Assessment of professional Argentine football players using the UNCa test

Martin Fernando Bruzzese[1], Nelio Eduardo Bazán[2], Nicolás Antonio Echandia[4], Leandro Gabriel Vilariño Codina[5], Hugo Alberto Tinti[5], Gastón César García[3]

[1]Futbolistas Argentinos Agremiados, Buenos Aires. [2]Universidad Nacional de Rosario, Rosario, Santa Fe. [3]Instituto Superior de Formación Docente 9003, San Rafael, Mendoza. [4]Universidad Nacional de Villa Mercedes, San Luis. [5]Instituto Alexander Morón, Buenos Aires.

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Summary

Objective: To evaluate the maximum oxygen consumption (VO2max) and the Maximum Aerobic Speed (MAS) with direct and portable measurement in field, in professional soccer players using the UNCa test.
Material and method: 9 professional soccer players (age: 26.8±5.12 years, mass: 78.7±5.8 kg, height: 177.3±5.8 cm), belonging to the first and promotion categories of AFA soccer league, were measured in the field with the UNCa test using direct gas measurement. A subsample of 3 players was also measured on treadmill. On treadmill and in the field, the same Medgraphics® VO_{2000} gas analyzer was used.
Results: In the field, a VO_{2max} of 52.18±5.86 ml/kg/min, and a MAS of 14.8±1.3 km/h were found. Also, a correlation between VO_{2max} and MAS of r = 0.75, and between MAS and the final speed reached (FSR) r=0.91. In the subsample, no differences were found between treadmill and field in VO_{2max}; 46.6±1.4 ml/kg/min and 48.1±2.2 ml/kg/min (p <0.001) respectively. Differences between MAS are shown; 17.0±0.0 km/h for the treadmill and 13.7±1.5 km/h for the field (p <0.001) replicating the protocol.
Conclusion: If professional players of the Argentine Football Association (AFA) were measured directly and in the field, applying the UNCa test for the first time. The VO_{2max} and MAS values were slightly lower than those published in the bibliography.

Key words:
Field test.
Maximal aerobics speed.
Team sports. VO_{2max}.

Evaluación de jugadores argentinos de futbol profesional utilizando el UNCa test

Resumen

Objetivo: Evaluar el consumo máximo de oxígeno (VO_{2max}) y la Velocidad Aeróbica Máxima (VAM) con medición directa y portátil en campo, en futbolistas profesionales utilizando el UNCa test.
Material y método: 9 futbolistas profesionales (edad: 26,8±5,12 años, masa: 78,7±5,8 kg, estatura: 177,3±5,8 cm), pertenecientes a las categorías primera y ascenso de futbol AFA, fueron medidos en campo con el UNCa test utilizando medición directa de gases. Una submuestra de 3 jugadores fue evaluada también en cinta. En cinta y en campo, se utilizó el mismo analizador de gases VO_{2000} de Medgraphics®.
Resultados: En campo se observó un $VO_{2máx}$ de 52,18±5,86 ml/kg/min, y una VAM de 14,8±1,3 km/h. Se halló una correlación entre el VO_{2max} y la VAM de r=0,75, y entre la VAM y la velocidad final alcanzada (VFA) r= 0,91. En la submuestra, no se encontraron diferencias entre cinta y campo en el VO_{2max}; 46,6±1,4 ml/kg/min y 48,1±2,2 ml/kg/min (p<0,001) respectivamente. Se observó diferencias entre las VAM; 17,0±0,0 km/h para la cinta y 13,7±1,5 km/h para el campo (p<0,001) replicando el protocolo.
Conclusión: Se midió de forma directa y en campo a jugadores profesionales de la Asociación del Fútbol Argentino (AFA) aplicando por primera vez el UNCa test. Los valores de VO_{2max} y VAM, fueron levemente menor a los publicado en la bibliografía.

Palabras clave:
Test de campo.
Velocidad aeróbica máxima.
Deportes de conjunto. VO_{2max}.

