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Original

The 180/20 intermittent athletic test: A new intermittent track test to assess the maximal aerobic speed in middle-distance runners

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ABSTRACT

Objective: The training of middle-distance runners is based on intermittent exercises. However, no study has proposed intermittent test to assess endurance performance for middle-distance athletes. The aims of the present study are 1) to develop a new specific testing for middle-distance runners entitled the 180/20 intermittent athletic test and to examine the validity of this test as compared to a standard continuous test 2) to check whether the maximal aerobic speed obtained from the180/20intermittent athletic test is related to the 800-m performance.
Methods: Nineteen male middle-distance runners (age: 21.3 ± 2.2 years, height: 1.75 ± 0.04 m, and body mass: 68.8 ± 3.8 kg) performed in a random order three field-tests: a standard test, the 180/20intermittent athletic test and 800-m time-trial. The new test consisted of repeated 180m distance runs interspersed with 20m of active recovery performed until exhaustion. The speed is increased by 0.5 $km.h^{-1}$ every 200 m.
Results: The results of this study showed the maximal aerobic speed achieved during the new test was significantly correlated to the maximal aerobic speed determined from a standard test (r=0.82, p<0.05) with low agreement limits (-1.69–1.48$km.h^{-1}$) without systematic bias (-0.10$km.h^{-1}$).The maximal aerobic speed in new test was better correlated to the 800-m running performance than the maximal aerobic speed achieved during a standard test(r=-0.78 and r=-0.66, respectively).
Conclusions: The 180/20intermittent athletic testis a valid test for scheduling intermittent training sessions in middle-distance runners.
Keywords: Intermittent exercise; Maximal aerobic speed; Field test; Time trial; Running performance.

El test atlético intermitente 180/20: Una nueva prueba de pista intermitente para evaluar la velocidad aeróbica máxima en los corredores de media distancia

RESUMEN

Objetivo: El entrenamiento de los corredores de media distancia se basa en ejercicios intermitentes. Sin embargo, ningún estudio ha propuesto pruebas intermitentes para evaluar el rendimiento de resistencia para atletas de media distancia. Los objetivos del presente estudio son 1) desarrollar una nueva prueba específica para corredores de media distancia denominada prueba atlética intermitente 180/20 y examinar la validez de esta prueba en comparación con una prueba continua estándar 2) verificar si el máximo la velocidad aeróbica obtenida de la prueba atlética intermitente 180/20 está relacionada con el rendimiento de 800 m.
Método: Diecinueve corredores de media distancia masculinos (edad: 21,3 ± 2,2 años, altura: 1,75 ± 0,04 m y masa corporal: 68,8 ± 3,8 kg) realizaron en orden aleatorio tres pruebas de campo: una prueba estándar, la prueba intermitente 180/20 prueba atlética y contrarreloj de 800 m. La nueva prueba consistió en recorridos repetidos de 180 m intercalados con 20 m de recuperación activa realizados hasta el agotamiento. La velocidad se incrementa en 0,5 km.h-1 cada 200 m.
Resultados: Los resultados de este estudio mostraron que la velocidad aeróbica máxima alcanzada durante el nuevo test se correlacionó significativamente con la velocidad aeróbica máxima determinada a partir de un test estándar (r=0,82, p<0,05) con límites de concordancia bajos (-1,69–1,48 km. h-1) sin sesgo sistemático (-0,10 km.h-1). La velocidad aeróbica máxima en la nueva prueba se correlacionó mejor con el rendimiento de carrera de 800 m que la velocidad aeróbica máxima alcanzada durante una prueba estándar (r = -0,78 y r=-0,66, respectivamente).
Conclusiones: El test atlético intermitente 180/20 es un test válido para la programación de entrenamientos intermitentes en corredores de media distancia.
Palabras clave: Ejercicio intermitente; Velocidad aeróbica máxima; Test de campo; Contrarreloj; Rendimiento de carrera.

