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Original

Association between VO2max, anthropometrical measures and change of direction test in young soccer players

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ABSTRACT

Objective: The use of the aerobic system is especially relevant due to the duration of the soccer game. In fact, the correct development of the aerobic system benefits the soccer player giving greater energy efficiency because the continuous change of energy system due to the intermittent nature of the game causes a high consumption of glycogen. The purpose of the present study was to evaluate oxygen consumption by means of the Yo-Yo intermittent test and anthropometrical measures, and different COD (change of direction) tests in young soccer players and to observe their possible relationship.
Methods: A total of forty-seven young male soccer players (age= 15.7 ± 1.2 years; height = 188.8 ± 5.8 cm, and body mass= of 75.7 ± 8.3 kg; 7.6 ± 2.0 years of experience) from the region of Baleares, Spain, performed the Yo-yo test and subsequently, COD was evaluated by tests in the following order (i) V-cut test; (ii) 505-COD test; and (iii) Illinois test.
Results: A correlation analysis between VO2max and BMI revealed a moderate negative correlation, r=-0.35, p=0.01, and between VO2max and 505-COD, showed a large negative correlation, r=-0.55, p=0.001.
Conclusions: The finding of the present study reveals that there is no relationship between VO2max and agility. Therefore, there is no single method to improve VO2max and agility since both are independent variables. The different agents involved should take this into account if they want to improve VO2max and plan some aerobic resistance exercises; and to improve agility they must plan agility exercises separately.
Keywords: Soccer; VO2max; Young soccer players; Change of direction; Agility.

Asociación entre V02max, medidas antropométricas y test de cambio de dirección en futbolistas jóvenes

RESUMEN

Objetivo: El uso del sistema aeróbico es especialmente relevante debido a la duración del partido de fútbol. De hecho, el correcto desarrollo del sistema aeróbico beneficia al futbolista otorgándole una mayor eficiencia energética ya que el continuo cambio de sistema energético debido a la naturaleza intermitente del juego provoca un alto consumo de glucógeno. El propósito del presente estudio fue evaluar el consumo de oxígeno mediante la prueba Yo-Yo intermitente y medidas antropométricas, y diferentes pruebas COD (cambio de dirección) en jóvenes futbolistas y observar su posible relación.
Métodos: Un total de cuarenta y siete jóvenes futbolistas masculinos (edad= 15.7 ± 1.2 años; altura = 188.8 ± 5.8 cm, y masa corporal= de 75.7 ± 8.3 kg; 7.6 ± 2.0 años de experiencia) de la región de Baleares, España, realizó la prueba Yo-yo y posteriormente, se evaluó la DQO mediante pruebas en el siguiente orden (i) prueba de corte en V; (ii) prueba 505-COD; y (iii) prueba de Illinois.
Resultados: Un análisis de correlación entre VO2max e IMC reveló una correlación negativa moderada, r=-0.35, p=0.01, y entre VO2max y 505-COD mostró una correlación negativa grande, r=-0.55, p=0.001.
Conclusiones: El hallazgo del presente estudio revela que no existe una relación entre el VO2max y la agilidad. Por lo tanto, no existe un método único para mejorar el VO2max y la agilidad ya que ambas son variables independientes. Los diferentes agentes implicados deberían tener esto en cuenta si quieren mejorar el VO2max y planificar algunos ejercicios de resistencia aeróbica; y para mejorar la agilidad deben planificar ejercicios de agilidad por separado.
Palabras clave: Fútbol; VO2máx; Jóvenes futbolistas; Cambio de direccion; Agilidad.

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Associação entre V02max, medidas antropométricas e teste de mudança de direção em jovens de futebol

