Journal of Sport and Health Research 2021, 13(1):117-124

Faundez-Casanova, C.; Vásquez-Gómez, J.; Souza de Carvalho, R.; Zamunér, A.; Castillo-Retamal, M. (2021). The $\dot{V}O_2$max in Chilean University Cross-Country Athletes: Comparison with Field Test and its Relationship with the Competition. *Journal of Sport and Health Research.* 13(1):117-124.

Original

EL $\dot{V}O_2$MAX. EN ATLETAS DE CROSS-COUNTRY UNIVERSITARIOS CHILENOS: COMPARACIÓN CON TEST DE CAMPO Y SU RELACIÓN CON LA COMPETICIÓN

THE $\dot{V}O_2$MAX IN CHILEAN UNIVERSITY CROSS-COUNTRY ATHLETES: COMPARISON WITH FIELD TEST AND ITS RELATIONSHIP WITH THE COMPETITION

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Didactic Association ANDALUCIA
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Received: 27/12/2019
Accepted: 03/05/2020

Journal of Sport and Health Research 2021, 13(1):117-124

RESUMEN

Objetivos; el objetivo de este estudio fue evaluar la asociación entre un test predictivo del consumo máximo de oxígeno ($\dot{V}O_2$máx.) y el rendimiento en una competición nacional de atletas de Cross-Country chilenos.

Métodos; participaron 18 atletas. Se midió el $\dot{V}O_2$máx. con una prueba de ergoespirometría (PE), y se estimó con la prueba de Cooper y de Klissouras. Se comparó el $\dot{V}O_2$máx. entre los tres métodos y fueron correlacionados con el rendimiento en la competición. Fue utilizado el programa SPSS v.22 ($p<0.05$).

Resultados; hubo diferencias en el $\dot{V}O_2$máx. entre los tres métodos [F (2. 53) = 14.147; $p<0.001$)], entre PE y Klissouras ($p<0.001$), pero no con la prueba de Cooper ($p=0.355$). El $\dot{V}O_2$máx. en la prueba de Cooper tuvo la mejor correlación con la competición ($r = - 0.908$; $p<0.001$).

Discusión; algunas investigaciones no encuentran diferencias entre la medición del $\dot{V}O_2$máx. en cinta rodante y pruebas de pista atlética. Sin embargo, se han encontrado correlaciones inversas entre pruebas en cinta rodante de $\dot{V}O_2$máx. y una prueba de campo, en que al realizar menor tiempo en la pista atlética hubo mayor consumo de oxígeno en el laboratorio.

Conclusiones; La prueba de Cooper es la que mejor se relaciona con la competición, de modo que podría predecir el rendimiento.

Palabras clave: capacidad cardiorrespiratoria, corredores, estudiantes.

ABSTRACT

Objectives; the aim of this study was evaluate the association between a predictive test of maximum oxygen consumption ($\dot{V}O_2$max) and performance in a national competition in Chilean Cross-Country athletes.

Methods; 18 athletes participated. The $\dot{V}O_2$max was measured with ergospirometer test (ET), and was estimated with the Cooper and Klissouras test. $\dot{V}O_2$max was compared between the three methods and were correlated to the competition performance. The SPSS v.22 program was used ($p<0.05$).

Results; there were differences in the $\dot{V}O_2$max between the three methods [F (2. 53) = 14.147; $p<0,001$)], between the ET with the Klissouras test ($p<0.001$), but no with the Cooper test ($p=0.355$). The $\dot{V}O_2$max in the Cooper test was the best correlation with the competition ($r = - 0.908$; $p<0.001$).

Discussion; some studies have found no differences between the direct measurement of $\dot{V}O_2$max on the treadmill and athletic track test. However, there are inverse correlations between an incremental treadmill test $\dot{V}O_2$max and a field test, where when performing less time on the running track there was a higher oxygen consumption in the laboratory.

Conclusions; it is concluded that, Cooper's test is the best related to competition, so it could predict performance.

