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Relationship between lower limb power output, sprint and change of direction performance in soccer players.

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Abstract

Introduction: Although soccer matches require players to perform repetitive power-related abilities, the impact of lower-body strength and power asymmetry on sprint and change of direction (COD) performance receives little attention. Therefore, this study aimed to establish the relationship between lower limb power, sprint, and change of direction (COD) performance. In addition, the relationship between lower limb power asymmetry and the above mentioned running tests was determined. Material and Methods: Twenty-four male soccer players from First Polish League (age = 24.8 ±8.2 years, body mass = 77.4 ±16.9kg, body height=179.5 ±14.5cm, soccer training experience = 10 ± 1.5years) took part in the study. To examine the relationship between linear sprint, lower limb muscle power, and COD performance (time and deficit), the following tests were performed: 5-and 20-m linear sprint, leg press exercise, and two 20-m COD sprints ("COD90" and "L" test). Result: Pearson correlation coefficients didn't show any statistically significant relationship between lower limb power and linear sprint speed as well as COD performance. The results indicate that the considered variables are independent physical characteristics. Conclusion: Relative lower limb-power output and low level of mean inter-limb asymmetry in power output does not affect 5- and 20-m linear sprint time and COD performance with 90° turn.

Keywords

agility, COD deficit, team sports, speed, power asymmetry

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Article

Relationship between lower limb power output, sprint and change of direction performance in soccer players

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Abstract: Introduction: Although soccer matches require players to perform repetitive power-related abilities, the impact of lower-body strength and power asymmetry on sprint and change of direction (COD) performance receives little attention. Therefore, this study aimed to establish the relationship between lower limb power, sprint, and change of direction (COD) performance. In addition, the relationship between lower limb power asymmetry and the above mentioned running tests was determined. Material and Methods: Twenty-four male soccer players from First Polish League (age = 24.8 ±8.2 years, body mass = 77.4 ±16.9kg, body height=179.5 ±14.5cm, soccer training experience = 10 ± 1.5years) took part in the study. To examine the relationship between linear sprint, lower limb muscle power, and COD performance (time and deficit), the following tests were performed: 5-and 20-m linear sprint, leg press exercise, and two 20-m COD sprints ("COD90" and "L" test). Result: Pearson correlation coefficients didn't show any statistically significant relationship between lower limb power and linear sprint speed as well as COD performance. The results indicate that the considered variables are independent physical characteristics. Conclusion: Relative lower limb-power output and low level of mean inter-limb asymmetry in power output does not affect 5- and 20-m linear sprint time and COD performance with 90° turn.

Keywords: asymmetry, COD deficit, COD, team sports, leg press.

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1. Introduction

Soccer matches require players to perform repetitive power-related abilities such as sprinting, jumping, accelerating, decelerating, changing direction, and cutting interspersed with periods of low to medium intensity activity (e.g., walking) [1]. Therefore, soccer players' locomotion speed tests are of great significance and popularity, e.g., covering a certain distance in a straight line (5m, 20m) or with a change of direction (COD) (Zigzag, 5-0-5). The ability to COD while running at high speed is of great interest because it seems to be a better reflection of match conditions [2, 3].

During COD, the participant's ability to accelerate, slow down, and re-accelerate in a new direction requires a rapid application of force. The acceleration phase in COD and linear sprints include similar technical factors, thus the improvement in acceleration may be beneficial in terms of subsequent accelerations after successive COD maneuvers and transitions between them [4–9]. Considering the significance of acceleration, it can also be assumed that linear speed and lower body power output could be related to COD performance [9].

A measure that helps in assessing the isolated COD capacity is the COD deficit. The COD deficit corresponds to the difference in speed between the linear sprint and the task of an equal distance with a COD [10,11]. The influence of various variables on the COD efficiency was analyzed, e.g., jump height, lower body power, and strength [4, 12, 13]. A study by Loturco et al. [3] did not confirm the relationship between the Zigzag test (COD 100°) and relative mean propulsive power output during the half squat and squat jump (progressively added load during both exercises) in youth soccer players. However, the authors showed a statistically significant positive correlation between the 10 and 20 m linear sprint and the COD deficit in the Zigzag test [3]. Furthermore, Nimphius et al. [11] showed a positive relationship between the 100° COD deficit and the 505 test. On the other hand, Pereira et al. [10] found a positive correlation between the 100° COD tests and mean propulsive power output (obtained in the squat jump and the countermovement jump) in female and male handball teams. Interestingly, the authors point out that the magnitude of the correlation coefficient between the aforementioned data may significantly differ depending on the mechanical requirements of each COD task, as well as when isolating the COD deficit [10]. Therefore, according to Nygard et al. [14] and Bourgeois [15] it seems that angles below 90° are more speed-oriented, while higher COD values than 90° are more force-oriented [14,15].

