

Relationship between speed and explosive power of lower limbs in semi-elite football players

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ABSTRACT

PURPOSE: *This study focuses on the relationship between speed (acceleration, maximum speed, and change of direction speed) and explosive power of lower limbs represented by countermovement jump (CMJ) in semi-elite football players.*

METHODS: *Twenty semi-elite football players ($n = 20$; 25.1 ± 6.2 years) participated in the study. All participants were assessed using the following 5 tests: countermovement jump (CMJ), 5-0-5 Agility test with dominant lower limb turn and non-dominant lower limb turn, 10-meter linear sprint, 30-meter linear sprint.*

RESULTS: *Pearson's correlations ($p \leq 0.05$) calculated the relationship between CMJ and speed tests. Subjects displayed a very large correlation between 10 and 30-meter sprints and CMJ ($r = -0.75$ and -0.76). There was a moderate correlation between 505 COD tests (non-dominant and dominant) and CMJ ($r = -0.54$ and -0.61 , respectively).*

CONCLUSIONS: *There are large to very large relationships between speed and power attributes in semi-elite soccer players, especially between linear speed and CMJ. Improving the explosiveness and power of lower limbs can lead to increasing velocity and enhancing sport-specific speed.*

Keywords: *acceleration, maximal speed, change of direction speed, countermovement jump, correlation*

INTRODUCTION

Speed abilities are one of the critical factors in team sports that contribute to the success of individuals and thus the victory of the entire team. UEFA technical reports, which examine Europe's most prestigious competition – Champions League, show that the most successful teams have the fastest players in their squads. At the same time, the analyses demonstrate the direction in which football and players' individual performances are evolving. For example, in the season 2018/19, the number of sprints above 30 km/h doubled compared to the previous year. (UCL 2019/19 Technical report, 2019). In 2019/20, Kylian Mbappe (Paris Saint-Germain FC) reached the highest speed of 33.98 km/h (UCL 2019/20 Technical report, 2020). In the following season, 7 players exceeded this limit (UCL 2020/21 Technical report, 2021).

Football performance is not only a matter of maximum speed. From the point of frequency of individual actions in a match, it seems that immediate stopping, change of direction, and short acceleration are the key aspects of modern football. Players change their direction more than 700 times during a ninety-minute match (Bloomfield et al., 2007). Research has also proved that most sprints last less than 5 seconds (Andrzejewski et al., 2013).

According to the data stated above, focusing on the speed abilities seems crucial and may give a player a significant advantage over the others during the match. The question for coaches is how these abilities can be developed and improved.

Keiner et al. (2019) examined the long-term influence of strength training on change of direction speed. They concluded that specifically aimed strength training has a considerable effect on the evolution of direction speed. Subjects of this research were divided into two groups, in which case a strength-training group achieved a 5–10% improvement in a 10-meter sprint compared to a control group. It was also proved that strength training influences the force-velocity profile. Increasing the maximum strength level can positively affect explosive power and velocity (Østerås et al., 2002).

Among research conducted to examine the correlation between maximum power, explosive power, and speed belongs a study by Wisloff et al. (2004). It compares speed in a 10 and 30-meter sprint with the performance in a vertical jump. Researchers discovered a very large correlation ($r = -0.72$) between acceleration speed (the 10-meter sprint) and jumping height (CMJ). They also proved ($r = -0.60$) dependence between maximum speed (30-meter) and jumping height (CMJ).

The researchers also pursued the speed and force-explosive parameters and compared them with half-squat performance. They found large to almost perfect correlations between the level of 1RM and the 10 m sprint time ($r = 0.94$), 30 m sprint time ($r = 0.71$), 10 m shuttle run ($r = 0.68$) and jumping height ($r = 0.78$).

The same results ascertained Cronin and Hansen (2005), who tested 5-meter sprint, 10-meter sprint, and 30-meter sprint and compared these results with the jumping height. Authors found a large correlation ($r = -0.60$) between starting speed (the 5-meter sprint) and jumping height (CMJ), as well as between acceleration speed (the 10-meter sprint) and jumping height (CMJ), where the correlation was largest ($r = -0.62$). Moderate correlation ($r = -0.52$) was found between maximum speed (the 30-meter sprint) and jumping height (CMJ).

On the other hand, studies (Popowczak et al., 2019; Salaj and Markovic, 2011) showed no or very little correlation between explosive power and speed ($r = -0.01$ and $r = -0.04$ to -0.33 , respectively).

