COMPARISON OF TWO TESTS TO DETERMINE THE MAXIMAL AEROBIC SPEED

Benhammou Saddek¹, Jérémy B.J. Coquart², Laurent Mourot^{3,4}, Belkadi Adel¹, Mokkedes Moulay Idriss¹, Bengoua Ali ¹, Mokrani Djamel ¹

¹ Laboratory for Optimizing Research Programmes on Physical and Sports, Institute of Sports and Physical Education, Abdelhamid Ibn Badis University of Mostaganem, Algeria.

² University of Rouen Normandy, UFR STAPS, France.

³ Research Unit EA3920, Prognostic Factors and Regulatory Factors of Cardiac and Vascular Pathologies, Exercise Performance Health Innovation Platform, University of Bourgogne Franche-Comté, Besançon, France.

⁴ Tomsk Polytechnic University, Tomsk, Russia.

Summary: The aims of this study were (a): to compare maximal physiological responses (maximal heart rate: HRmax and blood lactate concentration: [La⁻]) and maximal aerobic speed (MAS) achieved during a gold standard test (T-VAM) to those during a new test entitled: the 150-50 Intermittent Test (150-50_{IT}), and (b): to test the reliability of the 150-50_{IT}. Eighteen middle-distance runners performed, in a random order, the T-VAM and the 150-50_{IT}. Moreover, the runners performed a second 150-50_{IT} (retest). The results of this study showed that the MAS obtained during 150-50_{IT} were significantly higher than the MAS during the T-VAM (19.1 ± 0.9 vs. 17.9 ± 0.9 km.h⁻¹, $p < 0.001$). There was also significant higher values in HRmax (193 ± 4 vs. 191 ± 2 bpm, $p = 0.011$), [La⁻] (11.4 ± 0.4 vs. 11.0 ± 0.5 mmol.L⁻¹, $p = 0.039$) during the 150-50_{IT}. Nevertheless, significant correlations were noted for MAS ($r = 0.71$, $p = 0.001$) and HRmax ($r = 0.63$, $p = 0.007$). MAS obtained during the first 150-50_{IT} and the retest were not significantly different ($p = 0.76$) and were significantly correlated ($r = 0.94$, $p < 0.001$, intraclass correlation coefficient = 0.93 and coefficient of variation = 6.8 %). In conclusion, the 150-50_{IT} is highly reproducible, but the maximal physiological responses derived from both tests cannot be interchangeable in the design of training programs.

Key words: Maximal aerobic velocity, intermittent test, validity, reliability, runner.

Introduction

Different physiological parameters, such as maximal oxygen uptake ($\text{VO}_{2\text{max}}$) or even energy cost, are used to predict running performance potential in middle-distance runners (di Prampero et al. 1986). However, these physiological indicators require expensive (gas analyzer) and not always available tools, as well as technical expertise to interpret the results (Coquart et al. 2017). On the other hand, mathematically, the maximal aerobic speed (MAS in $\text{m}\cdot\text{min}^{-1}$ or $\text{km}\cdot\text{h}^{-1}$) corresponds to the division of the maximum oxygen uptake ($\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) by the energy cost ($\text{mL}\cdot\text{kg}^{-1}\cdot\text{m}^{-1}$). Consequently, MAS is considered as an important indicator for predicting the performance of middle-distance runners (Lacour et al. 1991; Billat et al. 2001), and a great tool to set the training loads (Los Arcos et al, 2019). Moreover, MAS could be assessed from field tests. Consequently, several original investigations have provided evidence of the relevance of MAS as a measure of aerobic fitness (Berryman et al. 2018) and the realism leads coaches to opt for field tests (Saddek 2016; Benhammou et al. 2019). Léger and Boucher (1980) were the first authors to propose a maximum field test called the University of Montreal track test (UM-TT). Subsequently, various protocols followed. The Vameval test (T-VAM) is a modified version of the UM-TT initially used to evaluate the MAS for athletes (Cazorla 1990). During this test, athletes run continuously, with a speed that increases steadily (in steps) over time. The MAS reached at the end of this test is obtained through an effort different from that executed during the training sessions of runners, which often involve intermittent exercises (rather than exercises where the intensity is maintained at a constant level). Indeed, the modern training for middle-distance runners is based on intermittent exercises (Vuorimaa et al. 2008). For this reason, a particular attention was paid to incremental intermittent testing during the last years to assess MAS (Bangsbo et al. 2008; Carminatti et al. 2013; Castagna et al. 2014). In order to remain in this logic, a new intermittent field test adapted to these requirements and entitled: the 150-50 Intermittent Test ($150\text{-}50_{\text{IT}}$) has been developed. This test consists of repeated 150m distance runs alternated with 50m of active recovery performed until exhaustion.