Keywords: cardiorespiratory capacity, runners, students.

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INTRODUCTION

The most important variables to evaluate resistance performance are metabolic thresholds, ventilatory thresholds, $\dot{V}O_2max$ and even the running economy (Tota et al., 2015). The $\dot{V}O_2max$ is the main variable for the assessment of the cardiovascular, pulmonary and metabolic systems in which the capacity to transport and use of oxygen is determined, therefore, it is the gold standard for measuring these functions (Poole & Jones, 2017). Such is the relevance of this variable, which has been asserted as the "Maximum oxygen uptake ($\dot{V}O_2max$) represents the runner's aerobic capacity and is thus an important determinant of success in distance running" (Støa et al., 2010).

The valuation of $\dot{V}O_2max$ it can be done indirectly or directly, through field or laboratory tests. The field tests have the advantage that they are applied in conditions closer to reality, since the athletic track is used, they are outdoors, they can be grouped, there is less financial cost and more similarities to competition situations (Maranhao Neto et al., 2017). The estimation of $\dot{V}O_2max$ has been carried out through various field tests and its results have been compared in the university context (Ortiz-Pullido et al., 2018), including some indirect tests such as the Cooper test have proven to be reliable in amateur runners (Alvero-Cruz, 2017) and valid in male university students (Bandyopadhyay, 2015).

On the other hand, the laboratory tests, although they have a higher economic cost due to the instruments used and the trained personnel that administer the equipment, are scarce, they allow for a greater control of the variables to measure such as speed, treadmill inclination, oxygen consumption, CO_2 production, respiratory rate, etc. One of the most applied tests to measure the $\dot{V}O_2max$ is the Bruce test, with which men and women who are physically active between 18 and 29 years of age (Spackman, 2001), have been evaluated to moderately trained young men and women runners (Miller, 2007) and young athletes (Hamlin, 2012).

Generally, field tests are used to assess runner performance, while the laboratory test are used to prescribe exercise and the exercise responses of the metabolic and cardiopulmonary assessments. However, to the best of our knowledge, no study has determined what is the most appropriate test, or provides the best projections of performance in official competitions (García et al., 2016; Reis et al., 2011). There is a gap in the knowledge about the relevance of field tests, such as the Cooper test, and some laboratory tests on the treadmill on the assessment of $\dot{V}O_2max$ and the performance projection in the official competition, since there is many differences between the competition and the two forms of assessment. For example, the field tests are carried out on a flat athletic track and the laboratory tests are performed on a treadmill that use increasing speed and sometimes elevation, but Cross-Country involves slope, descents, uneven terrain, etc.

The aim of the study was to evaluate the association between a predictive test of $\dot{V}O_2max$ and performance in a national competition in Chilean Cross-Country athletes.

MATERIAL AND METHODS

A total of 18 Cross-Country athletes (20.8 years old) were evaluated prior to the national university level competition, of the sample 11 were men and seven women. Five athletes were excluded from the analysis, two dues to injuries in competition and one who did not travel to competition (only 16 participate in the competition. Total = 13 athletes for analysis). The athletes followed a six-month training program with a weekly frequency of four sessions per week based on aerobic resistance (three days), resistance strength (two days), capacity and lactic power (two days).

The project “Variabilidad de la frecuencia cardíaca como herramienta pronóstica del rendimiento en deportistas universitarios” was developed to investigate the performance of university athletes, both collective and individual sports. The evaluations were oriented to aerobic, anaerobic, muscular strength and body composition performance. This project was submitted for evaluation by the ethics committee, corrections and suggestions were received, and these areas were improved. Finally, the new document was sent to the committee and approval was supported by the Scientific Ethics Committee of the Universidad Católica del Maule, Chile (n° 125/2018).