A brief review of the role of maximal strength and explosive power training in a change of direction speed claims that this type of training improves strength production in the vertical plane and thus contributes to improved performance in a change of direction speed. Specific factors influencing such performance types are unilateral strength, eccentric strength, reactive strength, and SSC (stretch-shortening cycle). From the point of maximum strength, the level of relative strength seems to be more important than the absolute one (Watts, 2015).

This research aims to examine the relationships between speed, which means the linear speed at 10 and 30-meter, change of direction speed, and explosive power of lower limbs represented by countermovement jump (CMJ).

MATERIALS AND METHODS

Participants

Twenty semi-elite football players ($n = 20$) participated in the study. All the participants were members of one team, competing in the 4th Czech football division. The average age of the players was 25.1 ± 6.2 years, the average height was $179,5 \pm 10,1$ cm, and the average weight was $81,3 \pm 9,2$ kg. All the participants were asked about their lower limb dominance; 16 out of 20 described themselves as right-footed and 4 as left-footed.

The study was conducted in accordance with the Declaration of Helsinki and followed the ethical standards of Masaryk University. Before the study, all participants were informed about the nature and aim of the research and were familiar with the potential risks of the study. All players agreed voluntarily with the participation in this study.

Design

The first test performed regarded the countermovement jump. The MyJump 2 software measured the jumping height and other parameters. It is considered valid and thus could be used as a cheaper substitute for the force plates (Stantona et al., 2017). CMJ can be regarded as the most valid and reliable test designed to assess the explosive power of the lower limbs (Markovic et al., 2004).

Another test the participants performed was a 10-meters linear sprint and a 30-meters linear sprint. Times were recorded by photocells (Brower Timing System, Brower Timing Systems, Draper, USA) at the start line, at the 10-meter mark, and the finish line (30-meter mark). The research by Wisloff et al. (2004) used the 10-meter linear sprint and 30-meter linear sprint tests to assess elite football players' acceleration and maximum speed levels.

The last test was the 505 COD test, which tested the change of direction speed and is very similar to the typical game situation in football. The player has to decelerate quickly from the maximum speed (a 15-meter sprint), turn in 180 degrees, and then accelerate back to the level of the photocells. Therefore, this test is used in research to examine the change of direction speed in team sports, especially football (Beato et al., 2019). 505 COD test is a highly reliable assessment with a coefficient of variation of 2.8% (Stewart et al. 2004).

All tests were conducted on the same day and under the same circumstances.

Statistical analysis

Test results are presented as mean \pm standard deviation. Statistica software (Statsoft Inc, Tulsa, Oklahoma, USA; version 12) was used for data processing. Pearson's correlation coefficient was used to evaluate the degree of linear correlation between variables. The magnitude of the association between variables was interpreted as trivial (0–0.1), small (0.11–0.3), moderate (0.31–0.5), large (0.51–0.7), very large (0.71–0.9), and almost perfect (0.91–1.0) (Hopkins, 2000). The proportion of the variance was defined by the coefficient of determination (r^2). The level of significance (α) was set at $p < 0.05$.

RESULTS

The study's results are processed in Table 1, where in the first column is the mean of the values and in the second is the standard deviation.

Table 1. Descriptive statistics of performed tests

	10m [s]	30m [s]	505 D [s]	505 ND [s]	CMJ [cm]
Mean	1.93	4.51	2.62	2.64	35.06
SD	0.12	0.18	0.12	0.15	3.67

Note: SD – standard deviation; 10m – 10-meters linear sprint, 30m – 30-meters linear sprint; D – dominant leg; ND – non-dominant leg; CMJ – countermovement jump