Considering the importance of continuous incremental field tests to assess runners endurance performance, a test that includes intermittent runs appeared necessary (Buchheit 2008). In addition, it is also necessary that the type of muscle work performed during the test should be as close as possible to that performed by the athlete during the exercise of his discipline (Manouvrier et al. 2016). It would thus seem preferable that the MAS determination test should be consistent with the actual efforts that produce the middle-distance runners in the field, and that it can be used as a reference for intermittent training sessions.

Therefore, the aims of this study are: (a) to compare the maximal physiological responses and MAS achieved during a continuous gold standard test (T-VAM) to those during the 150/50_{IT}, and (b) to examine the reliability of the 150/50_{IT} from test-retest procedure. We hypothesized that the 150/50_{IT} is a valid and reliable test.

Methods

Participants

Eighteen (22.6 ± 3.2 yrs, 67.7 ± 2.8 kg, 177 ± 4 cm, 21.8 ± 0.8 kg.m⁻²) trained (4 training session per week) male middle-distance runners participated in this study. All were familiar with the intermittent exercises as part of their training program. All participants were notified of the research procedures and gave their written consent. The protocol was approved by ethics committee of the Institute of Physical Education and sports at the University Abdelhamid Ibn Badis, Mostaganem, Algeria, and was performed according to the Helsinki Declaration.

Study design and procedures

After being informed of the purpose of this study, all the subjects performed successively three maximum tests sessions, separated each by 3 days, in random order:

- T-VAM (the gold standard test) in order to determine the reference MAS,
- 150-50_{IT} in order to compare the results to T-VAM and test the validity of 150-50_{IT},
- A second 150-50_{IT} to analyze the test-retest reliability.

All testing sessions were conducted at the same time of day, and under the same environmental conditions (temperature: 20 – 23°C and the wind speed on the track inferior to 2 m.s⁻¹). Maximal heart rate (HR_{max}) was recorded using a heart rate monitor (Polar S610i, Polar Electro Oy, Kempele, Finland). Fingertip blood sample was taken three minutes after the end of each test to measure the concentration of blood lactate [La⁻] by the Lactate Pro LT-1710 (Arkray®, Kyoto, Japan).

T-VAM consists to follow race speed controlled by audio beeps on a prerecorded file. Cones were placed every 20 m along the track as a reference. The speed at the first stage was set at 8.5 km.h⁻¹ and increases by 0.5 km.h⁻¹ every minute until exhaustion. Participants had to reach cone on each beep and adjusted their running speed. The test ended when the subject no longer capable of following the imposed rhythm of speed, for 3 consecutive occasions (delay on three consecutive cones). The MAS corresponds to the speed at the last completed stage (Cazorla 1990).

The 150-50 Intermittent Test (150-50_{IT})

The 150-50_{IT} is a field running test, which consisted of repeated 150m distance runs performed until exhaustion, alternated with 50m of active recovery (150-50). It takes place on a 400m athletics track (150/50 = 200 × 2 = 400m). The speed is imposed by an audio beep (designed at the 150-50_{IT}) at regular intervals. At each beep, the athlete should be at one of the cone level placed on the track every 30-m. The test starts at a speed of 8 km.h⁻¹. The speed is increased by 0.5 km.h⁻¹ every 200m, which corresponds to the successful overcoming of a level (Table 1). Subjects were instructed to reach as many stages as possible and incomplete stage is not considered. Finally, it should be noted that the total distance of 200 m for each stage (150 m run alternated with 50m of active recovery to allow an adaptation of the speed) was chosen because it been demonstrated that performance over a distance of 200 m can be used to predict performance in middle-distance runners (Brandon 1995).

