agility is defined specifically as CoD running, a stronger correlation is likely to emerge between performance variables such as speed and dynamic leg strength (Bloomfield et al., 2007).

However, studies that did not directly examine the correlation between these capacities, but instead investigated how improving one affects the other, reported mixed results. For example, high-resistance strength training did not show a meaningful effect on CoD speed, whereas programs targeting dynamic power (e.g., explosive strength training) revealed significant improvements in CoD performance (Brito et al., 2014; Hammami et al., 2016; Váczi et al., 2013; Garcia-Pinillos et al., 2014).

Matlák et al. (2014) also demonstrated that plyometric training can effectively improve agility, particularly CoD speed, in young football players.

Agility, defined as a complex movement coordination skill involving accelerations, decelerations, and directional changes, plays a critical role in football. Players are often required to make rapid decisions and adapt to constantly changing game scenarios. Agility is therefore closely related to overall performance, especially in both defensive maneuvers and offensive transitions (Sheppard & Young, 2006). A study by Chaouachi et al. (2014) showed that elite-level football players achieved significantly better results in agility tests compared to lower-level athletes, supporting the view that agility is a key determinant in performance level differentiation.

Returning to dynamic lower limb force, it has also been shown to be a major contributor to vertical jump performance, which is crucial in both offensive and defensive heading situations. Furthermore, dynamic leg power contributes to the execution of high-speed, accurate shots and long passes. The speed and accuracy of kicking actions are largely dependent on explosive lower limb strength (Trolle et al., 1993). Strength training can improve kicking performance as a result of increased force production (DeProft et al., 1988). Similar findings were reported by Taina et al. (1993), who found that maximal strength training of the lower limbs increased kicking speed.

Interestingly, Trolle et al. (1993) found that various types of resistance training did not affect kicking performance, and that high-load strength training did not improve kicking speed. Cabri et al. (1988) suggested that isokinetic strength training may be more effective for enhancing kicking performance in athletes.

The aim of our research was to investigate the relationship between dynamic lower limb force and change of direction speed, based on empirical performance data.

Based on the results, the study aims to provide recommendations for improving the effectiveness of training methods designed to enhance these performance variables.

Methodology

Although during a match the various conditional and coordinative abilities do not manifest in isolation but interact and contribute collectively to performance, their assessment is more commonly conducted using an isolated approach. In our research, with this consideration in mind, we selected several sport-specific motor tests aimed at evaluating key performance-related abilities, specifically agility and dynamic lower limb force. Given the inconsistent findings in the literature regarding the relationship between the development of these abilities, particularly between dynamic leg force and agility, we aimed to investigate what kind of correlations can be observed in the players included in our study.

While numerous parameters were assessed, the present study focuses specifically on the results related to change of direction (CoD) speed (as an indicator of agility) and dynamic lower limb force.

The study involved 15 participants, all male athletes registered in youth football teams. Their mean age was 11.67 years (SD = 0.900), indicating a homogeneous sample, as the age range was narrow (10–13 years). This provided a reliable basis for comparing agility test results while minimizing the influence of age-related variability.

The players participated in additional training sessions structured using a holistic training methodology, delivered individually or in small groups, in addition to their regular team practices. As a result, they trained 6 to 7 times per week.

Data collection occurred on two separate occasions, with a one-year interval between them. The assessments were carried out on an artificial turf surface. Each test was performed twice by the players, except for the explosive strength test, where three attempts were allowed, in accordance with literature recommendations (Csáki, 2020). For the statistical analysis, the mean execution time was used for each test, while for explosive strength, the longest distance achieved was considered.

To assess CoD speed, we used the T-test. The test area was set up within a 20x20 meter space using three cones, following the protocol described by Semenick (1990). The starting point was marked 80 centimeters before the timing gate. After crossing the photocell gate, the player sprinted 5 meters in a straight line to the first cone, performed a directional change by circling the cone, then continued 5 meters to the second cone. After a full turn around the second cone, the athlete ran 10 meters in a straight line to the third cone, circled it completely, and returned toward the first cone. Following another change of direction at the first cone, the player sprinted through the finish line. Performance was measured in seconds using the OXA Starter+ infrared gate timing system.

To measure dynamic lower limb force, we applied the standing long jump test, as vertical and horizontal jump tests are most commonly used for this purpose (Csáki, 2020; Matlák et al., 2014). The protocol followed Csáki's (2020) methodological recommendations. A 4-meter measuring tape was used to record the jump distances to the nearest centimeter. The baseline served as the starting point, from which the athlete was required to perform a maximal jump forward using arm swing and countermovement. Each athlete completed three attempts, and the farthest jump was recorded.