Although the impact and relationship between lower-body strength and power output have been extensively studied, the contribution of lower-body power-related asymmetry on sprint and COD performance receives little attention with inconsistent results of available data [13, 16–18]. Maloney et al. [13], Bishop et al. [13, 17, 19], and Michailidis et al. [17], concluded that lower leg inter-limb asymmetry (measured by single leg jump height) positively correlated with 20m linear sprint time. However, Maloney et al. [13] studied a group of healthy but untrained males, while Bishop et al. [19] and Michailidis et al. [17] conducted a study on a group of soccer players aged 10 to 15 years. In turn, Lockie et al. [18] found that lower-limbs asymmetry didn't impair performance in the T-test and 505 (both with 180° COD) test in team sports players. The authors suggested that an inter-limb asymmetry value close to 10% in a single-leg vertical jump height shouldn't attenuate running performance [18]. Bearing in mind that the sports discipline practiced has a significant impact on the degree of asymmetry in the body [20], it may be argued that excessive asymmetry may affect linear speed and COD abilities over time. It should be noted that soccer leads to the development of asymmetric musculoskeletal adaptation of the lower limbs, resulting in muscular asymmetries and body posture [21]. Michailidis et al. [17] noted that an inter-limb asymmetry of 10% may be unfavorable and lead to disturbances in movement patterns and injuries in children between 10 and 15 years old . Hence, more research is needed to assess the impact and relationship of limb asymmetry with power-related movements to maximize sports performance and prevent injury.

Therefore, this study aimed to establish the relationship between lower limb power output during the leg press exercise, along with power output asymmetry in this exercise, 5- and 20-m linear sprint, and COD performance assessed by the Zigzag and L test, and COD deficits in those tests. It was assumed that lower limb power output would positively correlate with sprint and COD performance, while the asymmetry would negatively correlate with COD performance.

2. Materials and Methods

2.1. Experimental Design

To examine the relationship between linear sprint, leg power inter-limb asymmetry and COD performance, the following tests were applied: 5- and 20-m linear sprint, leg press exercise, and two different 20-m COD sprints, ("ZigZag"-90° and "L" test-90°). Additionally, the COD deficit was calculated for each trial. Measurements were conducted in two sessions, 72h apart in counterbalanced order. In one session participants performed linear and COD sprints, and in the other one, the leg press exercises to assess the leg power interlimb asymmetry.

2.2. Study Participants

Twenty-four male elite soccer players from the First Polish League ((age = 24.8± 8.2 years, body mass = 77.4 ±16.9 kg, body height = 179.5 ±14.5 cm, soccer training experience = 10±1.5 years) took part in the study. The participants were all full-time professionals who trained daily. The tests were conducted during the winter break between the seasons to eliminate additional factors. Participants attended the study with valid medical examinations and showed no contraindications to participate in physical fitness tests. The players were instructed to maintain their normal dietary habits over the course of the study and not to use any supplements or stimulants for the duration of the experiment. All players or their legal guardians, because two of them were under eighteen years old, gave their written consent to participate in the research. The inclusion criteria were as follows: a) training experience above 8 years, b) competition in a first-league team, c) no injury in the 6 months prior to the tests, d) active participation in training sessions at least 5 times a week in the last 6 months. The study protocol was approved by the Bioethics Committee for Scientific Research (3/2021), at the Academy of Physical Education in Katowice, Poland, and performed according to the ethical standards of the Declaration of Helsinki, 2013.

2.3. Testing Procedures

The experimental sessions were conducted between 9:00 and 11:00 a.m. The session was preceded by a warm-up protocol, which included 5 minutes of jogging, several upper and lower body exercises like push-ups, body weight squats and split squats, a single 20 m sprint, 5 m sprint, one of each COD tests (90° and "L") and two sets of the leg press exercise. All sprint tests were performed on an indoor field with an artificial grass surface.