Figure 1
Material organization of the 150/50 intermittent test

Table1
The correspondence table of the 150-50_{IT}

Stage	Speed km.h ⁻¹	30 m	60 m	90 m	120 m	150 m	R	D
01	8	00:13,500	00:27,900	00:40,500	00:54,900	01:07,500	45''	150
02	8.5	00:12,705	00:26,258	00:38,117	00:51,670	01:03,529	45''	300
03	9	00:12,000	00:24,800	00:36,000	00:48,800	01:00,000	45''	450
04	9.5	00:11,368	00:23,494	00:34,105	00:46,231	00:56,842	45''	600
05	10	00:10,800	00:22,320	00:32,400	00:43,920	00:54,000	45''	750
06	10.5	00:10,285	00:21,257	00:30,857	00:41,828	00:51,428	45''	900
07	11	00:09,818	00:20,290	00:29,454	00:39,927	00:49,090	45''	1050
08	11.5	00:09,391	00:19,408	00:28,173	00:38,191	00:46,956	45''	1200
09	12	00:09,000	00:18,600	00:27,000	00:36,600	00:45,000	45''	1350
10	12.5	00:08,640	00:17,856	00:25,920	00:35,136	00:43,200	45''	1500
11	13	00:08,307	00:17,169	00:24,923	00:33,784	00:41,538	45''	1650
12	13.5	00:08,000	00:16,533	00:24,000	00:32,533	00:40,000	45''	1800
13	14	00:07,714	00:15,942	00:23,142	00:31,371	00:38,571	45''	1950

14	14.5	00:07,448	00:15,393	00:22,344	00:30,289	00:37,241	45''	2100
15	15	00:07,200	00:14,880	00:21,600	00:29,280	00:36,000	45''	2250
16	15.5	00:06,967	00:14,400	00:20,903	00:28,335	00:34,838	45''	2300
17	16	00:06,750	00:13,950	00:20,250	00:27,450	00:33,750	45''	2450
18	16.5	00:06,545	00:13,527	00:19,636	00:26,618	00:32,727	45''	2600
19	17	00:06,352	00:13,129	00:19,058	00:25,835	00:31,764	45''	2750
20	17.5	00:06,171	00:12,754	00:18,514	00:25,097	00:30,857	45''	2900
21	18	00:06,000	00:12,400	00:18,000	00:24,400	00:30,000	45''	3150
22	18.5	00:05,837	00:12,064	00:17,513	00:23,740	00:29,189	45''	3300
23	19	00:05,684	00:11,747	00:17,052	00:23,115	00:28,421	45''	3450
24	19.5	00:05,538	00:11,446	00:16,615	00:22,523	00:27,692	45''	3600
25	20	00:05,400	00:11,160	00:16,200	00:21,960	00:27,000	45''	3750
26	20.5	00:05,268	00:10,887	00:15,804	00:21,424	00:26,341	45''	3900
27	21	00:05,142	00:10,628	00:15,428	00:20,914	00:25,714	45''	4050
28	21.5	00:05,023	00:10,381	00:15,069	00:20,427	00:25,116	45''	4200
29	22	00:04,909	00:10,145	00:14,727	00:19,963	00:24,545	45''	4350
30	22.5	00:04,800	00:09,920	00:14,400	00:19,520	00:24,000	45''	4500
31	23	00:04,695	00:09,704	00:14,086	00:19,095	00:23,478	45''	4650
32	23.5	00:04,595	00:09,497	00:13,787	00:18,689	00:22,978	45''	4800
33	24	00:04,500	00:09,300	00:13,500	00:18,300	00:22,500	45''	4950
34	24.5	00:04,408	00:09,110	00:13,224	00:17,926	00:22,040	45''	5100
35	25	00:04,320	00:08,928	00:12,960	00:17,568	00:21,600	45''	5250

D: distance traveled (m). R: recovery.

Statistical analysis

The results are presented as mean $\pm$ standard deviation (SD). Normality of data was checked using the Shapiro–Wilk test. Student's t-test for paired sample was used to compare the differences between the T-VAM and the first 150-50_{IT}. The relationships between measurements were checked using Pearson correlation coefficient (r). The reproducibility was assessed by the coefficient of variation (CV), the intraclass correlation coefficient (ICC), and Bland and Altman plots. The level of statistical significance was set at $p < 0.05$. All statistical analyses were performed using SPSS for Windows 23.0 (SPSS Inc., IBM, Chicago, USA).

Results

MAS and maximal physiological responses (HR_{max} and [La⁻]) during T-VAM and the first 150-50_{IT} are presented in Table 2. The average for MAS obtained during the T-VAM was lower than that measured using 150-50_{IT} ($p < 0.001$), despite a high correlation coefficient ($r = 0.71$; $p = 0.001$).

