

Original Article

The improvement of the maximum aerobic speed in football through high intensity interval training

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Abstract:

The aim of this study was to evaluate the effects after a period of High Intensity Interval Training on Maximum Aerobic Speed (MAS).

To obtain the value of the Maximum Aerobic Speed the Gacon test was used, and on the basis of the results obtained the training sessions were scheduled, where the high intensity jobs were set at the speed corresponding to 120% of the MAS, while those at a low intensity of 60% of the MAS, a total of 12 specific sessions were held with works of the type 10" - 10" and 5" - 5".

At the end of the training period there was an average increase for the Maximum Aerobic Speed equal to 17.2%.

Key Words: Football athletic preparation; Gacon test; Maximum heart rate; Maximum oxygen consumption.

Introduction

The value of the Maximum Aerobic Speed (MAS) allows to understand the aerobic skills of an athlete and to adapt the workouts in an optimal way based on his real athletic conditions.

High Intensity Interval Training (HIIT), involves the alternation of short and intense anaerobic periods with short periods of aerobic recovery, and adapts well to a sport such as high intensity intermittent aerobic-anaerobic football, with breaks broadly variable and a mixed metabolic activity, where aerobic and anaerobic energetic processes are solicited alternately.

Material & methods

Participants:

An amateur football team took part in the experimentation for a total of 21 players, with heterogeneous football experiences.

The age of the players and the anthropometric characteristics are shown in table I.

The average age is 25.1 years, while the average height is 1.72 meters, and the average weight is 76.2 kg.

Table I - anthropometric characteristics

	age	height (m)	weight (Kg)
Player 1	38	1,73	75
Player 2	38	1,68	75
Player 3	37	1,72	76
Player 4	25	1,7	80
Player 5	17	1,65	75
Player 6	41	1,71	80
Player 7	18	1,69	79
Player 8	37	1,72	75
Player 9	21	1,8	79
Player 10	22	1,78	84

Player 11	17	1,77	81
Player 12	28	1,73	77
Player 13	25	1,69	73
Player 14	21	1,7	75
Player 15	21	1,74	74
Player 16	21	1,75	75
Player 17	22	1,69	71
Player 18	18	1,76	77
Player 19	20	1,66	68
Player 20	20	1,75	73
Player 21	20	1,76	78

Procedures:

To perform the study, empirical methods were used, such as the Gacon test and High Intensity Interval Training (HIIT).

Through the Gacon test we calculated the Maximum Aerobic Speed (MAS). At the end of the test the heart rate values and the concentration of lactic acid were found, which are used as further confirmation for the reliability of the test.

Test di Gacon

The Gacon Test is one of the most famous tests used by Italian team, coaches and fitness coaches. It's an accurate field test to determine $\text{VO}_{2\text{max}}$ and MAS (Maximum Aerobic Speed)¹.

To perform this test it is not necessary a particularly expensive instrumentation, so it is well suited to amateur teams.