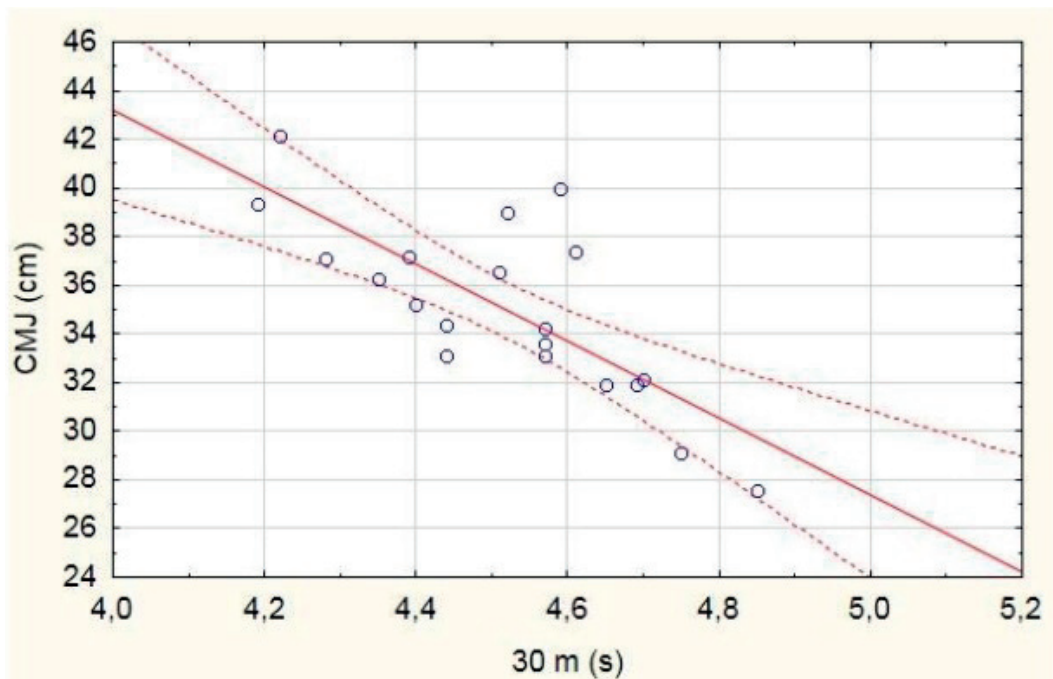
Table 2 shows the correlation matrix, while the individual columns show the dependencies between the individual variables, i.e., the performance in a 10-meter sprint, 30-meter sprint, 505 COD test non-dominant lower limb, 505 COD test dominant lower limb, and finally CMJ.

Table 2. Associations between the individual variables

	10m	30m	505 D	505 ND	CMJ
10m	1	0.98	0.59	0.6	-0.75
30m	0.98	1	0.58	0.58	-0.76
505 D	0.59	0.58	1	0.94	-0.61
505 ND	0.6	0.58	0.94	1	-0.54
CMJ	-0.75	-0.76	-0.61	-0.54	1

Note: 10m – 10-meters linear sprint, 30m – 30-meters linear sprint; D – dominant leg; ND – non-dominant leg; CMJ – countermovement jump

When comparing explosive power and speed, it can be stated that the largest correlation is between the performance in 30-meter sprint and jumping height ($r = -0.76$; $r^2 = 0.58$; $p < 0.05$).

**Figure 1.** Correlation between 30-meter sprint and CMJ

Very large correlation was also revealed between the 10-meter sprint and jumping height ($r = -0.75$; $r^2 = 0.56$; $p < 0.05$).