Regarding the results of HR_{max}, there was a significant difference between both tests ($p = 0.011$, Table 2). Nevertheless, these data were significantly correlated ($r = 0.63$, $p = 0.007$). The values of [La⁻] found during 150-50_{IT} are higher than those recorded during T-VAM ($p = 0.039$) and no significant correlation was noted between the both tests ($p = 0.467$).

Table 2
Physiological characteristics and performance for both tests

Variables	150-50 _{IT}	T-VAM	Correlation of Pearson	
MAS (km.h ⁻¹)	19.1 ± 0.9*	17.9 ± 0.9	p = 0.001	r = 0.71
HRmax (bpm)	193 ± 4*	191 ± 2	p = 0.007	r = 0.63
[La ⁻] (mmol.L ⁻¹)	11,4 ± 0,4*	11,0 ± 0,5	p = 0.467	r = 0,22

*:Significant difference between T-VAM and 150-50_{IT} ($p < 0.05$).

Finally, MAS obtained during the first 150-50_{IT} and the retest were not significantly different ($19.1 \pm 0.9 \text{ km.h}^{-1}$ vs. $19.4 \pm 1.6 \text{ km.h}^{-1}$, $p = 0.76$). Moreover, the correlation coefficient, coefficient of variation and intraclass correlation coefficient were of 0.94, 6.8 and 0.93, respectively. Figure 2 reports the Bland and Altman plot. Significant agreement was found between test-retest without systematic bias (0.20 km.h^{-1}) with low agreement limits (-1.58 - 1.41 km.h^{-1}).

Figure 2
Bland-Altman plot of test-retest reproducibility

Discussions

The main aim of this study was to compare the MAS achieved during a continuous gold standard test (T-VAM) to those during the 150/50_{IT}, and to check that the maximal physiological responses derived from both tests could be used interchangeably. Moreover, test-retest reliability of 150/50_{IT} was also studied. The major finding in the present study indicates that the MAS measured on T-VAM is significantly different of MAS achieved on the 150/50_{IT},

and the maximal physiological responses (HR_{max} and [La⁻]) derived from both tests are not interchangeable. Nevertheless, the 150/50_{IT} was reliable.

The parameters (MAS, HR_{max} and [La⁻]) reached at the end of T-VAM and 150/50_{IT} were significantly different. There was a difference between the MAS obtained in the two tests ranging between 1.5 km.h⁻¹ and 3 km.h⁻¹ a difference of 9 to 15%. However, MAS obtained during both tests were significantly correlated ($r = 0.71$, $p < 0.05$). The present results can be compared with previous studies comparing intermittent vs. continuous incremental field tests (Aziz et al. 2005; Dupont et al. 2010; Benhammou, 2020). Similar to our observations, authors (Schnitzler et al. 2010; Los Arcos et al. 2019) have previously reported significant differences between MAS obtained from a T-VAM and intermittent tests, but all these authors have noted a significant correlation with high correlation coefficients ($r > 0.67$). Thus, although the MAS are significantly different, the significant correlations (like those obtained in other studies: Schnitzler et al. 2010 and Los Arcos et al. 2019) seem to suggest the convergent validity of 150/50_{IT}.

The HR_{max} were different between T-VAM and 150/50_{IT} (Table 2), but wearing a heart rate monitor during the two tests allows to obtain a maximal HR close to the theoretical maximum ($FC_{max} = 220 - \text{age}$) (Nes et al. 2013) for all subjects. Our results contrast, however, with those reported by Dupont et al. (2010) who found similar values comparing the UM-TT (192.3 ± 8.0 bpm) and Yo-Yo intermittent recovery test (191.4 ± 7.8 bpm). The 150/50_{IT} also allows establishing an individual curve of the relationship between running speed and HR. There is an increase and then a slower stabilization or evolution of the heart rate, and then a slight decrease during the recovery ranges that allows observing the quality of the recovery of the athlete. This is the additional interest of the intermittent form of 150/50_{IT}, even if further studies need to be conducted.

The [La⁻] is one of the most frequently used biological parameters in sports biology (Petibois et al. 2001; Adel et al. 2019). A significant difference was noted between the two tests for [La⁻]. The results of this work show that 150/50_{IT} causes a greater accumulation of lactate ($+0.4$ mmol.L⁻¹) in comparison with VAM-T. These values at the end of the 150/50_{IT} allowed to confirm the major contribution of anaerobic metabolism (with higher speed during the last stages in comparison with the VAM-T). These results are in agreement with previous studies showing a major anaerobic participation during intermittent exercise (Buchheit et al. 2009).

