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Correlation Between VO2 Max, Speed, and Limb Muscle Explosive Power with Agility in Soccer Players

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ABSTRACT

Background: Agility is one of football's most critical anaerobic capacities. One component is the ability to change direction. Players change direction (Change of direction speed / CODS) every 2-4 seconds. Agility is influenced by several things, including speed and limb muscle explosive power, and is related to aerobic capacity, namely VO2 Max (maximum oxygen consumption) in the Running economy aspect. It is necessary to research the relationship between VO2 Max, speed, and explosive power of limb muscles with agility in soccer players.
Objective: Knowing the correlation between VO2 Max, speed, and limb muscle explosive power with agility in soccer players.
Methods: Twenty-seven male players (Diponegoro Muda PS Undip) were involved in this study (mean±SD; age 13.22 ± 0.18 years, weight 46.78 ±1.67 kg, height 158± 1.88 cm). This research is a correlational study using a cross-sectional design. Each player will be measured VO2 Max with the Multistage Fitness Test, speed with the 20-meter sprint test, the explosive power of the limb muscles with the surgent jump test, and agility (CODS) using the Illinois agility test. The hypothesis test used is Spearman's hypothesis test and linear regression test.
Results: Spearman correlation test found a strong relationship between VO2 Max and agility (r=-0.743; p= <0.001), there was a moderate relationship between speed and agility (r=0.556; p== 0.003), there was a strong relationship between muscle explosive power limbs with agility (r=-0.766; p= <0.001), and the results of linear regression of variables VO2 Max, speed, limb muscle explosive power on agility showed a strong relationship (r=0.806; r2= 0.650; p=<0.001).
Conclusion: Conclusions: VO2 Max correlates with agility; speed correlates with agility; limb muscle explosive power correlates with agility; and the variables of VO2 Max, speed, and limb muscle explosive power have a relationship with agility.

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1. Introduction

Indonesian football players still have weaknesses in skills, tactical abilities, and physical and mental strength. The fault of these players must be evaluated, and they must receive good coaching from SSB for a professional career [1]. Football players who are prepared to compete must develop anaerobic and aerobic capacity [2–4]. Anaerobic capacity, the most critical component of success in matches, is agility (agility) [5]. One of the agility components is the ability to change direction quickly and accurately (change of direction speed/CODS) [5,6]. Research shows that players change direction every 2-4 seconds and make 1200-1400 changes of direction during the game[7], so agility is considered the most influential activity in determining the outcome of the match [8].

One of the supporting factors that can affect CODS performance is sprint performance [3]. Players with good running ability will further develop the ability to penetrate and weaken the opponent's defense, win possession of the ball, and play a role in kicking the ball [9] as well as at the time of counterattack [10]. Running ability is related to the Running Economy (RE). RE is the need for oxygen (VO2) at a specific running speed which reflects the energy needed to run at a submaximal speed that reflects muscle endurance (endurance). With a good RE, so will obtain optimal running.

CODS also requires deceleration (braking force) followed by acceleration (pushing power), thus requiring great lower extremity strength[3]. In acceleration, deceleration, and change of direction, the strength developed by athletes is aimed at moving and controlling their body mass [5]. Muscular explosive power limbs play an essential role in agility because they provide an overview

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related to the quality of limb muscles [5,6] and play a role in the ability to run fast, jump, and change direction [11].

Aerobic capacity is also essential for soccer players because it plays a role in 80% of the total game time [3]. Aerobic capacity is assessed by VO2 Max (maximum oxygen consumption), which can reflect stamina and endurance in playing soccer [12]. Soccer players who have good aerobic performance will be able to survive in training sessions as well as in long matches [4].

VO2 Max values, running speed, limb muscle explosive power, and agility are essential things to assess because these components have relatively easy measurements but can provide an overview related to the fitness capacity of both aerobic and anaerobic soccer players. This study aims to determine the relationship between VO2 Max, speed, and limb muscle explosive power with agility in soccer players.