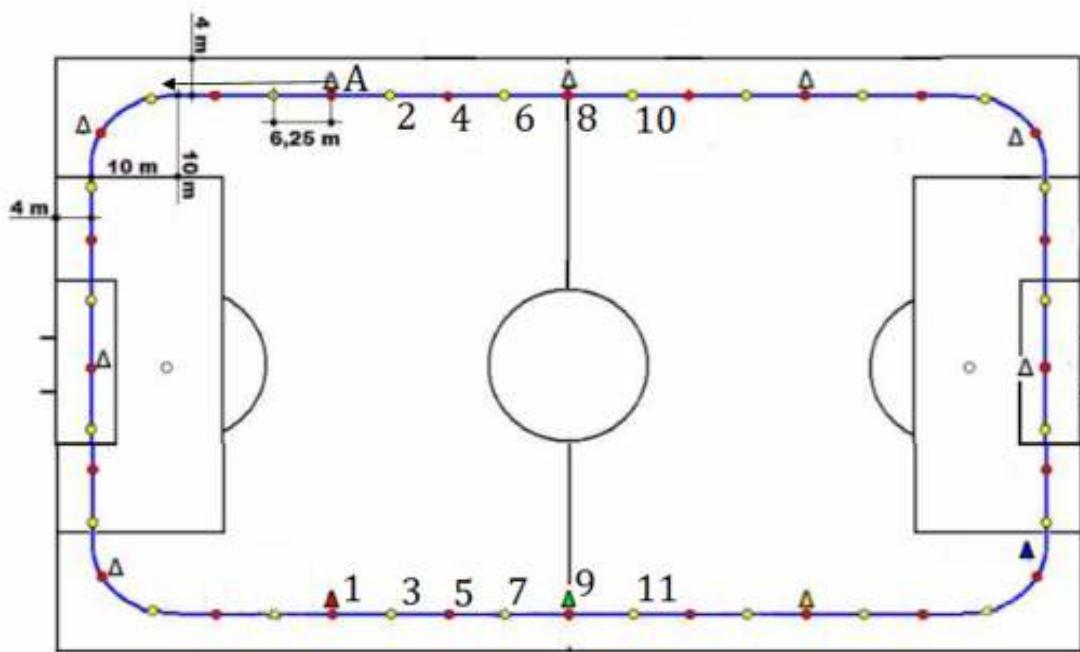
In order to perform the Gacon test, it is necessary to cover predetermined distances (see table II) in a time of 45 seconds with 15 seconds of pause before traveling the next distance.

Table II - Gacon Test

Step	Speed (Km/h)
1	10,0
2	10,5
3	11,0
4	11,5
5	12,0
6	12,5
7	13,0
8	13,5
9	14,0
10	14,5
11	15,0
12	15,5
13	16,0
14	16,5
15	17,0
16	17,5
17	18,0
18	18,5
19	19,0
20	19,5

The first distance to travel is 100 meters and is increased with each step of 6.25 meters. To identify the various distances we used some mark, arranging them as in figure I.

¹ Assadi H. and Lepers R., 2012

**Figure I - Gacon Test**

The departure will take place from point A and must reach point 1 (covering the first distance equal to 100 meters). For the start of the second step you will start from point 1 you will reach point 2 (covering one of 106.25 meters) and so on until you complete the test (see table II).

This training methodology is inserted in the pre-season period during the athletic preparation of the team.

To perform the Gacon test optimally the number of players that perform it must not exceed 7-8 players, so we divided the team into three groups so as to have 7 players to perform the test simultaneously. Each player is equipped with a Geonaute onmove 500 heart rate monitor, which is also equipped with a stopwatch that the players themselves can use to help themselves to recognize the appropriate pace.

The test begins with a whistle, at the end of the 45 seconds you will have a second whistle, which will follow a pause period of 15 seconds, at the end of the break you will have another whistle for the departure of the second distance (second step) and so away until the test is completed. The test ends when the player is no longer able to walk the distance in 45 seconds, and the last step completed will be recorded. This data will allow us to refer to Table II to identify the Maximum Aerobic Speed (MAS). After the last completed step, the heart rate and lactic acid concentration values will be recorded, which are shown in table III.

Table III

	MAS (Km/h)	Fc (b/m)	mmol/L
Player 1	12,5	186	11
Player 2	12,5	174	9,4
Player 3	13	172	8,9
Player 4	13,5	177	11,4
Player 5	13,5	201	13
Player 6	13	176	10,5
Player 7	13,5	193	9,6
Player 8	14	179	11,4
Player 9	14,5	194	9,3
Player 10	14	201	12,9
Player 11	14,5	189	10,2
Player 12	14	202	12,1
Player 13	14,5	188	11,3
Player 14	15,5	199	12,2
Player 15	15,5	204	13,4
Player 16	15	195	10,3

Player 17	16	181	11,4
Player 18	15,5	197	10,7
Player 19	16	200	12,8
Player 20	16	183	10,5
Player 21	16,5	185	11,7
Average	14,4	189,3	11,1
Standard Deviation	1,23	10,2	1,29

Considering that the Maximum Aerobic Speed is not estimated as we do not have the possibility to perform laboratory tests, after 48 hours we proceed to perform a control test, in order to evaluate if the test is reliable, to do this we do use of the calculation of the interclass correlation coefficient (ICC).