The 150/50_{IT} was found to have a high level of reliability in all studied parameters. The CV and ICC were within the acceptable ranges outlined by Hopkins et al. (2001). Therefore, the 150/50_{IT} must be considered as reliable.

Conclusion

Based on the present findings, the 150/50_{IT} it is highly reproducible but it overestimates the MAS, HR_{max} and [La⁻]. These physiological indices derived from 150/50_{IT} and T-VAM cannot be interchangeable when designing training programs. Future studies should be conducted to examine the validity of the 150/50_{IT}.

Acknowledgments

This study was supported by the University of Franche Comté and Tomsk Polytechnic University CE Program. The author thanks the subjects for their participation in the study as well as the Directorate General for Scientific Research and Technological Development (DG-RSDT).

References

1. ADEL, B., B. ABDELKADER, C. ALIA, B. OTHMAN, S. MOHAMED & A. HOUCIN, 2019. The Effect of High-Intensity Exercise on Changes of Blood Concentration Components in Algerian National Judo Athletes. *Acta Facultatis Educationis Physicae Universitatis Comenianae*. **59**(2), 148–160. <https://doi.org/10.2478/afepuc-2019-0013>.
2. AZIZ, A.R., F.H.Y. TAN & K.C. TEH, 2005. A Pilot Study Comparing Two Field Tests with the Treadmill Run Test in Soccer Players. *Journal of Sports Science & Medicine*. **4**(2), 105–112.
3. BANGSBO, J., F.M. IAIA & P. KRUSTRUP, 2008. The Yo-Yo intermittent recovery test : a useful tool for evaluation of physical performance in intermittent sports. *Sports Medicine (Auckland, N.Z.)*. **38**(1), 37–51. <https://doi.org/10.2165/00007256-200838010-00004>.
4. BENHAMMOU, S., M.M. IDRIS, M. LAURENT & B. ALI, 2019. Proposition d'un test d'effort intermittent pour déterminer la vitesse maximale aérobie (80/20_{VMA}). *Journal of Sport Science Technology and Physical Activities*. **16**(2), 95-107.
5. BENHAMMOU, S., M. LAURENT, M.M. IDRIS, B. ALI & B. ADEL, 2020. Assessment of maximal aerobic speed in runners with different performance levels: interest of a new intermittent running test. *Science & sports* (in press).

6. BERRYMAN, N., I. MUJICA, D. ARVISAIS, M. ROUBEIX, C. BINET & L. BOSQUET, 2018. Strength Training for Middle- and Long-Distance Performance: A Meta-Analysis. *International Journal of Sports Physiology and Performance*. **13**(1), 57–63. <https://doi.org/10.1123/ijsp.2017-0032>.
7. BILLAT, V., S. BERTHOIN, N. BLONDEL & M. GERBEAUX, 2001. La vitesse à VO₂ max, signification et applications en course à pied. *Staps*. no **54**(1), 45–61.
8. BRANDON, L.J., 1995. Physiological Factors Associated with Middle Distance Running Performance. *Sports Medicine*. **19**(4), 268–277. <https://doi.org/10.2165/00007256199519040-00004>.
9. BUCHHEIT, M., 2008. The 30-15 intermittent fitness test: accuracy for individualizing interval training of young intermittent sport players. *Journal of Strength and Conditioning Research*. **22**(2), 365–374. <https://doi.org/10.1519/JSC.0b013e3181635b2e>.
10. BUCHHEIT, M., H. HADDAD, G.P. MILLET, P.M. LEPRETRE, M. NEWTON & S. AHMAIDI, 2009. Cardiorespiratory and cardiac autonomic responses to 30-15 intermittent fitness test in team sport players. *Journal of Strength and Conditioning Research*. **23**(1), 93–100. <https://doi.org/10.1519/JSC.0b013e31818b9721>.
11. CARMINATTI, L.J., C.A.P. POSSAMAI, M. DE MORAES, J.F. DA SILVA, R.D. DE LUCAS, N. DITTRICH & L.G.A. GUGLIELMO, 2013. Intermittent versus Continuous Incremental Field Tests: Are Maximal Variables Interchangeable? *Journal of Sports Science & Medicine*. **12**(1), 165–170.
12. CASTAGNA, C., F. IELLAMO, F.M. IMPELLIZZERI & V. MANZI, 2014. Validity and reliability of the 45-15 test for aerobic fitness in young soccer players. *International Journal of Sports Physiology and Performance*. **9**(3), 525–531. <https://doi.org/10.1123/ijsp.2012.0165>.
13. CAZORLA, G., 1990 Field tests to evaluate aerobic capacity and maximal aerobic speed. In: *Proceedings of the International Symposium of Guadeloupe* (pp. 151–173).
14. COQUART J.B., P. MUCCI, M. L'HERMETTE, K. CHAMARI, C. TOURNY & M. GARCIN, 2017. Correlation of gas exchange threshold and first muscle oxyhemoglobin inflection point with time-to-exhaustion during heavy-intensity exercise. *The Journal of Sports Medicine and Physical Fitness*. **57**(3), 171–178. <https://doi.org/10.23736/S00224707.16.06053-9>.