RESUMO

Objetivo: A utilização do sistema aeróbico é especialmente relevante devido à duração do jogo de futebol. De facto, o correcto desenvolvimento do sistema aeróbico beneficia o jogador de futebol dando-lhe uma maior eficiência energética porque a mudança contínua do sistema energético devido à natureza intermitente do jogo provoca um elevado consumo de glicogénio. O objetivo do presente estudo foi avaliar o consumo de oxigênio por meio do teste Yo-Yo intermitente e medidas antropométricas e diferentes testes de COD (mudança de direção) em jovens jogadores de futebol e observar sua possível relação.
Métodos: Quarenta e sete jovens futebolistas masculinos (idade= 15,7 ± 1,2 anos; estatura = 188,8 ± 5,8 cm e massa corporal= 75,7 ± 8,3 kg; 7,6 ± 2,0 anos de experiência) da região de Baleares, Espanha, realizou o teste Yo-yo e, posteriormente, o COD foi avaliado por testes na seguinte ordem (i) teste V-cut; (ii) teste 505-COD; e (iii) teste de Illinois.
Resultados: Uma análise de correlação entre VO2max e IMC revelou uma correlação negativa moderada, r=-0,35, p=0,01, e entre VO2max e 505-COD, mostrou uma grande correlação negativa, r=-0,55, p=0,001.
Conclusões: O achado do presente estudo revela que não há relação entre VO2máx e agilidade. Portanto, não existe um método único para melhorar o VO2máx e a agilidade, pois ambos são variáveis independentes. Os diferentes agentes envolvidos devem ter isso em consideração se quiserem melhorar o VO2máx e planejar alguns exercícios aeróbicos de resistência; e para melhorar a agilidade devem planejar exercícios de agilidade separadamente.
Palavras-chave: Futebol; VO2max; Jovens jogadores de futebol; Mudança de direção; Agilidade.

Introduction

Soccer is an intermittent sport that requires different physical characteristics for the development of performance. This intermittence involves the use of the different metabolic substrates, both aerobic and anaerobic, as well as the different muscle fibers in a constant way.

The use of the aerobic system is especially relevant due to the duration of the game (more than 90 minutes) and the distance covered, between 10 and 13 km.[1] The correct development of the aerobic system benefits the soccer player giving greater energy efficiency because the continuous change of energy system, due to the intermittent nature of the game, causes a high consumption of glycogen. However, if the player has a good aerobic capacity, he/she will be able to attenuate glycogen depletion by utilizing the fat aerobic system in phases of the game where medium/high intensity is not required.[2] Therefore, a higher oxygen consumption will allow the player to recover better between actions of different intensity, thereby decreasing glycogen depletion.[3] Elsewhere, it has also been positively correlated that the higher the VO2max, the better the performance at medium/high intensities.[4] This can occur in counter-attack or retreat situations or when there is constant pressure on the opponent. Thus, the development of the aerobic capacity of soccer players in training becomes essential. In addition, in this phase of biological maturity, major changes occur at the cardiorespiratory level where the type of sport acquires special relevance. Thus, a study reported that in young people the post-exercise recovery capacity was higher in participants of mixed sports (such as soccer) versus sedentary subjects and those practicing other sports modalities.[5] Another recent study reported that soccer practice has a positive effect on the cardiorespiratory system expressed in VO_2max.[6] Although VO2max fluctuates in professional soccer players, those who compete at higher levels of play and in championships demonstrate greater values.[7] Therefore, the evaluation of maximal oxygen consumption to assess performance is essential in young soccer players. Furthermore, it is important to measure this parameter in a way that is related to the nature of the sport, i.e., intermittently. In this respect, the YO-YO intermittent test has been extensively used by different researchers to assess VO2max in soccer players.[8–12]

It is clear that performance in intermittent sports such as soccer is not only limited to high VO_2max levels; during matches players perform approximately 1,350 activities (every 4-6 s), such as accelerations/decelerations, COD and jumps, all interspersed with short recovery periods.[13,14] Therefore, there are other performance indices such as agility. This parameter requires COD and movement of the whole body in a precise and intentional manner, being of great use in activities that require speed and attention, such as in soccer.[15] In this regard, COD occur constantly in dribbling, unmarking and defensive situations. COD involve muscle action of the stretch-shortening cycle producing greater force in the shortest possible time.[16] Moreover, in game situations where spaces are limited, COD are one of the most effective solutions. In fact, COD are considered one of the most important physical qualities for predicting success in a wide variety of field sports.[17,18] Furthermore, it has been suggested that higher COD speed could be the most important performance factor during a match.[19] This highlights the importance of COD in high performance soccer. Nevertheless, the development of this parameter in the later stages of adolescence is not clear.[20] Hence, the assessment of COD by performing different tests is essential for the evaluation of the explosive strength and performance of the soccer player.[21,22]

Currently, the relationship between repeated sprints and VO2max is known. Da Silva et al.[23] found a positive correlation between these two parameters, and another previous study reported similar findings.[4] This is consistent because as previously reported, a higher VO2max will propitiate a change of energy system for the sparing of the phosphagen system. However, the literature on the relationship between VO2max and COD is limited, and still unclear. Therefore, given the importance of both parameters, it is of scientific interest to observe the possible correlation between these two parameters in young players. Thus, the main objective of this study was to evaluate oxygen consumption by means of the Yo-Yo intermittent test and anthropometrical measures, and different COD tests in young soccer players and to observe their possible relationship.