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O teste atlético intermitente 180/20: Um novo teste intermitente de pista para avaliar a velocidade aeróbia máxima nos corredores de meia distância

RESUMO

Objetivo: O treinamento de corredores de meio-fundo é baseado em exercícios intermitentes. No entanto, nenhum estudo propôs teste intermitente para avaliar o desempenho de resistência para atletas de meia-distância. Os objetivos do presente estudo são 1) desenvolver um novo teste específico para corredores de meio-fundo intitulado teste atlético intermitente 180/20 e examinar a validade deste teste em comparação com um teste contínuo padrão 2) verificar se o a velocidade aeróbia obtida no teste atlético intermitente de 180/20 está relacionada ao desempenho de 800 m.

Métodos: Dezenove corredores de meio-fundo do sexo masculino (idade: 21,3 ± 2,2 anos, estatura: 1,75 ± 0,04 m e massa corporal: 68,8 ± 3,8 kg) realizaram em ordem aleatória três testes de campo: um teste padrão, o teste intermitente 180/20 teste atlético e contra-relógio de 800 m. O novo teste consistiu em corridas repetidas de 180m intercaladas com 20m de recuperação ativa realizada até a exaustão. A velocidade é aumentada em 0,5 km.h-1 a cada 200 m.

Resultados: Os resultados deste estudo mostraram que a velocidade aeróbia máxima alcançada durante o novo teste foi significativamente correlacionada com a velocidade aeróbica máxima determinada a partir de um teste padrão (r=0,82, p<0,05) com limites de concordância baixos (-1,69–1,48km. h-1) sem viés sistemático (-0,10km.h-1). A velocidade aeróbica máxima em novo teste foi melhor correlacionada com o desempenho de corrida de 800 m do que a velocidade aeróbia máxima alcançada durante um teste padrão (r=-0,78 e r=-0,66, respectivamente).

Conclusões: O teste atlético intermitente 180/20 é um teste válido para o agendamento de sessões de treinamento intermitente em corredores de meio-fundo.

Palavras-chave: Exercício intermitente; Velocidade aeróbica máxima; Teste de campo; Contra-relógio; Desempenho de corrida.

Introduction

The maximal aerobic speed (MAS) is a crucial factor for predicting the performance of middle-distance[1] and long-distance running[2]. It is well established that MAS is a great tool for coaches to prescribe adequate training loads[3–4].However, although several valid and reliable incremental field tests have been developed to determine MAS, these tests do not always consider the specificity of the different sports disciplines and the evolution of training methods.

Various tests have been proposed to determine MAS during laboratory or field testing[3]. The VAM-EVAL test (VAM-T) [4] is one of the most frequently used tests to determine MAS. The test protocol starts at a speed of 8.5 km·h^{-1} and increases by 0.5 km·h^{-1} every minute until exhaustion. This test was proposed for aerobic metabolism(i.e., metabolism with preponderance of the oxidative phosphorylation pathway) evaluation during running[5] and rely on a prolonged continuous bout of running. However, this effort is radically different from that done during daily training in middle-distance runners.

Indeed, while middle- and long-distance running performance is continuous in nature, it is well known that runners, and especially middle-distance runners, practice mainly fast intermittent exercises involving a major contribution from anaerobic energy sources[6] compared with long-distance runners who practice more continuous exercise of lower intensity to develop aerobic capacity[7]. Nevertheless, the evaluation of the MAS is done practically using often the same type of tests (continuous incremental tests) in both middle- and long-distance runners. It is however necessary that the type of muscle work performed during the test should be well related to both the runner's performance and the type of exercise performed during training[8]. It would thus be more appropriate that the MAS determination test rely on the actual efforts (i.e., short intermittent exercises) produced by middle-distance runners, since it can be used as a reference for intermittent training.

On the other hand, in the past 2 decades, a particular attention was paid to incremental intermittent testing to determine aerobic metabolism performance, but mainly in team sports[8–11].These tests are often composed of shuttle runs, with changes of direction. However, this type of testing appears somewhat inappropriate for middle-distance athletes who perform straight-line running during the competitions (i.e. without direction change) and practice intermittent running in theirs training sessions. To our knowledge, no intermittent straight-line running test to assess especially aerobic metabolism performance in middle-distance runners has been proposed.