We conducted both descriptive and correlational statistical analyses. For each measured variable, we calculated the mean and standard deviation. As the normality test indicated a normal distribution, we used an independent samples t-test. For the correlation analysis, a significance level of $p \leq 0.05$ was applied. In the tables, statistically significant correlations ($p \leq 0.05$) are marked with an asterisk. Data analysis was performed using the SPSS-27 statistical software.

Results and discussion

Let's first look at the results of running speed with direction changes (agility) and dynamic leg strength between the two measurement times. In the first measurement, in the agility, the average execution time on the right side was 9.78 seconds (SD = 0.717), while in the second measurement this value decreased to 9.20 seconds (SD = 0.534). This reduction indicates an improvement in the players' performance, which can be partly attributed to practice and the effect of repetition.

In the first measurement on the left side, the mean was 9.98 seconds (SD = 0.812), which also decreased in the second measurement to 9.38 seconds (SD = 0.612). The results demonstrate progress in performance on the left side as well (Table 1).

During the agility tests, a lower standard deviation was observed in the second measurement on both sides, reflecting more consistent performance among the players.

Table 1. Changes in agility test results between two measurement time points

	Measurement	Mean (sec)	SD	Asymp. Sig. (2-tailed)
	1st measure	9,86	0,717	
Agility right	2nd measure	9,24	0,534	0,000***
	1st measure	10,06	0,812	
Agility left	2nd measure	9,45	0,612	0,000***

Wilcoxon test *p≤0.05; ** p≤0.01; ***p≤0.001 Source: Own elaboration

The results of dynamic lower limb power also improved between the two measurements. The average result in the first measurement was 167.59 cm, which increased to 179.47 cm in the second measurement (Table 2).

Table 2. Changes in dynamic lower limb power test results between two measurement time points

	Measurement	Mean	Asymp. Sig. (2-tailed)
Standing long jump	1st measure	167,59 m	
	2nd measure	179,47 m	0,000***

Wilcoxon test *p≤0.05; ** p≤0.01; ***p≤0.001 Source: Own elaboration

Our main research question was whether there is a correlation between agility (change-of-direction running speed) and the explosive power of the lower limb muscles. Dynamic lower limb power, encompassing explosiveness, speed, and muscular strength of the lower extremities, plays a key role in soccer performance (Czimbalmos et al., 2020). Bloomfield and colleagues (2007) state that dynamic lower-body power substantially contributes to change of direction running speed. Since these abilities are trainable factors, and were therefore emphasized in our training sessions, the development of one or more of them is expected to lead to improved performance (Bloomfield et al., 2007). With this in mind, we now turn to the results. Dynamic lower limb power is a crucial ability, as it plays a significant role in both speed and agility. The results indicated that no significant correlation was found between the two measured abilities. A weak correlation was observed, but it was not statistically significant. The same observation has been confirmed by several other studies: generally, only low correlations are reported between strength, speed, and agility (e.g., Sheppard & Young, 2006; Buttifant et al., 1999; Young et al., 1996). For instance, Marković (2007) reported correlation coefficients ranging between 0.33 and 0.44, which, although statistically significant, indicate only weak to moderate relationships. Strength tests, regardless of their apparent relevance, explain only a small proportion of the variance in agility performance. Similarly, in the case of reactive agility, no strong associations were found, likely due to the fact that agility is not merely a physical attribute but rather a complex interplay of physical, technical, and perceptual factors.

The literature presents divergent findings regarding the relationship between agility and Dynamic Lower Limb Power. While some studies have identified strong associations in short-distance, change-of-direction running tasks (Sheppard & Young, 2006), others investigating the effects of high-resistance strength training have reported no significant relationships (Brito et al., 2014; Hammami et al., 2016). Our findings therefore contribute to the current scientific discourse by highlighting that improvements in both explosive lower-limb power and change-of-direction running speed may independently result in substantial performance gains, yet their interrelationship is complex and influenced by multiple factors.

The correlation coefficient (ρ) for agility on the right side was -0.270, and for the left side -0.384. This indicates a weak negative correlation between standing long jump performance and agility (speed) measurements based on the second measurement. Since the coefficient ranges between -1 and +1 (where -1 represents perfect negative correlation and +1 represents perfect positive correlation), the results suggest that if any association exists, it is very weak.

The significance levels were $p = 0.295$ for the left side and $p = 0.128$ for the right side, indicating no statistically significant relationship between the two variables at the 5% significance level (significance would be considered at $p < 0.05$). Therefore, based on this sample, it cannot be conclusively stated that a true correlation exists between the two measured outcomes (Table 3).