The study was carried on in the Laboratory Human Performance of the Universidad Católica del Maule. Weight and height of the athletes were measured with a DETECTO scale model 3P7044 with a capacity of

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140 kg (USA). Cardiopulmonary exercise testing using Bruce protocol (ET) was applied to measure $\dot{V}O_2max$ with a Cortex Metalyzer 3B ergospirometer (Germany) on a h/p cosmos mercury treadmill (Germany), where the criterion for determining $\dot{V}O_2max$ was a respiratory exchange ratio (RER) ≥ 1.15. Heart rate (HR), VCO_2, VO_2 and rating of perceived exertion (RPE) were also evaluated. One week later, the athletes took the Cooper test on a 400-meter athletic clay track, where the distance traveled was recorded and the $\dot{V}O_2max$ was estimated with the formula [22.351 × distance (km) – 11.288] (García et al., 1996). A week after, the Klissouras test (1000 meters) was performed on the same athletic track, the time was recorded and the $\dot{V}O_2max$ was calculated with the formula [(652.17 – time seconds) / 6.762] (Salas et al., 2016). After another week, eight men and five women participated in the main competition of the year, by teams and by sex, in which the partial and final times of competition were recorded, in the distances of six and eight km for women and men, respectively. The performance of the aerobic tests and the competition were within the competitive mesocycle.

For data analysis, the SPSS program, version 22, was used. Average values and standard deviation of the variables were obtained, and the assumption of normality was checked with the Shapiro-Wilk test. The differences between sex for the performance in the $\dot{V}O_2max$ and in competition were checked with the Student's T test for independent samples or U Mann-Whitney test. The possible differences were determined between the performances in the three methods of $\dot{V}O_2max$ were determined with a one-way repeated measures analysis of variance (ANOVA) followed by Bonferroni's post hoc test. Finally, the correlation between the $\dot{V}O_2max$ tests and performance in the competition was assessed using the Pearson or Spearman tests. Statistical significance was assumed when the *p*-value was <0.05. Significance levelwas set at 5%.

RESULTS

The results show that there are differences between men and women with respect to basic anthropometric variables, in the performance in $\dot{V}O_2max$ methods and the competition (Table 1).

The repeated measurements of the ANOVA test showed that there were statistically significant differences between $\dot{V}O_2max$ of the three applied methods [F (2. 53) = 14.147; p<0.001). Bonferroni's post hoc test showed that the $\dot{V}O_2max$ measured with the ergospirometry system in the ET was not different from the $\dot{V}O_2max$ estimated by the Cooper test (p=0.355). However, the $\dot{V}O_2max$ values estimated by the Klissouras test were higher than the values obtained in the ET (p<0.001) and in the Cooper test (p=0.002).

Regarding the correlation analysis, there was a significant relationship between the $\dot{V}O_2max$ measured in the ET and the distance traveled in the Cooper test (r = 0.867, p<0.001) and with the time to complete the Klissouras test (r = -0.857; p<0.001).

From all the athletes who underwent the ET and the two field tests, only 13 of them participated in the competition. Correlation analysis considering those 13 participants revealed that the Cooper test was the one that showed the best correlation with the competition results, expressed in partial and final times performed in the competition (Table 2).

DISCUSSION

The main results of this study are that the measured of $\dot{V}O_2max$ by means of the ET on a treadmill, it does not show statistically significant differences with that obtained in the Cooper test. Also, that $\dot{V}O_2max$ and the distance traveled during the Cooper test are those that have better association with the results in the competition.

Regarding the values of $\dot{V}O_2max$ measured directly on treadmill, our findings are in agreement with those reported by some authors (Redkva et al., 2012; Torres et al., 2016). Torres et al., (2016) reported 58.2 ± 6.7 and 48.9 ± 7.3 $ml·kg·min^{-1}$ in 46 endurance athletes, men and women from 17 to 20 years old, respectively. In addition, Redkva et al., (2012) indicate that 12 male military runners (aged 20 year old) had a $\dot{V}O_2max$ of 57.9 ± 4.2 $ml·kg·min^{-1}$. On the other hand, Mooses et al., (2015) reported values of 71.4 ± 6.4 $ml·kg·min^{-1}$ in thirtheen 25 years old distance runners, which is higher than the values reported in the present study.