Correspondence: Gastón C. García
E-mail: garciagaston@yahoo.com.ar

Introduction

During a professional football match, players can cover distances between 10,000 and 12,000 metres, and although players are running at different speeds[1], oxygen consumption is clearly an important variable concerning this physiological demand. It is defined as the possibility of doing physical work due to the subject's capacity to transport and metabolise O_2 in a unit of time. An individual's maximum capacity for physical work can be studied through maximum oxygen consumption (VO_{2max}). In professional players, the VO_{2max} varies between 55 and 75 ml/kg/min, depending on the level of play in their league[2-4]. One way that this variable can be implemented and used in players' physical training is through maximum aerobic speed (MAS), which is the minimum speed at which the VO_{2max} is reached in a test of progressive characteristics[5]. This variable can be used to plan running training[6-9]. To identify its value, it is necessary to know the VO_{2max} which requires a portable gas analyser. This technology is not available in many clubs in Argentina. However, it is possible to use the final speed reached (FSR) from an indirect field test to estimate the MAS[10] because both correspond to very similar intensities[11].

As opposed to a direct test, the field tests have the advantage of measuring several subjects at the same time, they are cheaper, they do not require too much time and the athlete is measured where they actually train[12]. There are several tests to estimate MAS, including the Montreal University Test –UMTT[13] with an increment protocol of 1 km · h^{-1} every 2 minutes, the VAM-EVAL Test with a protocol of 0.5 km·h^{-1} every 1 minute[14], the 45-15 Test with a protocol of 0.5 km·h^{-1} every 45 seconds with a break of 15 seconds[15], the 5-minute Test[16], the *Shuttle Squared Test* with a protocol of 0.5 km · h^{-1} every 1 minute[17], and the Catamarca National University Test - UNCa test with a protocol of 1 km · h^{-1} every 1 minute[18].

Among the aforementioned tests, the UNCa test was validated among physical education students comparing the MAS on a treadmill with the FSR on the pitch (r= 0.82) and subsequently among amateur football players (r= 0.81) and amateur rugby players (r= 0.87)[18-20]. Due to its protocol (1.0 km · h^{-1} every 1 minute), it implies using less time compared to other tests[19]. The test route follows a 120-metre hexagon. A hexagon is used for two reasons, a) measuring the athletes where they actually train (training ground or pitch) without having to use an athletics track (as required by the aforementioned tests) and b) not using tests with 'there and back' characteristics (Course Navette, YoYo test, among others) that underestimate the MAS[10,14,17].

While the UNCa test has been validated[18] and used among athletes from different disciplines[19,20], it has not been applied to professional football players. This study proposes to apply the UNCa test to Argentine professional football players to measure VO_{2max} and MAS in the field.

Material and method

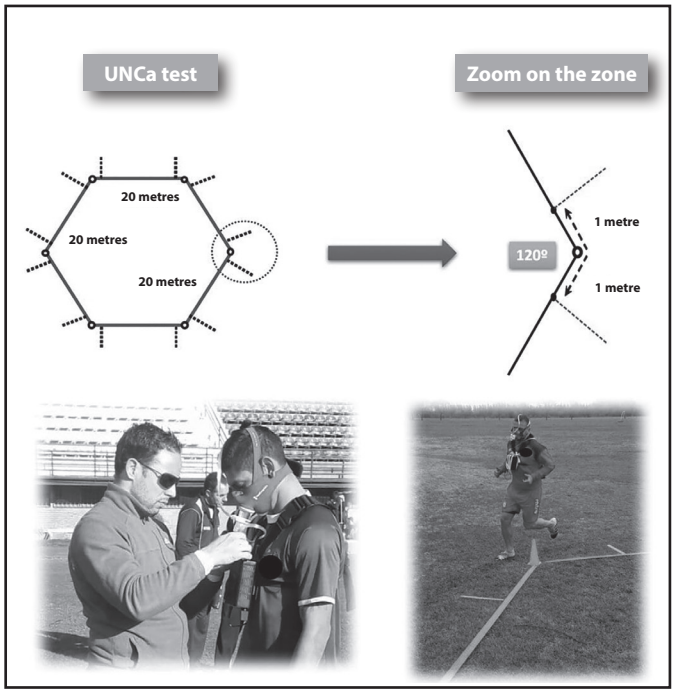
The study had an observational design and a relational analytical analysis level. It used a convenience sample.