Table IV shows the results for the control of the first test.

Table IV

	MAS (Km/h)
Player 1	13,0
Player 2	13,0
Player 3	13,5
Player 4	13,0
Player 5	14,0
Player 6	13,5
Player 7	13,5
Player 8	14,5
Player 9	14,5
Player 10	14,0
Player 11	14,0
Player 12	14,5
Player 13	14,0
Player 14	15,5
Player 15	16,0
Player 16	14,5
Player 17	16,5
Player 18	15,0
Player 19	15,5
Player 20	15,5
Player 21	17,0

From the calculations made with Excel we have obtained a value for the interclass correlation coefficient equal to 0.951 so we can state that the first test is reliable, and the data of the first test will be used to calculate the gaits for the workouts.

The average value of the Maximum Aerobic Speed (MAS) is 14.4 Km/h with a standard deviation of 1.2. The lowest overall speed was 12.5 km/h, while the highest speed was 16.5 km/h.

From the test data it is considered necessary to divide the team into three slow (L), medium (M) and fast (V) training groups. For each of these three groups, the Maximum Aerobic speed will be taken into consideration by calculating the average of each group.

The L group will be made up of the players who in the Gacon test obtained values for the Maximum Aerobic Speed included between 12.5 Km/h and 13.5 Km/h. The M group will be made up of players who have obtained values between 14.0 km/h and 15.0 km/h in the Gacon test. The group V will be composed of the players who in the Gacon test obtained values between 15.5 Km/h and 16.5 Km/h.

The average value of the Maximum Aerobic Speed that made up the L group was 13.07 Km/h, while for the M group it was 14.36 km/h, and for the V group it was 15.86 Km/h.

The training sessions include high intensity periods set at 120% of the Maximum Aerobic Speed value and low intensity periods set at 60% of the Maximum Aerobic Speed value, taking as parameter the average value of the Maximum Aerobic Speed of each group. A total of 12 training sessions are planned, intermittent jobs will be of type 5" - 5" (5 seconds at high intensity and 5 second at low intensity), and 10" - 10" (10 seconds high intensity and 10 seconds low intensity). Each session will consist of three intermittent series lasting 4 minutes and 4 minutes of pause with active recovery.

For group L, for type jobs 5" - 5", the distance to be covered at high intensity is equal to 21.8 meters, while the distance to be covered at low intensity is equal to 10.9 meters . A rectangular course measuring 21.8 meters x 10.9 meters (see figure II) is traced for the training session.

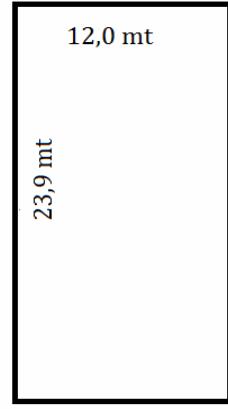
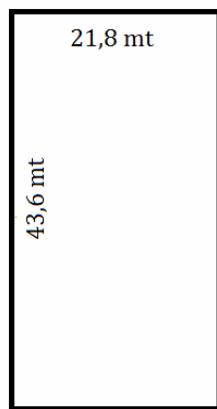
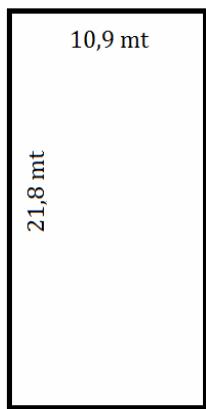


Figure II - Job type 5" - 5" group L Figure III - Job type 10" - 10" group L Figure IV - Job type 5" - 5" group M
For type jobs 10" - 10", the distance to be covered at high intensity is equal to 43.6 meters, while the distance to be covered at low intensity is equal to 21.8 meters. A rectangular course measuring 43.6 meters x 21.8 meters is drawn for the training session (see figure III).