2.3.1. Linear Sprint Test

The running times were recorded by two pairs of dual-beam Witty Gate photocells (Microgate, Bolzano, Italy) with a measuring precision of 0.01 s. After the warm-up, participants performed two maximum 20m sprints with a 5-minute rest interval between them. The participants started with the front foot placed 0.5 m behind the first timing gate to prevent any early triggering of the start gate. The participants started when ready to eliminate the effects of reaction time. The best time from both attempts was retained for further analysis [22].

2.3.2. Change of Direction Tests

After the linear sprint test, participants rested for 5 minutes and then performed the COD tests. Each participant performed two tests with 90° COD in randomized order: Zig-Zag and L-test (Figure 1 and Figure 2) [9]. The participant's task' was to cover a 20m section with designated cones with changes in direction and movement pattern. During the L-test, the manner of distraction was specified, first a 5m sprint, then a 5m stand-up step twice, then a reverse run. Each running test was performed twice with a 3-minute rest-interval between attempts. The fastest time from each COD test was retained for further analysis.

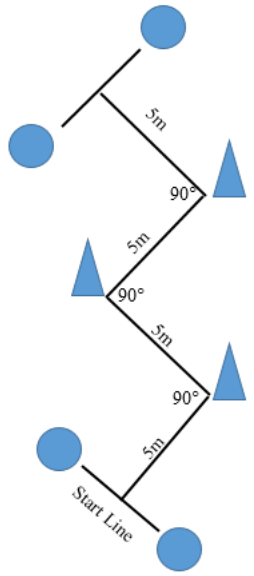

Fig. 1. Schematic presentation of the 90° change of direction test. Circles represent the positions of the photocells.

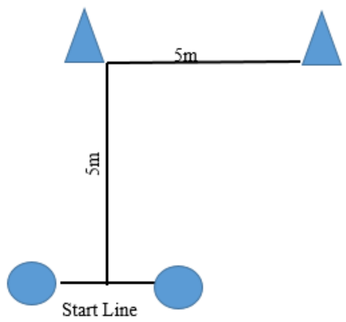

Fig. 2. Schematic presentation of the L-test. Circles represent the position of photocells.

2.3.3. Lower-Body Power Output

Through the second experimental session, peak power output during the leg press exercise was assessed using the Keiser Air420 leg press pneumatic machine (Keiser Corporation, Fresno, CA, USA). The load was 120% of the subject's body weight [23]. The Keiser pneumatic resistance system utilizes air-pressurized resistance to maximize safety and allows for precision loading within 1kg. The Keiser Leg Press device, thanks to independent plates, evaluates both limbs, which allows to obtain the results of strength, power, and asymmetry between the limbs. In addition, the repeatability and reliability of the device has been confirmed in previous studies [12, 24]. After the warm-up, each subject performed two repetitions with both legs, then with the right and left legs separately. The device plates are pushed out from a sitting position with the knee joints bent at 90 degrees until fully extended. The participants were informed that the extension of the lower limbs, i.e., the concentric phase, should be performed as quickly as possible. There was a 3-minute rest interval between attempts. Peak power was retained for the analysis.

2.3.4. Asymmetry index

The following formula was used to identify the percentage of asymmetry between the lower limbs. In both formulas used, the results of the percent difference between the limbs were presented [25].

$$LSI\ (\%) = (2 * (Right\ leg - Left\ leg) / (Right\ leg + Left\ leg)) * 100$$

2.4. Statistical Analysis

Statistical analyses were performed using Statistica 9.1 (Hillview, Palo Alto, CA, USA). Data are presented as means and standard deviations (SD) with 95% confidence intervals (CI). Pearson product-moment correlation coefficient was used to analyze the relationships between the sprint and power performance. Correlations were evaluated as follows: trivial (0.0–0.09), small (0.10–0.29), moderate (0.30–0.49), large (0.50–0.69), very large (0.70–0.89), nearly perfect (0.90–0.99) and perfect (1.0) [26]. The significance level for the correlation analysis was set as $p < 0.05$.

3. Results

All data are presented in Table 1, while values of individual lower limb symmetry index are presented in Figure 3. Pearson product-moment correlation coefficient test did not show any statistically significance correlation between lower limb power performance and linear sprint time as well as COD tests performance (Table 2).