Methods

The research was carried out in March. Young soccer players were recruited at the end of 2020-2021 season. The data collection was previously followed by 48 hours of rest. The Yo-Yo test IR-Level 1 was evaluated. Subsequently, COD evaluation was performed in the following order (i) V-cut test; (ii) 505-COD; and (iii) Illinois test. Two attempts were made with a 3-minute recovery. A standardized 12-minute warm-up was performed prior to the measurements. This consisted of several exercises including ballistic stretching.

Participants

Forty-seven young male soccer players (age= 15.68 ± 1.20 years; height = 188.84 ± 5.81 cm, and body mass= of 75.74 ± 8.37 kg; 7.64 ± 2.02 years' experience) from the region of Baleares, Spain, were recruited from the city of Palma de Mallorca. These players trained three times a week (90 min per session) and played one match a week. The training sessions were based on technical and tactical content development (70% of training time), technical skill improvements (10% of training time), and general

improvements in physical condition (20% of training time). Generally, training sessions comprised a warm-up, main part, and cooldown.

The participants' parents obtained information about the main aims of the investigation and signed informed consent forms. The study was conducted in accordance with the ethical principles of the Helsinki declaration for human research and was approved by the Research Ethics Committee of the Pontifical University of Comillas (2021/74). Inclusion criteria for the participants in this study were (i) reporting normal vision and no history of any neuropsychological impairments that could affect the results of the experiment, (ii) being an active player with a federation license, (iii) not presenting any injuries during the previous two months, and (iv) giving their consent.

Anthropometric measurements

Body mass (kg) was assessed by bioelectric meter (Tanita BC-730) with an accuracy of 0.1 kg. Height (cm) was determined with a stadiometer (type SECA 225, Hamburg, Germany) with an accuracy of 0.1 cm. Body mass index values were also obtained.

Yo-Yo Intermittent Recovery Test – Level 1 (YYIRT Level 1)

The test was carried out in accordance with the guidance given by González-Fernández et al..[12] The YYIRT Level 1 consists of 4 initial out-and-back runs (0 to 160 meters) at 10-13 km/h and 7 runs (160 to 440 meters) at 13.5-14 km/h. Subsequently, the running speed continues to increase progressively by 0.5 km/h after every 8 runs until the participant is unable to reach the finish line in time twice. The completed number of levels and the total distance travelled in meters at the end of the test were recorded.

Change-of-direction assessment

Data collection was performed by the same researchers. The participants performed a total of three COD tests. The tests are described below. Time was stopped once the athlete passed the finish line in every test and between the timing gates using the Chronojump-Boscosystem® (Barcelona, Spain) photocells developed by de Blas et al..[24]

V-Cut

Along the lines established by Gonzalo-Skok et al.,[25] the test consists of running a distance of 25 m., performing 4 changes of direction of 45 degrees every 5 m. A line is placed separated by two cones, spaced 0.7 m apart, where each player must step beyond the line with at least one foot for the test to be valid. The best record of two attempts was collected. The coefficient of within-subject variation was 0.43%.

505-COD

This test was performed under the guidelines of Nimphius et al..[26] The test consisted of performing a 15 m sprint and a 180º turn with the dominant leg. For the turn to be valid the participants had to step on the line located at 15. The time was recorded from 10 m from the start and 5 m after the change of direction. A photocell was placed at 10 m from the start to record the time. Two attempts were made, separated by 3 minutes. The best time (s) was recorded. The coefficient of within-subject variation was 2.01%.

Ilinois agility test

This test was performed as described by Šimonek et al.,[27] a total of 5 direction changes are performed in a period of between 13 and 19 s and a total distance of 60m. There are 90º and 180º direction changes. Each participant performed two attempts separated by 3 min. The best of the two attempts was recorded. The coefficient of within-subjects variation was low (2%).