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Table 1. Mean ± SD for performance in aerobic methods and competitions of Cross-Country athletes (diff: differences; *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$). ET: ergospirometer test; RER: respiratory exchange ratio; $\dot{V}O_2max$: oxygen uptake maximum.

	All	Male	Female	Diff (M-F)
Total	**18**	**11**	**7**	
Age (years)	20.8	21.3	20	
(X ± SD)	(1.6)	(1.5)	(1.3)	
Weight (kg)	62.1	67.6	53.6	***
(X ± SD)	(8.5)	(5)	(5.1)	
Height (m)	1.67	1.72	1.59	***
(X ± SD)	(0.09)	(0.06)	(0.04)	
BMI ($k·gm^{-2}$)	22.2	22.7	21.3	
(X ± SD)	(1.8)	(1)	(2.4)	
ET				
$\dot{V}O_2max$ ($ml·kg·min^{-1}$)	55.1	59.8	47.7	***
(X ± SD)	(7.8)	(4.4)	(5.8)	
$\dot{V}O_2max$ ($L·min^{-1}$)	3.4	4	2.5	***
(X ± SD)	(0.8)	(0.3)	(0.3)	
Heart rate ($beats·min^{-1}$)	186.5	186.6	186.3	
(X ± SD)	(7.9)	(9.2)	(6.2)	
RER	1.2	1.2	1.2	
(X ± SD)	(0.03)	(0.03)	(0.03)	
RPE	16.3	16.4	16.3	
(X ± SD)	(1.2)	(1.4)	(1)	
Cooper test				
Distance (m)	3146.2	3397.5	2751.4	***
(X ± SD)	(377.6)	(132.1)	(278.1)	
$\dot{V}O_2max$ ($ml·kg·min^{-1}$)	58.9	64.4	50.2	***
(X ± SD)	(8.4)	(3.2)	(6.2)	
Klissouras test				
Time (seconds)	197.5	179.8	225.3	***
(X ± SD)	(27.4)	(9.5)	(22.5)	
$\dot{V}O_2max$ ($ml·kg·min^{-1}$)	67.2	69.8	63.1	***
(X ± SD)	(4.1)	(1.4)	(3.3)	
Competition	**13**	**8**	**5**	
Splite time 1 (min), 2,000 m	8.9	8.5	9.5	**
(X ± SD)	(0.6)	(0.3)	(0.6)	
Split time 2 (min), 4,000 m	16.9	15.9	18.5	**
(X ± SD)	(1.6)	(0.9)	(1.2)	
Final time (min), 6,000 m			27	
(X ± SD)			(1.7)	
Final time (min), 8,000 m		31.3		
(X ± SD)		(2.3)		

These differences may be due to the level of the athletes' training, In this same variable Wagner et al., (2013) find values of $\dot{V}O_2max$ from 3.8 ± 1.1 to 4.1 ± 0.7 $L·min^{-1}$ in six men and seven women that particpate in college Cross-Country (20 years old), and Dellagrana et al., (2015) report values of 4.08 ± 0.57 $L·min^{-1}$ in 33 young moderately trained male runners (18 ± 0.9 years). In absolute terms, $\dot{V}O_2max$ of our athletes was lower when considering men and women as a whole, but men separately had a value similar to that found by Dellagrana et al., (2015).

Table 2. Relationship between the performance in the competition and the Cooper test (*: $p<0.05$; **: $p<0.01$; ***: $p<0.001$).