15. DI PRAMPERO, P.E., G. ATCHOU, J.C. BRÜCKNER & C. MOIA, 1986. The energetics of endurance running. *European Journal of Applied Physiology and Occupational Physiology*. **55**(3), 259–266. <https://doi.org/10.1007/BF02343797>.
16. DUPONT, G., M. DEFONTAINE, L. BOSQUET, N. BLONDEL, W. MOALLA & S. BERTHOIN, 2010. Yo-Yo intermittent recovery test versus the Université de Montréal Track Test: relation with a high-intensity intermittent exercise. *Journal of Science and Medicine in Sport*. **13**(1), 146–150. <https://doi.org/10.1016/j.jsams.2008.10.007>.
17. HOPKINS, W.G., E.J. SCHABORT & J.A. HAWLEY, 2001. Reliability of power in physical performance tests. *Sports Medicine (Auckland, N.Z.)*. **31**(3), 211–234. <https://doi.org/10.2165/00007256-200131030-00005>.
18. LACOUR, J.R., S. PADILLA, J.C. CHATARD, L. ARSAC & J.C. BARTHÉLÉMY, 1991. Assessment of running velocity at maximal oxygen uptake. *European Journal of Applied Physiology and Occupational Physiology*. **62**(2), 77–82. <https://doi.org/10.1007/BF00626760>.
19. LÉGER, L. & R. BOUCHER, 1980. An indirect continuous running multistage field test: the Université de Montréal track test. *Can J Appl Sport Sci*. **5**:77–84.
20. LOS ARCOS, A., J.S. VÁZQUEZ, F. VILLAGRA, J. MARTÍN, J. LERGA, F. SÁNCHEZ, J. BERTÓ & J.J. ZULUETA, 2019. Assessment of the maximal aerobic speed in young elite soccer players: Université de Montréal Track Test (UM-TT) vs. treadmill test. *Science & Sports*. **34**(4), 267–271. <https://doi.org/10.1016/j.scispo.2019.03.010>.
21. MANOUVRIER, C., J. CASSIRAME & S. AHMAIDI, 2016. Proposal for a Specific Aerobic Test for Football Players: The “Footeval”. *Journal of Sports Science & Medicine*. **15**(4), 670–677.
22. NES, B.M., I. JANSZKY, U. WISLOFF, A. STOYLEN & T. KARLSEN, 2013. Age predicted maximal heart rate in healthy subjects: The HUNT fitness study. *Scandinavian Journal of Medicine & Science in Sports*. **23**(6), 697–704. <https://doi.org/10.1111/j.1600-0838.2012.01445.x>.
23. PETIBOIS, C., G. CAZORLA & L. LEGER, 2001. Les analyses métaboliques dans le contrôle biologique de l’entraînement. *Staps*. no **54**(1), 77–88.
24. SADDEK, B., 2016. Vers un nouveau test d’évaluation de la vitesse maximale aérobie (VMA) des footballeurs de différent niveau. *Proceedings of the internationale Congress of Sciences and Football “Image, Multimedia and New Technologies”*, Valenciennes, France.150-151.

25. SCHNITZLER, C., G. HECK, J.C. CHATARD & V. ERNWEIN, 2010. A simple field test to assess endurance in inexperienced runners. *Journal of Strength and Conditioning Research*. **24**(8), 2026-2031. <https://doi.org/10.1519/JSC.0b013e3181d2c48d>.
26. VUORIMAA, T., M. AHOTUPA, K. HÄKKINEN & T. VASANKARI, 2008. Different hormonal response to continuous and intermittent exercise in middle-distance and marathon runners. *Scandinavian Journal of Medicine & Science in Sports*. **18**(5), 565–572. <https://doi.org/10.1111/j.1600-0838.2007.00733.x>.