Statistical analysis

All analysis were conducted using Statistica (version 13.1; Statsoft, Inc., Tulsa, OK, USA) and the significance level was set at $p<0.05$. Descriptive statistics were calculated for each variable. Normal distribution and homogeneity tests (Kolmogorov–Smirnov and Levene's, respectively) were conducted on all metrics. The data presented a normal distribution. Subsequently, Pearson's correlation coefficient rho was used to examine the relationship between the VO2max and anthropometrical measures (BMI), and physical fitness (505-COD, VCut test and Illinois Agility test). We adopted the following criteria to interpret the magnitude of these correlations: Trivial: ≤0.10; small: 0.10 to 0.29; moderate: 0.30 to 0.49; large: 0.50 to 0.69; very large: 0.70 to 0.89; almost perfect: ≥ 0.90.

Descriptive statistics were calculated for each variable (Table 1).

Table 1. Anthropometrical measures and physical fitness parameters in the experiments (mean ± SD).

Young soccer players (*n*=47)				
	Mean (SD)	IC Lower 95%	IC	IC Upper 95%
Anthropometrical measures				
Age (years)	16.23±1.07	15.92	0.31	16.54
Height (cm)	171.65±4.73	170.30	1.35	173.00
Body mass (kg)	66.00±10.51	63.00	3.00	69.01
BMI (%)	21.11±3.20	20.20	0.92	22.03
Physical fitness parameters				
VO2max (mL/min/kg)	39.99±5.57	38.40	1.59	41.59
CMJ (cm)	33.11±5.45	31.55	1.56	34.67
Illinois (sec)	18.90±1.41	18.50	0.40	19.31
505-COD (sec)	2.56±0.60	2.39	0.17	2.73

VO2max was estimated by the next equation: Yo-Yo IR1 test: VO2max (mL/min/kg) = IR1 distance (m) × 0.0084 + 36.4 28. BMI: Body Mass Index; CMJ: Countermovement Jump

First, a correlation analysis was performed between VO2max and anthropometric measures (BMI) and physical fitness parameters (CMJ, Illinois and 505-COD) and the values revealed a negative moderate correlation between VO2max and BMI (r=-0.35, p=0.01) and a large negative correlation between VO2max and 505-COD (r=-0.55, p=0.001). However, the results did not show any significant correlation among physical fitness parameters. (More information in Table 2, Figure 1 and 2).

Table 2. Correlation between VO2max and anthropometric measures and physical fitness parameters.

	Young soccer players (*n*=47)			
	BMI (%)	CMJ (cm)	Illinois (sec)	505-COD (sec)
VO2max (mL/min/kg)	r=-.24	r=.19	r=.24	r=-.55
	p=.01*	*p*=.19	*p*=.11	*p*=.001**

*Denotes significance at p<0.05, and ** denotes significance at p<0.01.

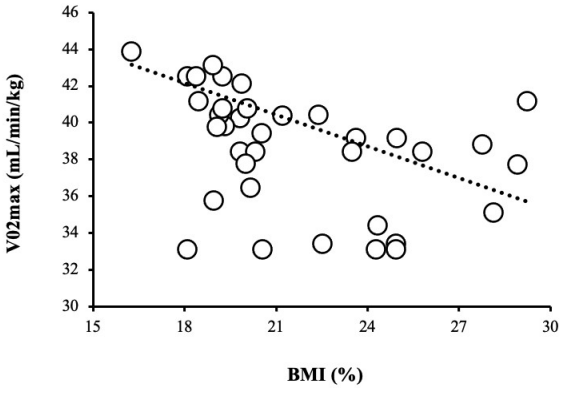

Figure 1. Correlations analysis between VO2max and BMI.

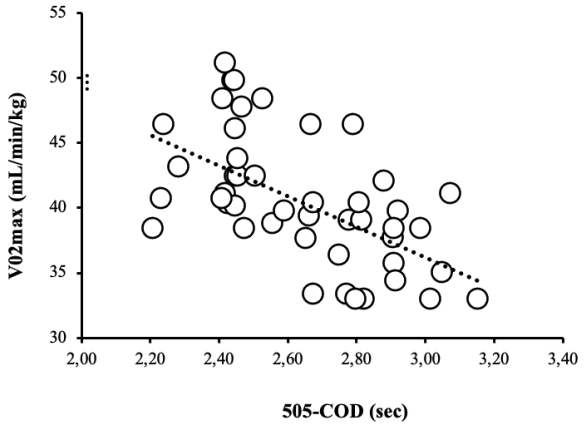

Figure 2. Correlations analysis between VO2max and 505-COD.