Sample and population

9 professional football players were assessed on the pitch using direct measurement. Subsequently, 3 of them were measured again using direct measurement, in the laboratory on a treadmill. The players belonged to clubs from the province of Buenos Aires (conurbation) from the top categories of Argentine football, in the AFA league (Argentine Football Association). All the players were Argentine nationals. The players were measured on the pitch, on the training ground, with the UNCa test using a VO2000 portable gas analyser made by Medgraphics®. A sub-sample, comprising 3 players, was assessed on the same club's laboratory treadmill. The study was organised abiding by Resolution 1480/11 of the Argentine Public Health Ministry, Guide for Research using Human Beings. Participation in this study was voluntary and the players were informed beforehand about each of the tests. Data remained anonymous. A medical support team was constantly present during the assessments.

Field measurement (UNCa test): the subjects run around the perimeter of a 120-metre hexagon. (See Figure 1). The angle between the sides was 120º. The speed is dictated by an audio signal[21]. On each side of the hexagon, there is a 2-metre zone that the participant must have reached when the test beep is heard (see zoom on Figure 1). The test has 2 warm-up stages: 3 minutes at 8.0 km·h^{-1}, and 2 minutes at 10.0 km·h^{-1}. Without stopping, from there on, the speed increases by 1.0 km·h^{-1} every minute, until exhaustion. Exhaustion is understood to be when the subject is late to the arrival zones (vertex of the hexagon) on 2 occasions, or they quit the test because they cannot keep up the audio signal running pace. Incomplete stages are not counted.

Figure 1. Hexagon from the UNCa test.



Laboratory measurement: In the laboratory, the average temperature during the test varies between 22-24°C. Prior to the test, warm up took place at 2 speeds: 2 minutes at 8.0 km/h and 2 minutes at 10.0 km/h. The test began immediately afterwards. The test was incremental, beginning at 10 km/h and increasing by 1 km/h every 2 minutes in the first three stages and then every minute, until exhaustion. Exhaustion is understood to be when the subject can no longer keep up the treadmill speed and quits the test. The gradient of the treadmill is not increased throughout the test. The peak running speed reached at the exhaustion point must be maintained for 1 minute (FSR). The device uses Breezesuite software for processing and data analysis. Body mass and stature were also measured.

On the treadmill and on the pitch, the same VO_{2000} gas analyser by Medgraphics® was used, with the following dimensions: 10.5 x 5 x 14 cm, and a weight of 740 g. It contains a galvanic cell that analyses O_2 with accuracy of ±0.1 %, and a non-dispersed infra-red system, that measures the production of CO_2 with accuracy of ±0.2 %. The data was averaged out in 10 s intervals. The following physiological variables were measured: maximum consumption (VO_{2max}), carbon dioxide production: VCO_2 (ml/kg/min), ventilation (ml/min), heart rate (HR) and the MAS (km/h). The VO_{2max} was accepted when at least 3 of the following criteria were met: a) levelling (plateau) of the VO_{2max}, despite an increase in the treadmill speed, VO2 <150 ml O_2; b) a respiratory gas exchange ratio was reached (VCO_2/VO_2) that was equal to or greater than 1.09; c) the heart rate during the last minute exceeded 95% of the maximum heart rate expected for their age; and d) the subjects could no longer continuing running despite verbal stimulus. The VO_{2max} was expressed in relative values (ml/kg/min).[5] The MAS was located jointly with the VO_{2max}.[22-24]. If the player completed another stage after achieving the VO_{2max}, the speed was considered to be FSR (final speed reached) in the last complete stage,18 to differentiate it from the MAS. The following were also calculated in both measurements: ventilatory threshold 1 (VT1) and ventilatory threshold 2 (VT2) in ml/kg/min and as a % of the VO_{2max}, and the respiratory exchange ratio (RER). The VT1 was determined by using the criteria of an increase both in the ventilatory equivalent for oxygen (VE/VO_2) and the oxygen pressure at the end of exhalation ($P_{ET}O_2$) with no concomitant increase in the ventilatory equivalent for carbon dioxide (VE/VCO_2). VT2 was determined using the criterion of an increase in both the VE/VO_2 and VE/VCO_2 and a drop in $P_{ET}CO_2$.