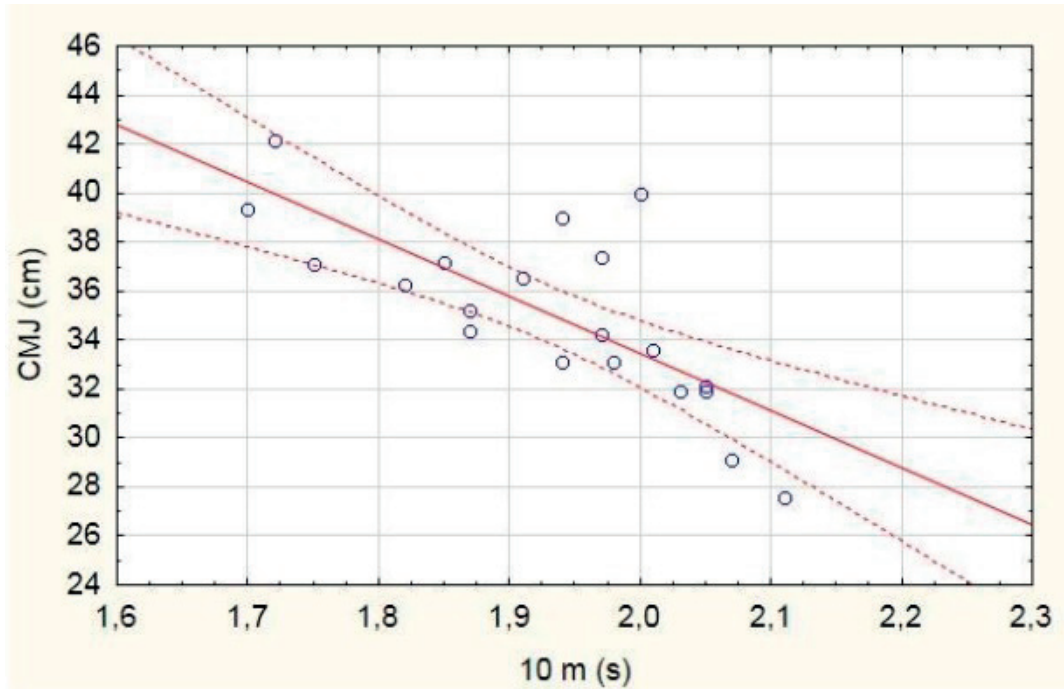


Figure 2. Correlation between 10-meter sprint and CMJ

Large correlation was also demonstrated in 505 COD tests (non-dominant and dominant) and jumping height test, respectively ($r = -0.54$ and -0.61 ; $r^2 = 0.29$ and $r^2 = 0.37$; $p < 0.05$).