2. Methods

2.1 Participants

Of the forty-five male soccer players (Diponegoro Muda PS Undip), twenty-seven players met the inclusion criteria (male soccer players aged 12-14 years), and there were no exclusion criteria (History of injury to both arms and limbs; shoulder; wrist; lower limb; limb; muscle, or are receiving therapy for muscle/bone/tendon injury). Subjects Twenty-seven male players (Diponegoro Muda PS Undip) were involved in this study (mean±SD; age 13.22 ± 0.18 years, weight 46.78 ±1.67 kg, height 158± 1.88 cm).

2.2 Design

This type of research is correlational using a cross-sectional design. Each subject was measured VO2 Max with the Multistage Fitness Test, speed with a 20-meter sprint test, limb muscle explosive power with the surgent jump test, and agility (CODS) using the Illinois agility test.

2.3 Tests

Data collection was carried out in August 2022 at the Diponegoro University Stadium. The data collection begins with warming up the players for 15 minutes and then measuring weight and height. Then the aerobic capacity data was taken, namely the measurement of the VO2 Max value using a submaximal exercise test.[13] In this study, VO2 Max was measured using a multistage fitness test (MFT) [12]. In this test, the subject will run continuously between two lines 20 meters apart. Adjust the sound of the audio recording "beep/bleep".

The running speed will increase gradually according to the sound of "beep/bleep" on the audio recording [14,15] After that, a speed test is carried out using a simple field method calculation [16]. A simple running test is carried out at a distance of 20 meters 7-10, then using a stopwatch, assesses the time required by each player to cover the distance. After that, the explosive power of the limb muscles was measured using a Surgent jump test where the player would jump vertically, and the player's jump range was measured [17]. Subjects were allowed to jump three times. The data used is the average of the results of three jumps. The last test carried out was the agility test. The Illinois agility test was chosen to assess the speed of changing directions because it involves acceleration and direction changes when running linearly [18].

2.4 Statistical analysis

Statistical analysis of this study used univariate analysis to determine the descriptive picture of each variable. Then the measurement of the normality of the data using the Shapiro Wilk analysis because the sample in the study was small, with less than 50 samples. Bivariate analysis was carried out using Spearman's analysis because the normality test showed that the data were not normally distributed. Then a multivariate test was performed using linear regression.

3. Result

Table 1. Variable Characteristics

Characteristic	mean±SD	Median (Min-Maks)	*Saphiro wilk test* (p)
Age	13,22 ± 0,18	14 (12-14)	0,000
Height	158±1,88	161 (139-174)	0,037
Weight	46,78 ±1,67	47,90 (31,5-62,5)	0,233*
BMI	18,58 ± 0,42	18,06 (15,09-23,42)	0,520*
VO_2 max	43,44±1,63	47,16 (29,26-54,63)	0,008
Speed	3,50± 0,09	3,35 (2,59-4,48)	0,456*
Limb Muscle Explosive Power	43,65±1,94	44,33 (26,33-66,33)	0,580*
Agility	17,76 ± 0,35	17,31 (15,98-23,45)	0,001

SD= Standard deviation; Min=Minimum; Max= Maximum; *normal (p>0,05)

Measurement results of independent variables (mean±SD; VO2 Max 43.44±1.63 ml/kg/min; speed (sprint 20 m) 3.50±0.09 s; limb muscle explosive power (surgent jump test) 43, 65±1.94 cm; agility (Illinois agility test) 17.76±0.35 s). Normality test results (normal: p> 0.005; p VO2 Max = 0.008; p speed = 0.456; p limb muscle explosive power = 0.580; p agility = 0.001).