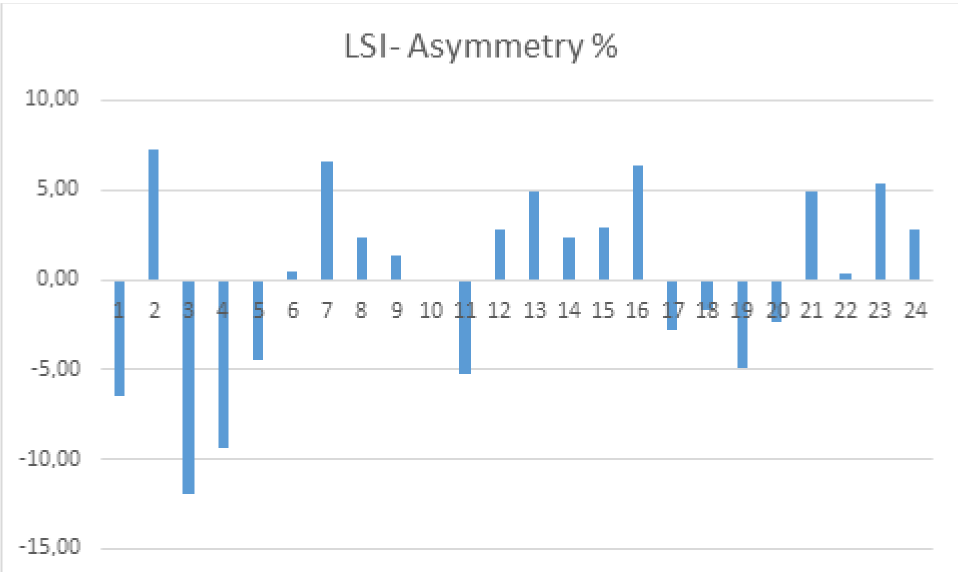

Fig. 3. Limb symmetry index (LSI) – individual asymmetry percentage for the leg press exercise.
* Dominant left lower limb "-", dominant right lower limb "+".

Table 1. Descriptive data for all measured tests.

Test (N = 24)	Mean ± SD	95% CI
5 m	1.02 ± 0.06	0.969 to 1.071
20 m Linear Sprint (s)	2.95 ± 0.12	2.80 to 3.10
COD90 (s)	6.65 ± 0.17	6.32 to 6.99
COD90def	3.7 ± 0.14	3.515 to 3.885
L-test (s)	5.57 ± 0.24	5.36 to 5.92
Power both legs /leg press/ (W)	28.36 ± 3.64	26.942 to 29.778
Power right leg /leg press/ (W)	16.34 ± 1.9	15.523 to 17.157
LSI [27] (%)	4.16 ± 2.89	3.952 to 4.368

Mean ± standard deviation (SD); CI – confidence intervals; COD – change of direction; L-test DEF- L-test deficit ; LSI – limb symmetry index

Table 2. Pearson correlation between all measured data.

	5m	20m	ZigZag	$ZigZag_{def}$	L-test	$L\text{-}test_{def}$
Relative Peak Power both legs	-.372	-.244	-.218	-.059	-.242	-.133
Relative Peak Power right leg	-.191	-.175	-.205	-.101	-.216	-.141
Relative Peak Power left leg	-.317	-.277	-.196	-.004	-.143	-.012
LSI	-.193	-.179	.008	.161	.258	.364

4. Discussion

The aim of the research was to check whether relative lower limb power output during leg press exercise and the degree of its asymmetry has an effect on COD and linear sprint performance. The main finding of this study was that the relative lower limb-power output during leg press exercise and a low level of inter-limb asymmetry in power output does not relate with the 5- and 20-m linear sprint time and COD performance with 90 degree angle.