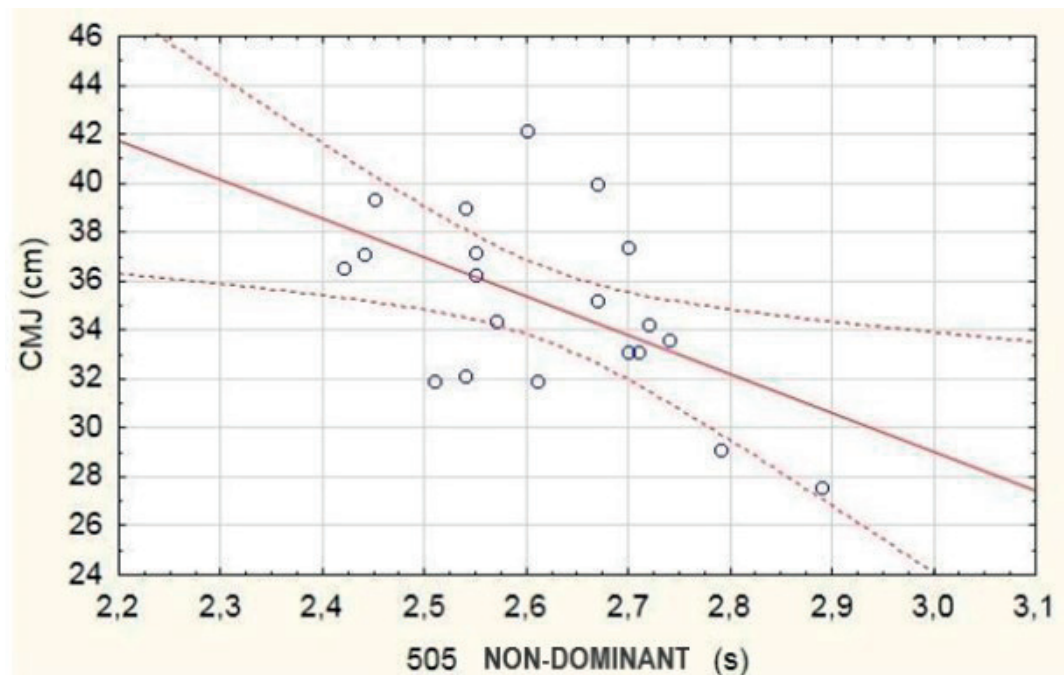


Figure 3. Correlation between 505 COD non-dominant and CMJ

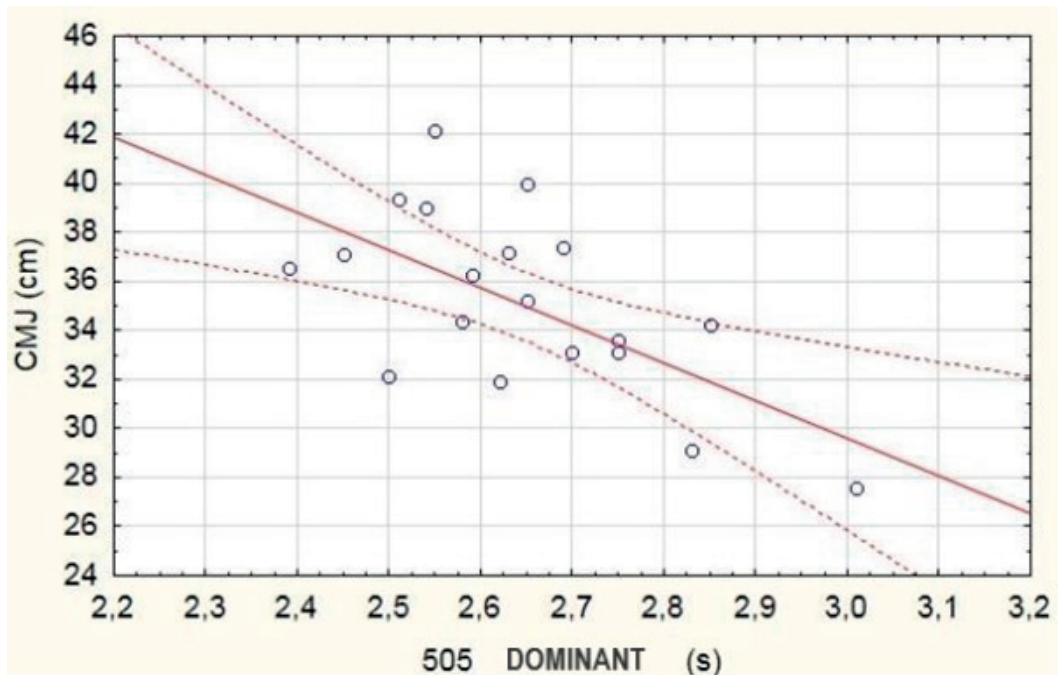


Figure 4. Correlation between 505 COD dominant and CMJ

DISCUSSION

Results of the study imply that the speed abilities for performance in acceleration speed (a 10-meter sprint), maximum speed (a 30-meter sprint), and change of direction speed (505 COD test) improve significantly as the jump height increases.

These conclusions were also confirmed by Wisloff et al. (2004) and Cronin and Hansen (2005), who proved a strong relationship between explosive power and linear speed. As a matter of interest, the researchers discovered that increasing a sprint distance positively affects the influence of jumping height on resultant sprint time. On the contrary, further studies like Ates and Cetin (2016), McFarland et al. (2016), and our research show that jumping height has a larger impact on starting and acceleration speed.

Scientists have united opinions regarding the relationship between linear speed and vertical jumping height, representing lower limbs' explosive power.

However, research that assesses the degree of correlation between change of direction speed and explosive power is often contradictory. The main factors include greater coordination and technical complexity of movement. It is not just about acceleration and transition to maximum speed in the straight plane. Still, it is necessary to have a good level of eccentric strength for deceleration and adequate isometric strength to utilize motion and transition to the concentric phase responsible for the subsequent acceleration. The correct mechanics of movement must condition the individual steps. From the point of view of the biomechanics of movement and the use of the ATP-CP system, the whole process seems to be even more demanding (Švantner et al., 2021).

Other factors affecting the research outcomes indisputably include the variability in tests used to measure the change of direction speed and participants' selection concerning their sport and physical abilities.

The outcomes of our research confirm the conclusions of Suarez-Arrones et al. (2020) and Keiner et al. (2019). On the opposite, Salaj and Markovic (2011) and Petersona et al. (2006) revealed only a slight correlation between explosive power and change of direction speed.

CONCLUSION

According to currently available literature and research, both strength and explosive-strength training can influence the level of speed abilities.

Positive effect on the SSC (stretch-shortening cycle), influencing the force-velocity curve, and improving force production in horizontal and vertical planes are the most probable mechanism that may cause such adaptations.

Strength and conditioning training in sports, where sprints and jumps occur, should work on the entire force-velocity curve. Athletes should train in both – the maximum strength and plyometric. However, it is crucial to prepare athletes between extreme points, which are strength-speed, peak power, and speed-strength. The optimally set training program thus works with different loads and different speeds of movement to achieve specific adaptations that will improve sports performance. Good coaches should always consider the game-specific demands when creating training plans.

However, this issue needs further examination, particularly the relationship between explosive power parameters and change of direction speed, which is a more complex movement than linear speed.

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