Table 3. Results of the correlation analysis between agility and explosive lower limb power

			2nd Measurement Standing Long Jump	2nd Measurement Agility Right
Spearman's rho	2nd Measurement Standing Long Jump	Correlation Coefficient	1,000	-,270
		Sig. (2-tailed)	.	,295
		N	17	17
	2nd Measurement Agility Right	Correlation Coefficient	-,270	1,000

		Sig. (2-tailed)	,295	.
		N	17	17

			2nd Measurement Standing Long Jump	2nd Measurement Agility Left
Spearman's rho	2nd Measurement Standing Long Jump	Correlation Coefficient	1,000	-,384
		Sig. (2-tailed)	.	,128
		N	17	17
	2nd Measurement Agility Left	Correlation Coefficient	-,384	1,000
		Sig. (2-tailed)	,128	.
		N	17	17

Spearman's correlation; *p≤0.05; ** p≤0.01; ***p≤0.001 Source: Own elaboration

Sample size (N): The sample size here was 15 (N = 15), which is relatively small, so the results should be interpreted with caution, as the strength of the correlation may differ in a larger sample.

A recent study on youth soccer players of a similar age group (Franca et al., 2024) examined the relationship between Dynamic Lower Limb Power and agility. The authors reached an interesting conclusion: body composition (specifically body fat percentage) proved to be a stronger predictor of agility than vertical jump performance, which showed only moderate correlations with agility, similar to the findings of the present study. Although lower-limb explosiveness contributes to sprinting and change-of-direction ability to some extent, it is not a sufficient factor on its own and was found to be particularly relevant only for longer sprint distances (35 m). These results suggest that agility and speed are complex abilities in which, alongside muscular power development, favorable body composition plays a crucial role. Consequently, in the training programs of youth soccer players, strength development should be complemented by strategies for body weight and fat control, as well as the practice of functional, sport-specific movement patterns. Achieving optimal performance therefore requires a multidimensional development strategy that does not rely solely on lower-limb strength but also accounts for body composition and complex movement coordination.

Conclusions

In our study, we began with the premise that previous research has reported inconsistent findings regarding the relationship between agility and dynamic lower-limb strength. When agility is defined as the ability to perform sprinting with changes of direction, it is more likely that performance attributes such as speed and dynamic lower-limb strength are interrelated. The present study specifically examined this relationship, focusing on sprinting with directional changes and dynamic lower-limb strength. Our results indicated that there was no significant correlation between these two performance variables. Although a weak association was observed, it did not reach statistical significance.

Based on the findings, it can be concluded that, among male youth soccer players, the speed of sprinting with changes of direction (agility) and dynamic lower-limb strength both improved significantly over the one-year observation period; however, no significant correlation was detected between them. The performance gains observed in agility tests for both right- and left-sided execution, along with the increases in dynamic lower-limb strength, clearly demonstrate that a structured, holistic training program effectively enhances both abilities. Nonetheless, the correlation analysis revealed a weak negative relationship, which was not statistically significant, indicating that a direct link between these two capacities cannot be confirmed in the current sample.

Our findings support previously reported evidence in the literature, suggesting that the development of dynamic lower-limb strength and agility can independently, as well as synergistically, contribute to improving soccer performance. However, detecting stronger associations would require studies with larger sample sizes and participants across different age groups and training levels. From a practical perspective, training programs should specifically address both lower-limb strength and change-of-direction sprinting, as simultaneous improvement in these qualities may contribute to players' stable and rapid performance on the field.

In summary, the correlation between the two measurement outcomes is weak and not significant; therefore, based on the current sample, it cannot be stated that there is a strong association between standing long jump performance and agility test results. The results show a trend toward a weak relationship, but it is not statistically meaningful.

Limitations of the study

This study has several limitations that should be acknowledged. First, the relatively small sample size (N = 15) limits the statistical power and the generalizability of the findings. The sample was composed exclusively of 10–13-year-old youth soccer players, meaning that the results cannot be extrapolated to other age groups, genders, or sports. Moreover, the measurement tools applied were limited: lower-limb explosive strength was assessed only through the standing long jump, and agility was evaluated exclusively with the T-test, each capturing only one aspect of these complex performance qualities. In addition, the short-term design did not allow for the assessment of long-term training adaptations, and the absence of a control group makes it difficult to attribute performance changes solely to training effects. Finally, although weak, tendential relationships were observed between dynamic lower-limb strength and agility, the correlations did not reach statistical significance, which necessitates cautious interpretation of the results.

Future research should therefore employ larger and more diverse samples, incorporate multiple testing methods, and adopt longitudinal designs to provide a more comprehensive understanding of the relationship between explosive lower-limb strength and agility in youth athletes.

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