Discussion

The main aim of this study was to evaluate oxygen consumption by means of the Yo-Yo intermittent test and COD in young soccer players and to observe their possible relationship.

One of the main findings is the significant correlation between VO2max and BMI (r=-0.24). This relationship indicates that BMI is inversely proportional to VO2max. Therefore, it could be determined that those people with a lower BMI have a greater capacity to process a greater amount of oxygen during the practice of physical exercise. This means that the lower the BMI, the greater the respiratory capacity to maintain the intensity and duration of the exercise. These data agree with those found by Nevill et al.,[29] in which they related BMI to VO2max and showed how a lower BMI, within healthy parameters, is essential to achieve optimum VO2max. In this context, it is known that aerobic fitness (VO2max) increases with a greater practice of physical exercise. However, it has been identified that this association is curvilinear, with greater initial benefits (gains in physical condition) with sedentary adolescents (those who report low levels of exercise) also considering factors such as weight, age and sex.[30,31] This message should be received by those physical activity and sport professionals who are trying to encourage sedentary adolescents to improve their sports performance. Besides, Alonso-Fernández et al.[32] reported that the association between VO2max and BMI was more pronounced in the lower weight groups.

The data from the present study show a significant negative correlation between VO2max and the agility observed by the 505-COD (r=-0.55). Therefore, the relationship between VO2max and agility was inversely proportional. Agility has been shown to be a relevant factor that can improve the quality of performance of any athlete.[33] In contrast to the results found and following Handaru et al.[34] VO2max can affect agility performance in the game, the greater the aerobic capacity, the greater the ability to repeat an effort with a perfect technical execution after recovering from the previous effort. The finding of the present study contrasts with the findings of de Arazi et al.,[35] who suggested that aerobic power and agility were significantly related. This is determined by the fact that VO2max is one of the most important factors in the performance of the athlete. However, agile movements focused on change of direction are actions that require anaerobic metabolism in high-intensity situations, which are really the actions that determine success in a match.[36] This could be explained by the fact that players with a greater aerobic capacity tend to be the midfielders who cover greater distances during soccer matches, while attackers tend to be more specialized in COD to perform dribbling and passing.[37,38] In addition, adaptations to longer distances cause changes in type II muscle fibers, like greater capillarization and oxidative capacity, also producing a loss of explosive strength.[39] In contrast, COD could lead to neural nerve adaptations and linear sarcomeric hypertrophy, which in turn leads to an increase in power.[40]

In this respect, it could be discerned that trying to improve VO2max will not entail any benefits in agility and if the objective is to improve this skill, it will be necessary to follow a specific training program for its enhancement.

It this respect, soccer skills such as dribbling or feinting actions are also essential when carrying or driving the ball from one place to another, to take advantage of free space or to deceive the opponent and gain a competitive advantage. Furthermore, VO2max plays a key role in maintaining the ATP-PCr stores and makes it possible to carry out actions of COD and agility, aspects of the game that are decisive for performance[17]. Thus, the above-mentioned skills have a direct relationship with the capacity to repeat short efforts and high intensity actions. Therefore, COD depend more on VO2max, thus smaller variations in BMI and 505-COD are a better representation of COD ability with less dependency on sprinting and illinois and CMJ values.

This study has several limitations such as the sample size. other limitations are that measurements were not taken at different times of the season to assess improvement due to maturity, as well as comparing players by age ranges and position. In addition, one of the limitations of the study is the lack of data on the body composition of the participants, data that would make the relationships found between the different variables more reliable.

As conclusion, the results of this study show that maximal oxygen uptake or VO2max and BMI, are inversely related. A minimum and appropriate BMI is essential to achieve a higher VO2max. Therefore, in order to increase VO2max, it is necessary to reduce BMI to be able to achieve improvements. This finding may help athletes, coaches, physical therapists, and club managers to become familiar with the need for proper weight maintenance for athletes to control their BMI and ultimately increase VO2max.

Furthermore, the finding of this present study also reveals that there is no relationship between VO2max and agility. COD-focused agility movements are actions that require anaerobic metabolism in high-intensity situations, which are different from VO2max capacity. Therefore, there is no single method to improve VO2max and agility, since both are independent variables. Consequently, the different agents involved must take this into account if they want to improve VO2max and agility, and must plan some exercises separately. Although, correlations appear between the study variables, they may be influenced by other aspects that have not been considered and, therefore, it is necessary to continue research in this line.

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