Therefore, the aims of the present study were: 1) to develop a new specific testing entitled the 180/20 intermittent athletic test ($180/20_{IAT}$) for middle-distance runners, and to examine the validity of this test, 2) to check that the MAS obtained from the $180/20_{IAT}$ is related to the 800-m performance.

We hypothesize that the $180/20_{IAT}$ is valid and that the relationships between the MAS and the 800-m performance time will be stronger than the one obtained from the VAM-T.

Method

Subject

Nineteen male middle-distance runners, regularly active (5 times/week) participated in the study. The age, height, body mass, body mass index (BMI) and years of training were 21.3±2.2 years, 1.75±0.04 m, 68.8±3.8kg, 22.3±0.9 kg/m^2 and 6.1 ± 1.7 years, respectively. All have been training in middle-distance running regularly for more than 4 years and were accustomed to intermittent exercises as part of their training. All subjects were notified of the research procedures and gave their written consent. The protocol was approved by ethics committee of the Institute of Sports and Physical Education and was performed according to the Helsinki Declaration.

Procedures

All the subjects were evaluated on three occasions on a 400 m tartan running track at least 72 hours apart and in a random order. Day 1: the VAM-T; day 4: the $180/20_{IAT}$. To assess the relationship with performance during both tests, a 800-m time-trial performed on the 8th day was reflective of an athlete's current aerobic fitness. The tests were performed at the same hour of day after eating and under similar experimental conditions (18-20°C, 1.3-1.5 m.s^{-1} runway wind speed measured by a weather station: PCE-AM81, PCE Instruments®, Strasbourg, France). All subjects were advised to refrain from smoking, caffeinated drinks and high-intensity exercise during the 48 hours prior to testing. Heart rate peak (HRpeak) was monitored telemetrically every 5s throughout the test (Polar S610i, Polar® Electro Oy, Kempele, Finland). Three minutes after each test, fingertip blood samples were collected in

order to measure blood lactate [La] by the Lactate Pro LT-1710 (Arkray®, Kyoto, Japan). These two parameters were used as exhaustion criteria.

VAM-EVAL test (VAM-T)

The VAM-T is a modified version of the University of Montreal Track (UM-TT)[12]. The only relevant difference between the two tests is the distance between the cones placed along the 400 m track (i.e., 50m for UM-TT vs. 20m for VAM-T), thus allowing to adjust the speed between the cones to the sound signals, which makes the VAM-T easier to conduct to young athletes. The VAM-T is commonly used, which consisted to follow race speed controlled by audio beeps on a prerecorded file. Cones were placed every 20m 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 cones on each beep and adjusted their running speed. The test ended when the subject was no longer capable of following the imposed speed. The MAS (abbreviated: MAS_{VAM-T}) corresponds to the speed at the last completed stage[4]. The reliability of VAM-T has already been studied [CV was 3.5 % (90 % confidence limits: 3.0;4.1)][13].

The 180/20 Intermittent Athletic Test(180/20$_{IAT}$)

The 180/20$_{IAT}$ is a track running test adapted to the training mode of the middle distance runners (intermittent exercises), without changes of direction and which can be used as a training session. The test consisted of repeated short 180m distance runs interspersed with 20m active recovery periods performed until exhaustion (180/20). It takes place on a 400m athletics track (180/20 = 200 × 2 = 400m). The speed is imposed by an audio beep designed at the 180/20$_{IAT}$. The latter issues "beep" at regular intervals. At each beep, the athlete should be at one of the cones placed on the track every 20 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. Subjects were instructed to reach as many stages as possible and incomplete stage is not considered. The test stopped when the subject was at least 3m behind the appropriate cone at the moment of the audio signal on 2 consecutive times. The MAS (abbreviated: $MAS_{180/20IAT}$) corresponds to the speed reached at the last completed stage.