Statistical analysis

The data was analysed using the SPSS statistics package from IBM® 22.0. The Shapiro-Wilk test was performed beforehand to corroborate the presence of normality. Then descriptive statistics were applied to calculate the median and standard deviation. The ratios between the various variables were calculated using the Pearson correlation coefficient. Descriptive statistics were applied to the sub-sample assessed on the treadmill. In all cases, an alpha $p<0.05$ was accepted.

Results

9 professional football players were assessed, with an average age of 26.8±5.12 years, an average body mass of 78.7±5.8 kg, and a height of 177.3±5.8 cm.

Table 1 presents the cardiorespiratory variables measured on the pitch on players with particular interest in the VO_{2max}, the MAS and the FSR. On the other hand, it was seen that the time of the tests varied between 488 and 739 s with an average of 593 s.

Table 2 highlights the high correlation existing between the FSR and the MAS (0.919 p=0.000).

Table 3 shows the sub-sample (N=3) measured on the treadmill and pitch, with the same protocol. The average VO_{2max} values were 46.6±1.4 ml/kg/min on the treadmill and 48.1±2.2 ml/kg/min on the pitch, thereby presenting a difference of 1.5±1.9 ml/kg/min (3.02%). The MAS values were: 17.0±0.0 km/h on the treadmill and 13.7±1.5 km/h on the pitch, thereby presenting a difference of 3.3±1.1 km/h (24.9%).

Table 1. Variables measured during the UNCa test.

#	VO_{2max} ml/kg/min	VO_{2max} ml/min	MAS Km/h	RER	HR bpm	VE l/min	VT2 %	VT2 ml/kg/min	FSR Km/h	Dist. m	Time s
1	61.1	5190	16	1.04	-	161.3	80	49.0	17	2140	676
2	59.3	4332	17	1.10	204	162.2	84	50.1	18	2440	739
3	56.4	4344	15	1.10	189	130.4	82	46.6	15	1860	613
4	54.8	4000	15	1.12	186	105.1	76	41.5	15	1860	613
5	49.5	4354	13	0.95	202	104.4	83	41.0	14	1360	488
6	49.3	3622	15	1.23	185	144.3	82	40.5	15	1860	613
7	48	3984	14	1.03	190	110.7	88	42.3	15	1600	550
8	45.7	3380	15	1.22	-	132	76	35.1	15	1860	613
9	45.5	3728	13	1.07	199	119.1	85	38.7	14	1360	488
X	52.18	4,103.8	14.8	1.10	193.6	129.9	81.8	42.8	15.3	1,786.7	593
DS	5.86	533.2	1.3	0.1	7.9	22.3	4.0	4.9	1.3	353.8	82.8

VO_{2max}: maximum oxygen consumption, MAS: maximum aerobic speed, HR bpm: heart rate in beats per minutes, RER: respiratory exchange ratio, VE: maximum ventilated volume, VT2: ventilatory threshold, %VT2%: % of the VO_2 in the VT2, FSR; final speed achieved in the last complete stage. Dist: Accumulated distance, Time: accumulated test time.

Table 2. Correlations.

Ratio	Coefficient	Value *p*
VO_{2max} (ml/kg/min) and VT2	0.916	0.001
VO_{2max} (ml/kg/min) and MAS (km/h)	0.755	0.019
MAS (km/h) and VE_{max} (L/min)	0.808	0.008
FSR and VO_{2max} (ml/kg/min)	0.783	0.012
FSR and MAS (km/h)	0.919	0.000

VO_{2max}: consumo de oxígeno máximo, VAM: velocidad aeróbica máxima, VE_{max}: volumen ventilado máximo, VT2: umbral ventilatorio, VFA: Velocidad final alcanzada.

Table 3. Assessment on the treadmill (sub-sample n=3).