For group M, for type jobs 5" - 5", the distance to be covered at high intensity is equal to 23.9 meters, while the distance to be covered at low intensity is equal to 12.0 meters . A rectangular route measuring 23.9 meters x 12.0 meters is drawn for the training session (see figure IV).

For type jobs 10" - 10", the distance to be covered at high intensity is equal to 47.9 meters, while the distance to be covered at low intensity is equal to 23.9 meters. A rectangular route measuring 47.9 meters x 23.9 meters is drawn for the training session (see figure V).

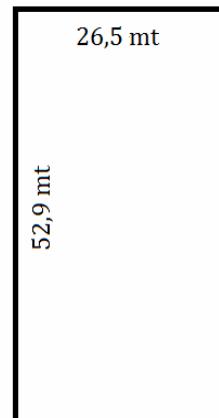
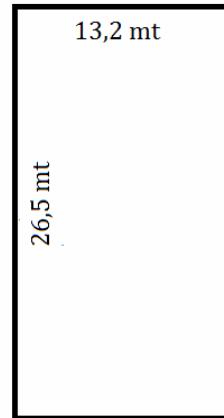
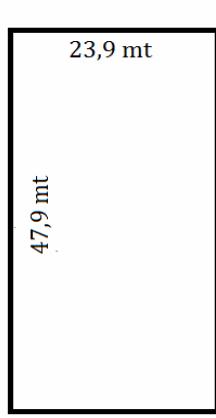


Figure V - Job type 10" - 10" group M Figure VI - Job type 5" - 5" group V Figure VII - Job type 10" - 10" group V

For group V, the type jobs 5" - 5", the distance to be covered at high intensity is equal to 26.5 meters, while the distance to travel at low intensity is equal to 13.2 meters . A rectangular route with dimensions of 26.5 meters x 13.2 meters is drawn for the training session (see figure VI).

For type 10" - 10" jobs, the distance to be covered at high intensity is equal to 52.9 meters, while the distance to be covered at low intensity is equal to 26.5 meters. A rectangular course measuring 52.9 meters x 26.5 meters is drawn for the training session (see figure VII).

The training model used for the development of Maximum Aerobic Speed through High Intensity Interval Training is shown in table V.

Table V - Job type

date	Job type
02/09/2018	5" - 5"
05/09/2018	5" - 5"
08/09/2018	10" - 10"
11/09/2018	5" - 5"
12/09/2018	5" - 5"
15/09/2018	5" - 5"
16/09/2018	5" - 5"
19/09/2018	10" - 10"
23/09/2018	10" - 10"
26/09/2018	10" - 10"
30/09/2018	5" - 5"
02/10/2018	10" - 10"

There were 7 training sessions with 5" - 5" type of work and 5 training sessions with 10" - 10" type of work. At the end of the training sessions, the Gacon test is resumed, in table VI the results.

Table VI

	MAS (Km/h)	Fc (b/m)	mmol/L
Player 1	16,0	188	10,7
Player 2	15,5	171	8,9
Player 3	15,5	168	8,7
Player 4	15,5	176	11,5
Player 5	16,5	200	12,9
Player 6	16,5	176	10,8
Player 7	16,0	192	9,9
Player 8	16,0	179	11,3
Player 9	17,5	192	9,2
Player 10	16,5	203	13
Player 11	17,5	188	9,8
Player 12	16,0	201	12,3
Player 13	16,0	188	11,6
Player 14	17,5	198	12,4
Player 15	18,5	203	13,5
Player 16	18,0	196	10
Player 17	18,0	179	11,4
Player 18	18,0	196	10,8
Player 19	17,0	197	12,7
Player 20	19,0	182	10,3
Player 21	18,0	185	11,9
Average	16,9	188,6	11,1
Standard Deviation	1,23	10,7	1,40

Also in this case, to check the reliability of the test, a control test is repeated after 48 hours and the relative value of the interclass correlation coefficient is calculated with Excel.