800 m time trial

Participants completed a 800m time trial on a 400 m tartan outdoor track, at least 72 hours following the 180/20$_{IAT}$. Subjects completed a 20 min warm-up in the following sequence: 10 min run, 5 m stretching and a 5 min up-tempo run. Participants were asked to run the distance in the shortest possible time and wore the same kind of garments (running shoes, lightweight t-shirts and light shorts). The time in seconds was collected after exercise.

Statistical analysis

The results are presented as mean ± standard deviation (SD). The assumption of normality was verified with the Shapiro-Wilk test. As data were normally distributed, parametric tests were used. In order to test the validity of 180/20$_{IAT}$, the MAS and other characteristics (i.e., HRpeak and [La]) between both tests (VAM-T vs 180/20$_{IAT}$) were compared from Student´s t-test for paired sample. Moreover, the relationships between MAS_{VAM-T} and $MAS_{180/20IAT}$was examined from Bravais and Pearson test, and quantified using Pearson correlation coefficient (r) and confidence intervals (95% CI). The correlation coefficients were interpreted in accordance with the thresholds proposed by Hopkins[14]:r<0.1, trivial; 0.1≤ r<0.3, small; 0.3≤ r<0.5, moderate; 0.5≤ r<0.7, large; 0.7≤r<0.9, very large; and 0.9≤ r<1, almost perfect. Furthermore, Bland and Altman plots were used to determine the bias and limits of agreement between MAS_{VAM-T} and $MAS_{180/20IAT}$.The relationship between 800-m running performance and MAS during each test has been examined from Bravais and Pearson test, and quantified using Pearson correlation coefficient. 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

A significant difference was found between the distance travelled during 180/20$_{IAT}$ and VAM-T (Table 1). However, a significant correlation was observed between the distance covered during both tests (p = 0.01, r = 0.71, likely very large).

No significant differences were found between MAS_{VAM-T} and $MAS_{180/20IAT}$. Moreover, no significant difference was noted for HRpeak and [La] between the VAM-T and 180/20$_{IAT}$ (Table 1). MAS (p< 0.01, r= 0.82, CI 95%: 0.41–0.87, likely very large), HRpeak (p=0.02, r= 0.50, CI 95%: 0.04–0.67, likely moderate) and [La] (p<0.01, r= 0.72, CI 95%: 0.34–1.00, likely very large) between both tests were significantly correlated.

Figure 2A shows the linear regression between MAS_{VAM-T} and $MAS_{180/20IAT}$, whereas Figure 2B presents the Bland and Altman plot of MAS obtained during both tests. Systematic bias (-0.10km.h^{-1}) and limits of agreement (-1.69–1.48 km.h^{-1}) are low.