	Cooper test			
	$\dot{V}O_2max$ ($ml·kg·min^{-1}$)	**p-value**	**Distance (m)**	**p-value**
Female, split time 1 (2,000 m)	-0.737		-0.737	
Female, split time 2 (4,000 m)	-0.994	**	-0.994	**
Female, final time (6,000 m)	-0.987	**	-0.986	**
Male, split time 1 (2,000 m)	-0.443		-0.587	
Male, split time 2 (4,000 m)	-0.649		-0.631	
Male, final time (8,000 m)	-0.482		-0.475	
Total, split time 1 (2,000 m)	-0.908	***	-0.909	***
Total, split time 2 (4,000 m)	-0.943	***	-0.942	***

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When it comes to the comparison between the laboratory assessment and the field, some studies have found no differences between the direct measurement of $\dot{V}O_2max$ on the treadmill and athletic track test, Cárdenas (2011) did not report significant differences in 11 young athletes (21 years old) who performed medium and background tests, although the relationship between the Bruce test and other one on the progressive and incremental athletic track based on the critical speed of each athlete, was r = 0.29. Nor do Lim et al., (2016) report differences between an incremental test on a treadmill and an incremental one based on the RPE on an athletic track when studying 50 young men (23.9 years) who performed vigorous athletic training (p>0.05), nor Mooses et al., (2015) found differences between an incremental field test on the track, based on standard speed for all athletes, and an incremental test on a treadmill (p=0.105) after measuring 13 distance runners, but they show a strong relationship in running economy between a laboratory and field test (r = 0.719, p=0.006) considering oxygen consumption and speed. In this sense, Redkva et al., (2012) found inverse correlations between $\dot{V}O_2max$ incremental treadmill test and a field test (1,200; 2,400 and 2,800 meters test), where performing less time on the athletic track there was a greater oxygen consumption in the laboratory (r = - 0.52 to – 0.61).

In our study, compared to those recently exposed, we found no differences in $\dot{V}O_2max$ between the ET and the Cooper test, but a significant difference was observed with the Klissouras test. It seems that some of those discrepancies may be due to the protocol of each test applied, both in the laboratory and in the field. However, the relationships between the two assessment methods of our study, direct and indirect, are within the same line as some of the research cited, since there was a strong correlation with the Cooper test (r = 0.867) and an inverse relationship with the time used in the 1000 meter test (r = - 0.857).

Some of the research that we have found to be related to the $\dot{V}O_2max$ measured in the laboratory with the performance in tests of half long-endurance, in this case Støa et al., (2010) reported a strong correlation between the direct measurement of $\dot{V}O_2max$ and the time to travel five km (r = 0.75) in eight elite runners with an average of 29 years old, and the research by Mclaughlin et al., (2010) reported a correlation of r = - 0.902 between the $\dot{V}O_2max$ and the time to complete 16 km in 10 men and seven women runners with an average age of 33 years old. A moderate correlation between $\dot{V}O_2max$ and the speed it takes to cover 3000 meters has also been found (k=0.55) in 18 middle distance runners with an average of 20 years old (Bragada et al., 2010). In recent years, Da Silva et al., (2015) showed correlations ranging from 0,65 to 0,79 between $\dot{V}O_2max$ and the maximum aerobic speed in a race of 10 km in 21 recreational runners from 30 to 49 years old. In our research with university runners, we have found higher and significant, correlations between $\dot{V}O_2max$ of the ET and the competition for the partial times at 2,000 and 4,000 meters (r = - 0.81, p=0.001, r = - 0.884, p<0.001, respectively), which is in line with the abovedmentioned research for distances of 3,000 and 5,000 meters. Despite this, and as already stated, the results of the Cooper test have had the best correlation with the competition.

The Cooper test has a greater relationship with the partial time in the women and the total sample, and the competition final time in women, and therefore can be taken as an adequate method for the assessment of aerobic power, and possibly be a performance prediction method in said competition for them. Given this, it is suggested to apply the Cooper test for the assesment of Cross-Country runners of this study.

One possible limitation of the study may be the sample size, however, in literature there are researches that used samples smaller than 15 subjects. Therefore, we can assume that without this limitation in the future, a greater statistical power can be shown in the results.

CONCLUSIONS

Cooper test is the one that best correlates with the partial times in the competition, overall for women. In this way, the field test could be a predictor of performance in competition.

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