#	Test	VO_{2max} (ml/kg/ /min)	MAS (km/h)	RER	HR lpm	VT2 (ml/kg/ /min)	VT2 %	FSR Km/h
5	Pitch	49.5	13	0.95	202	41.5	83	14
	Treadmill	45.9	17	1.07	198	39.8	87	18
6	Pitch	49.3	15	1.10	189	46.6	82	15
	Treadmill	48.2	17	1.13	178	39	81	17
9	Pitch	45.5	13	1.07	199	38.7	85	14
	Treadmill	45.7	17	1.16	187	35.3	78	17

VO_{2max}: Maximum oxygen consumption, MAS: maximum aerobic speed, RER: respiratory exchange ratio, HR bpm: heart rate, VT2: ventilatory threshold 2, VT2%: % of the VO_{2max}, FSR; final speed reached in the last complete stage.

Table 4. Studies published on professional football players that measured on the pitch.

Studies	Sample	VO_{2max} ml/kg/min	MAS Km/h	VT2 %	Test
Measurement on the pitch					
Dupont *et al.*[6] 2004	n=22	60.1±3.4	15.9±0.8	no	UMTT
Dupont *et al.*[25] 2005	n=11	59.4±4.2	17.2±1.3	no	UMTT
Zouhal *et al.*[26] 2013	n=7	58.0±6.0	17.1±0.6	no	VamEval
Present study	n=9	52.2±5.9	14.8±1.3	81.8±4.0	UNCa

VO_{2max}: maximum oxygen consumption, MAS: maximum aerobic speed, VT2: ventilatory threshold 2.

Discussion

For the first time, professional football players from the Argentine Football Association (AFA) were measured directly and on the pitch using the UNCa test.

The VO_{2max} obtained on the pitch was slightly lower than in other studies[6,25,26]. They are shown in Table 4 and were carried out on the pitch using portable analysers. Dupont *et al* obtained VO_{2max} of 60.1±3.4 on French football players. The same work team obtained similar values in another study: 59.4±4.2. Zouhal *et al*,[25] obtained a VO_{2max} of 58.0±6 among 7 French football players.

Regarding the maximum aerobic speed on the pitch (MAS), it was lower compared to other studies[6,25,26]. Dupont *et al*, reported an initial MAS of 15.9±0.8 km/h^{-1}, among 22 football players from the national league in France, using the UMTT, that after physical preparation involving high intensity interval training, was improved to 17.3±0.8 km/h^{-1}. In a second study using footballers, Dupont *et al*,[25] obtained a MAS of 17.2±1.3 km/h^{-1}. Zouhal *et al*[26], measured the MAS using the VAM-EVAL test on 7 national level football players in France to plan high-intensity interval work. The author reported a MAS of 17.1±0.6 km/h^{-1}.

A strong correlation was observed between the FSR and the MAS which gives it a practical value; if the physical trainer does not have a gas analyser, they can use the speed obtained in the last complete stage as a reference to design the aerobic strength training[7,10,17-22]

The difference observed between the MAS on the treadmill and pitch is similar to what was reported by other studies[11,18,23,24]. The speeds are not exchangeable, where the speed on the pitch is less than the treadmill MAS[11,18,23,24]. This confirms that the MAS is protocol-dependent, as opposed to the VO_{2max} that was similar in both environments.

Finally, using a gas analyser made it possible to study sub-maximum parameters such as ventilatory thresholds, that are relevant in football players to assess their physiological profile. It is demonstrated that the VO_{2max} indicator is less sensitive to changes in the status of the professional football players' training compared to the ventilatory thresholds[27]. In the majority of the papers published, the second threshold or the ventilatory threshold 2 (VT2) stands between 80 and 88 % of the VO_{2max}[27-29], which coincides with 81.8 % of the VO_{2max} described in this paper.

It is considered necessary to continue researching the application of the UNCa test in professional football. This paper involved a small sample of players, and it is typical of this type of research which involves top-performing athletes (professional players). However, the results obtained can help plan training[30].

Conclusions

Professional football players from the Argentine Football Association (AFA) were measured directly and on the pitch for the first time applying the UNCa test. The VO_{2max} and MAS values were slightly lower than those published in the bibliography. If no portable equipment is available to analyse ventilated gases, the FSR from the last complete stage of the UNCa test can be used to organise the aerobic strength training loads.

Conflict of interests

The authors do not declare any conflict of interests.

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