The results of the Spearman test from table 2 and table 3 showed a significant correlation with strong strength between agility and VO2 Max (r=-0.743; p= <0.001), a significant correlation with moderate strength between agility and speed (r=0.556; p=0.003), a strong correlation significant with strong strength between agility and limb muscle explosive power (r=-0.766; p=<0.001), significant correlation with moderate strength between body weight and VO2 Max (r=0.449 ; p=0.0019), significant correlation with moderate strength between body weight and limb muscle explosive power (r = 0.489 ; p = 0.01), a significant correlation with moderate strength between height and VO2 Max values (r = 0.598 ; p = 0.001), a significant correlation with moderate strength between height and speed (r=-0.421; p=0.029), a significant correlation with moderate strength between height and limb muscle explosive power (r=0.644; p=<0.001), and a significant correlation with moderate strength between height and agility (r= -0.471; p=0.013).

The results of multiple linear regression analysis from Table 4, between VO2 Max, speed, and explosive power of limb muscles with agility with a significance level of = 5%, a significant correlation was obtained (Sig: <0.001), F count> F Table (F count = 14.225; F table = 3.01) it means VO2 Max, speed, and explosive power of the limb muscles had affected the agility. Correlation analysis showed a relationship with strong strength (r=0.806; r2=0.65). This

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indicates that the variables of VO2 Max, speed, and explosive power of the limb muscles affect 65% of agility.

Table 2. Relationship between body weight and Height with VO2 Max, Speed, Limb Muscle Explosion, and Agility

	Weight	Height
VO_2 Max	r = 0,449 p = 0,019§ n = 27	r = 0,598 p = 0,001§ n = 27
Speed	r = - 0,148 p = 0,46 n = 27	r = - 0,421 p = 0,029§ n = 27
Limb Muscle Explosion	r = 0,489 p = 0,01§ n = 27	r = 0,644 p = <0,001§ n = 27
Agility	r = -0,358 p = 0,067 n = 27	r = -0,471 p = 0,013§ n = 27

§Significant (P<0,05); r= correlation coefficient

Table 3. Correlation test of VO2 Max, speed, and explosive power of limb muscles with agility

	Agility
VO_2 Max	r = -0,743 p < 0,001§ n = 27
Speed	r = 0,556 p = 0,003§ n = 27
Limb Muscle Explosion	r = -0,766 p < 0,001§ n = 27

§Significant (P<0,05); r= correlation coefficient

Table 4. Analysis of the Relationship of VO2 Max, Speed, and Explosive Power Limbs with Agility

Variable	Regression Coefficient
constant	22,107
VO_2 Max	-0,078
Speed	0,612
Limb Muscle Explosion	-0,072
F count	14,225
F table	3,01
R	0,806
R square (R^2)	0,650
Sig	<0,001§

§Significant (<0,05)

The results of multiple linear regression analysis from Table 5 on the relationship between weight, height, VO2 Max, speed, and explosive power of limb muscles with agility with a significance level of = 5%, obtained a significant relationship (Sig: <0.001), F value count> F Table (F count = 8.625; F table = 2.661) which shows that weight, height, VO2 Max, speed, and explosive power of limb muscles together affect the dependent variable, namely agility. Correlation analysis showed a relationship with strong strength (r=0.820; r2=0.73). It shows that weight, height, VO2 Max, speed, and limb muscle explosive power have an effect of 67.3% on agility.

Table 5. Analysis of the Relationship of VO2 Max, Speed, Limb Muscle Explosion, Height, and Body Weight with Agility

Variable	Regression Coefficient
Constant	22,680
VO_2 Max	-0,088
Speed	0,433
Limb Muscle Explosion	-0,083
Height	-0,006
Weight	0,042
F count	8,625
F table	2,661
R	0,820
R square (R^2)	0,673
Sig	<0,001§

§Significant (<0,05)

4. Discussion

The study results are in accordance with the hypothesis that the variables of VO2 Max, speed, and limb muscle explosive power have a relationship with agility from the Spearman and linear regression tests.