In table VII the results of the control test.

Tabella VII

	Km/h
Player 1	16,0
Player 2	15,0
Player 3	15,5
Player 4	15,5

Player 5	16,0
Player 6	16,5
Player 7	16,0
Player 8	15,5
Player 9	17,5
Player 10	17,0
Player 11	17,5
Player 12	16,5
Player 13	16,5
Player 14	17,0
Player 15	18,5
Player 16	18,5
Player 17	18,0
Player 18	18,0
Player 19	17,0
Player 20	19,0
Player 21	18,0

From the calculations we obtain a value for the Interclass coefficient equal to 0.961, so we can state that the second Gacon test is also reliable.

TOOLS:

- Geonaute onmove 500 heart rate monitors (figure VIII);



Figure VIII - Geonaute onmove 500 meter



Figure IX - EkF Diagnostics Lactate Scout lactate meter

- EkF Diagnostics Lactate Scout lactate meter (figure IX).

Results

After the training period there were some improvements to the values of the Maximum Aerobic Speed. Overall, the team recorded an average increase of 17.2% (see figure X) with an average speed increase of 2.5 km/h.

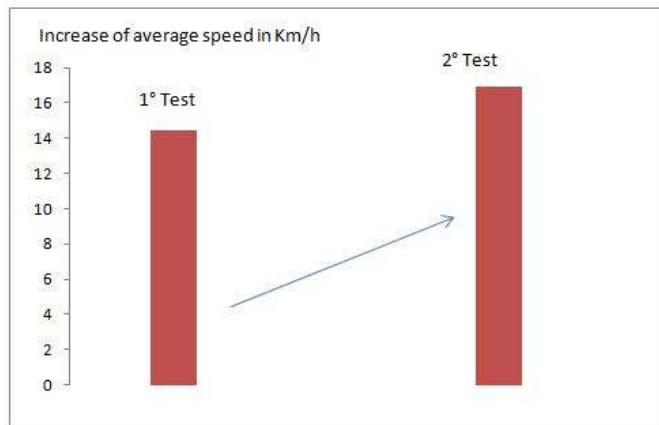


Figure X - Increase of average speed

The average group improvement was 21.9% for the L group, with an average increase in Maximum Aerobic Speed equal to 2.9 Km/h. For the M group, 15.8% with an average increase of the Maximum Aerobic Speed equal to 2.3 Km/h. For group V of 14.5% with an average increase of Maximum Aerobic Speed equal to 2.3 Km/h. The values of the Maximum Aerobic Speed between the fastest and the slowest players have decreased from 32% to 22.6% (see figure XI).

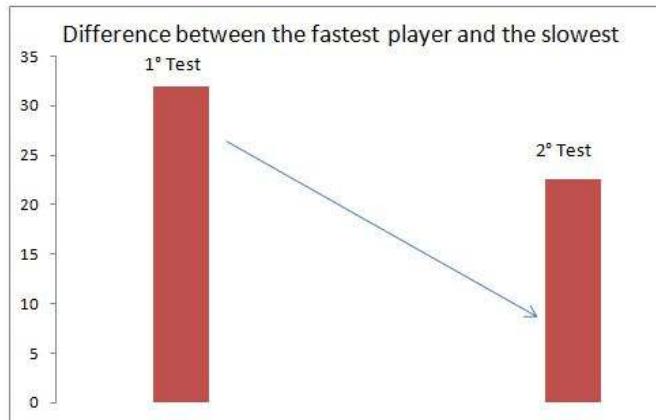


Figure XI - difference between the fastest player and the slowest

The variance is decreased from 1.51 to 1.16 the standard deviation from 1.23 to 1.08 (see figure XII).