In studies conducted on handball players (men and women), moderate to very large positive correlations between the mean propulsive power output during vertical jumps (squat and countermovement jump) and COD performance (T-test, COD90) were observed [10]. Wisloff et al. [28] found strong positive correlations between half squat maximum strength, 30m sprints, jumps (countermovement jump height), and shuttle tests in professional soccer players [28]. On the other hand, Loturco et al. [3], noted no significant relationships between mean propulsive power (squat jump and half squat) and COD (with 100° turn) among young soccer players. In this study also no statistically significant correlations between lower limbs power output and the sprint time with COD performance was noticed. The differences in the results of particular authors [10, 28] may result from the use of different types of tests. Since the specificity of movement during COD requires not only acceleration, deceleration and re-acceleration, but also maintaining coordination, stabilizing the body and lowering the center of gravity of the body, not all tests will reflect these requirements, which may affect the correlations. The authors also noted that different levels of correlation might occur depending on the mechanical requirements of the COD test used [10]. As noted by Nimphius et al. [27] there is no single COD requirement for all athletes, and there is probably no single test that is universally valid. Each test should reflect its objective (e.g. complete test in minimum time or maximum speed) and match the test accordingly. The above mentioned authors found that there was no single method for evaluating COD that could explain the differences obtained in particular research projects [27].

The lack of a significant correlation between lower limbs' relative power output and its asymmetry with the data obtained during the runs in this study may be caused by the small asymmetry values. It should be checked whether, recruiting a group of athletes with higher values of asymmetry, would result in higher correlations or not. In addition, the correlation between COD, L-test, and % asymmetry is not significantly related. This may result, as suggested by Lockie et al., [18] from slight differences in the asymmetry between the power of the lower limbs. Lockie and co-authors [18] noticed that participants with greater training experience cope better with technical tasks, and thus perhaps their asymmetries are made up by the technique of performing a movement. Moreover, they noticed that the association of COD and asymmetry can be considered as an indicator of an participants level of fitness [18].

Bishop et al. [19] noticed that larger asymmetries were associated with lower jumping efficiency, the asymmetry of the countermovement jump on one leg was task-dependent, with sprint times of 5, 10, 20 m [19]. Pardos-Mainer et al. [17] in studies on soccer players noticed that there is a relationship between lower limb power asymmetries and COD in adolescent girls, which had no effect on physical performance [16]. However, according to the knowledge obtained during the research, greater than 10% [17, 18] asymmetry between the lower limbs may result in disturbance of movement patterns and errors in the correct performance of exercises during training tasks. It has been observed that asymmetries of less than 10% [17, 18] are associated with shorter times in running tests, and the magnitude of the asymmetry may explain the disturbances occurring during COD [13]. The asymmetry detected in less trained individuals will decrease after the application of appropriate training stimuli [27]. Previously in soccer, sprint and endurance tests were applied most often, while currently specialists more frequently decide to introduce COD tests that reflect match conditions[28]. The tests allow to monitor the physical fitness of participants, as well as to detect asymmetry[17,18,29]. For participants with detected asymmetry greater than 10% [17, 18], additional, equalizing training units should be used, which will improve their motor performance [3].

5. Conclusions

Our research was conducted on a group of professional athletes, which may not apply to the general public. Similar conclusions have already been drawn from research conducted with youth soccer players [3]. There were several limitations in the described studies that should be considered in the design of subsequent protocols to obtain more accurate results. Research in the field of lower limb asymmetry should select a group with greater asymmetry values than the one described above. It is also worth using individualized % training loads instead of standardized ones, what will increase the reliability of the results. Future research should include variable angles of turning in COD tests. In addition, the authors noted the need to apply the same number of direction changes to the right and left respectively, as well as to apply a first shift take-off to both right and left sides. In order to expand the research, more participants of different age, sex and training experience must be recruited, as well as subjects with a higher inter-limb power asymmetry. It is also suggested to use different turning angels in COD tests. A variety of COD angles used in the tests allows for the differentiation of variables, reflection of match conditions and a broader presentation of the research problems considered [28]. Additionally, it may be desirable to evaluate muscle activity during COD tests with Electromyography clothing. Such changes would allow for more detailed results which could be used for a wider audience. In addition, examining muscle activity during the tests performed would help to specify which muscles generate bigger asymmetries. Further studies on the variables influencing CODDEF are conducted to obtain reliable answers to emerging new questions. It is also interesting and worth checking whether the results in other professional groups will be similar to the results of soccer players of this study. Future studies should concentrate on the influence of lower limb power asymmetry of adductors and abductors on COD performance, as well as on the effects of post activation potentiation of selected muscles on this motor ability.

The results indicate that Lower Limb Power Asymmetry, 20m Straight Line Running, COD, and L-Test are separate physical characteristics.

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