The anthropometry of players also influences their physical abilities of players. Body weight positively correlates with VO2 Max with moderate strength (r = 0.449), which means that the more weight you gain, the higher the player's VO2 Max value. Body weight positively correlates with limb muscle explosive power with moderate strength (r=0.489). VO2 Max or maximum oxygen consumption can vary, which is related to the player's physical size [4]. One of the influencing components is BMI (Body Mass Index). Every 1.37 kg/m2 increase in BMI will reduce VO2 Max/LBM by 1ml/kg/min [24]. Body weight has a positive relationship with limb muscle explosive power because body weight alone cannot distinguish the proportions of muscle mass, fat mass, and muscle mass. Lean body mass so that people with high body weight are likely to have a higher ratio of muscle mass when compared to those with low body weight; this is following research conducted by Bialoskórska M et al. (2016) [20]. In addition, the study by Clemente FM, et al. (2020) also shows that maximal oxygen consumption can vary, which is related to the player's physical size [7].

Height correlates with VO2 Max, speed, limb muscle explosive power, and agility. The relationship between height and VO2 Max (r=0.598) shows a positive relationship with strong strength, which means that the taller a person is, the higher the VO2 Max value. The relationship between height and speed (r=-0.421) indicates a connection with moderate strength with a negative direction between height and speed. The taller a player is, the shorter the time needed to complete a 20-meter running track. The relationship between height and limb muscle explosive power (r = 0.644) indicates a moderate relationship with a positive direction, which means that the taller a player is, the higher the explosive power of the player's muscles (the more significant the range of upright jumps that can do). The relationship between height and

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agility (r = -0.471) indicates a moderate relationship with a positive direction. The taller a player is, the shorter the time required to complete the Illinois agility test.

Regarding the relationship between height and limb muscle explosive power, from the results of research conducted by Fara N, et al. (2021), it was found that there was a significant positive relationship between limb length and vertical jump ability [17]. The effect of height is also due to genetic factors associated with body structure related to lever length (length of arms and limbs), where length largely determines the capacity to move quickly [20].

The results of the analysis of the relationship between VO2 Max and agility (r = -0.743) showed that VO2 Max had a significant negative correlation value with a strong correlation strength with agility, indicating that the higher the VO2 Max value, the shorter the time required to complete the agility test trajectory in Illinois agility test. The relationship between VO2 Max and agility in soccer players is related to the aerobic performance of players. Players with good aerobic performance will be able to survive in training sessions and matches that require a long time [4]. Moreover, based on research, player agility is important in determining match results[8]. One component of agility is the ability to change direction quickly and accurately (change of direction speed / CODS).2.21 Football players change direction every 2-4 seconds and make 1200-1400 changes of direction during the game [7].

A good CODS requires good speed, and one of the supporting factors that can affect CODS performance is the performance of sprints or sprints. Running at submaximal speeds and the RE itself reflects endurance data. A good RE means that when running, it uses less oxygen when compared to a bad RE, which means that running uses much more oxygen even at the same speed and condition so that a player who has a good RE will be able to run optimally. Thus, this is related to agility, where VO2 Max in the RE aspect contributes to agility because, in the agility test, players are required to run and maneuver to change direction according to the Illinois agility test route.

The results of the analysis between speed and agility (r=0.556) showed that speed had a significant positive correlation value with a moderate correlation strength with agility, which means that the higher the time required to complete a 20-meter running track, the higher the time needed to complete the test track agility on the Illinois agility test. This can also be interpreted that the faster a player completes the 20-meter running track, the faster the player will complete the agility test on the Illinois agility test. Based on the research that has been done, there is a low to moderate correlation value between speed and agility. These studies, among others conducted by Draper and Lancaster, showed a significant but low value (r=0.47) when comparing the relationship between the performance of the Illinois agility test and the 20-meter sprint time. Another study by Paulole et al. reported significant ($p<0.05$) but showed a low to moderate correlation (r = 0.53) between the 40-yard sprint and the T-test for changes in directional velocity [6].