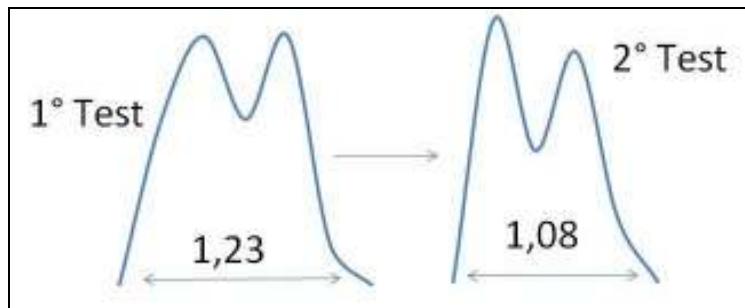


Figure XII - Standard Deviation

Both for the mean values of the heart rate and for the values of the lactic acid concentration there were no significant differences.

Discussion

The present study showed how an Interval Training at High Intensity is effective in football teams for the improvement of the Maximum Aerobic Speed (MAS), with improvements up to 28% with an increase of 3.5 Km/h.

The Maximum Aerobic Speed (MAS) measured through the Gacon test allows us to evaluate the general condition of a player. It is the minimum speed at which the maximum oxygen consumption $\text{VO}_{2\text{max}}$ is reached, the Maximum Aerobic Speed can be maintained for about 5-6 minutes (6-8 minutes for high level players).

Gacon tests were used to measure the Maximum Aerobic Speed.

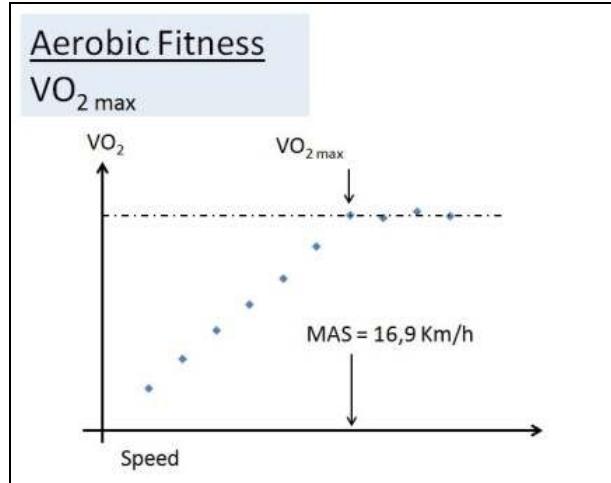
The Gacon test is an incremental test with intermittent exhaustion, with a working duration of 45 seconds and 15 seconds of pause, and allows us to determine the Maximum Aerobic Speed.

The reliability of the test was found both by the values of the interclass correlation coefficient, and by the values of the heart rate and by the values of the concentration of lactic acid.

The use of high speed (high intensity) in training means that a higher percentage of $\text{VO}_{2\text{max}}$ can be used allowing a positive adaptation.

Maximum Aerobic Speed

The Maximum Aerobic Speed (MAS) is the speed at which a human consumes the maximum possible amount of oxygen reaching the threshold of maximum oxygen consumption ($\text{VO}_{2\text{max}}$). Below this threshold, most of the energy needed to produce physical effort comes from the aerobic mechanism, above this threshold the oxygen consumption remains constant and the additional power required is provided by the aerobic mechanism by acid production lactic acid (see figure XIII).

**Figure XIII - $\text{VO}_{2\text{max}}$**

The consumption of oxygen, despite the production of lactic acid, continues to rise until it reaches a maximum limit, a value that establishes the maximum oxygen consumption (Di Prampero, 1987).

Maximum Oxygen Consumption ($\text{VO}_{2\text{max}}$)

The maximum oxygen consumption is a global and integrated measure of the maximum intensity of an exercise that a subject can tolerate for quite long periods (Cerretelli & Di Prampero, 1987).

Conclusions

It is an almost experimental method, of the type Resulted-Based Evidence (RBE). The training methodology was well supported by the players, adapting well to the amateur teams. The feedback parameters (heart rate and lactic acid concentration) provided positive values for the calculation of the Maximum Aerobic Speed by means of the Gacon test, respectively for heart rate s values between 170 b/min and 204 b/min close to the maximum values, while for the concentration of lactic acid the recorded values vary from 8.7 mmol/L to 13.5 mmol/L.

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