The results of the analysis between the explosive power of the limb muscles and agility at (r = -0.766) showed that the explosive power of the limb muscles had a significant negative correlation with the strength of the strong correlation to agility, which means that the higher the explosive power of the limb muscles (the higher the person's upright jump), the shorter the time needed to complete the agility test track on the Illinois agility test. Strength is an important contributor to CODS. In acceleration, deceleration, and change of direction, the strength developed by the athlete is aimed at moving and controlling his body mass [5]. Agility requires deceleration (braking force) followed by acceleration (propulsion force). Thus, the contribution of lower extremity strength plays a critical role in producing good agility.[3] An increase in lower body strength after training will result in more incredible running speed.[23] The results of research conducted by Muda et al. show a correlation between the countermovement jump and the 20-meter CODS test. But the yield is low. Djevalikian also reported that there was a low and insignificant correlation between the strength of the vertical jump and boomerang running involving seven changes of direction with r=-0.15 [6].

The results of the analysis between agility and VO2 Max, speed, and explosive power of the limb muscles obtained the value of F count > F table with a significance level of = 5% so that it can be concluded that the independent variables include VO2 Max, speed, and explosive power of the limb muscles together. Affects the dependent variable, namely agility. A correlation coefficient of 0.806 is obtained, which indicates a strong relationship between the independent variable and the dependent variable with a coefficient of determination of 0.650, which means that there is a 65% influence percentage by the variable VO2 Max, speed, limb muscle explosive power on agility. These results follow the initial hypothesis that there is a correlation between VO2 Max, speed, limb muscle explosive power, and agility.

Agility is the most critical component of success in a match [5], and one component of agility is the speed of changing direction. This component requires deceleration (braking force) followed by acceleration (pushing force) of a significant lower extremity force and, in this case, limb muscle explosive power [3]. An increase in lower body strength after training will result in more incredible running speed. [23]

Agility is the most critical component of success in a match [5], and one component of agility is the speed of changing direction. This component requires deceleration (braking force) followed by acceleration (pushing force) of a significant lower extremity force and, in this case, limb muscle explosive power [3]. An increase in lower body strength after training will result in more incredible running speed [23].

The results of the analysis between VO2 Max, speed, limb muscle explosive power, height, and body weight obtained a correlation coefficient of 0.820, which indicates a strong relationship with the coefficient of determination of 0.673, which means that there is a 67.3% influence percentage by the VO2 Max variable, speed, limb muscle explosive power, height, and body weight indicate that VO2 Max, speed, limb muscle explosive power, height, and body

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weight on agility. Thus, there is an influence of 2.3% percentage of weight and height variables on player agility.

5. Conclusion

Based on this research, it was found that there was a relationship between VO2 Max and agility where the higher the VO2 Max, the shorter the duration needed to complete the agility test; in other words, the higher the VO2 Max, the more agile a player will be. There is a relationship between speed and agility where the faster the running ability of a player, the more agile the player is. There is a relationship between limb muscle explosive power and agility where the higher the jump range produced by the player, the shorter the duration required to complete the agility test; in other words, the greater the explosive power of the player's limb muscles, the more agile the player will be.

Further research is needed in other age groups, and it is necessary to compare the player's abilities based on the age and time of training that the player has received. It is necessary to research other variables that affect player agility, such as decision-making or other variables. It is necessary to collect data at the same location and time.

Ethical Approval

The research protocol has received approval and ethical feasibility from the Medical and Health Research Ethics Commission (KEPK) of the Faculty of Medicine, Diponegoro University with No.302/EC/KEPK/FK-UNDIP/VIII/2022.

Conflicts of Interest

The authors are listed to certify that they have NO affiliations with or involvement in any organization or entity with any financial interest.

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Author Contributions

Annisa Himmatul Aulia, Sumardi Widodo, and Darmawati Ayu Indraswari conceived of the presented idea. Annisa Himmatul Aulia developed the theory and performed the computations. Sumardi Widodo, Darmawati Ayu Indraswari, and Gana Adyaksa verified the analytical methods. Sumardi Widodo, Darmawati Ayu Indraswari, and Gana Adyaksa encouraged Annisa Himmatul Aulia to investigate the findings of this work. All authors discussed the results and contributed to the final manuscript

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