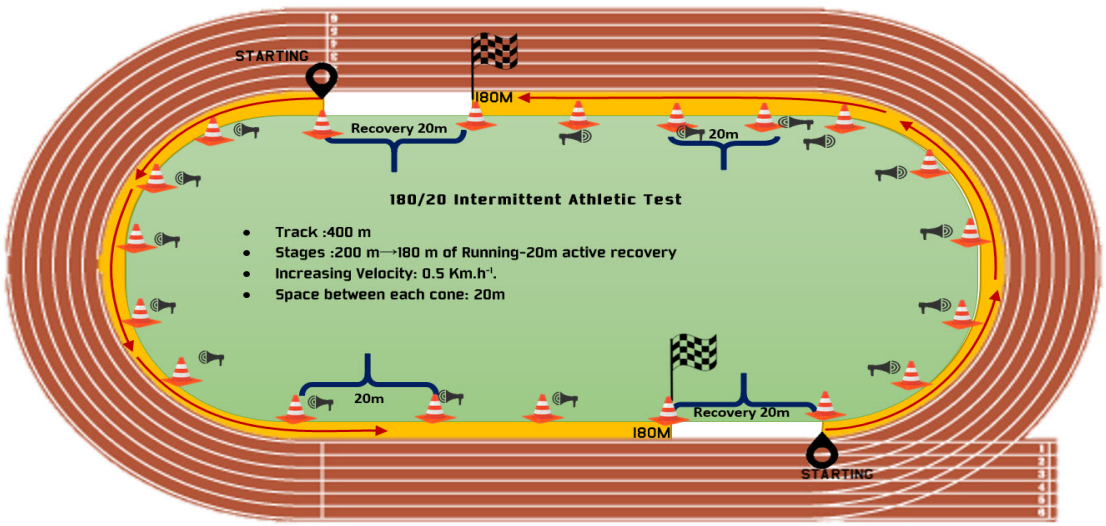

Figure 1. Material organization of the 180/20 intermittent athletic test

Table 1. Physiological characteristics and the performance realized during both tests.

Variables	VAM-T	$180/20_{IAT}$	*p*
MAS ($km.h^{-1}$)	19.1 ± 1.1	19.2 ± 1.4	0.57
HRpeak (bpm)	191.3 ± 2,2	191.8 ± 3.1	0.42
[La] ($mmol.L^{-1}$)	11.3 ± 0.6	11.5 ± 0.7	0.08
Distance traveled (m)	5253 ± 705	4168 ± 520	

p: p value; MAS: maximal aerobic speed; HRpeak: the heart rate peak; [La] : blood lactate concentration; 180/20IAT : 180/20 intermittent athletic test; VAM-T: VAM-EVAL test. *Significant difference ($p < 0.05$).

The average time for the 800 m time trial was 125 ± 6s (range: 112–135s) which corresponds to a velocity of 23 $km.h^{-1}$. The velocity represented 119.3 ± 6.0% (range: 108–133%) of the first $MAS_{180/20IAT}$, and 119.8 ± 5.5% (range: 108–129%) of MAS_{VAM-T}. Significant relationships were found between 800-m performance and $MAS_{180/20IAT}$ and MAS_{VAM-T}. Pearson's correlation showed a very large negative (r = -0.78, $p < 0.01$) relationship between 800-m performance and $MAS_{180/20IAT}$ (Figure 3A), and large negative relationship (r = -0.66, $p < 0.01$) between 800-m performance and MAS_{VAM-T}. (Figure 3B).

Discussion

The aims of the present study were to develop and examine the validity of a new intermittent running test named the $180/20_{IAT}$, as well as to analyze the relationship between $MAS_{180/20IAT}$ and the 800-m performance in middle-distance runners.

The major finding of the present study is that the MAS achieved in the$180/20_{IAT}$ is significantly associated with MAS measured on traditional track test (VAM-T), and the maximal variables derived from both tests are non-significantly different. In addition, the results showed that the $180/20_{IAT}$ was strongly correlated with performance on 800-m.

In the present study, we observed that the $180/20_{IAT}$ elicits similar MAS, HRpeak, and [La] to a classic graded continuous field test (VMA-T). VMA-T was carried out with the aim of obtaining a measure of MAS[4], which we used as a reference in this study. Moreover, MAS obtained during both tests were significantly correlated (r= 0.82, p<0.05), with very large correlation coefficient. These results are consistent with those of other studies comparing VMA-T with Yo-Yo intermittent recovery test[15,16], or yet recently with treadmill intermittent protocol[17]. Therefore, the validity of the $180/20_{IAT}$to determine MAS seems similar or even better than that of other tests already validated. This result is moreover largely confirmed by our low 95% interval of agreements.

It should be noted, however, that the increments in speed were different for the two tests (0.5 $km.h^{-1}$ per 1 min stage in the VAM-T, 0.5 $km.h^{-1}$per 200m stage in the $180/20_{IAT}$). For the $180/20_{IAT}$, the total distance of 200m for each stage (180m run with a short rest of 20m to allow an adaptation of the speed) was chosen because middle-distance runners use short intermittent exercises (from a distance of about 200m) as part of their training[6]. In addition, this

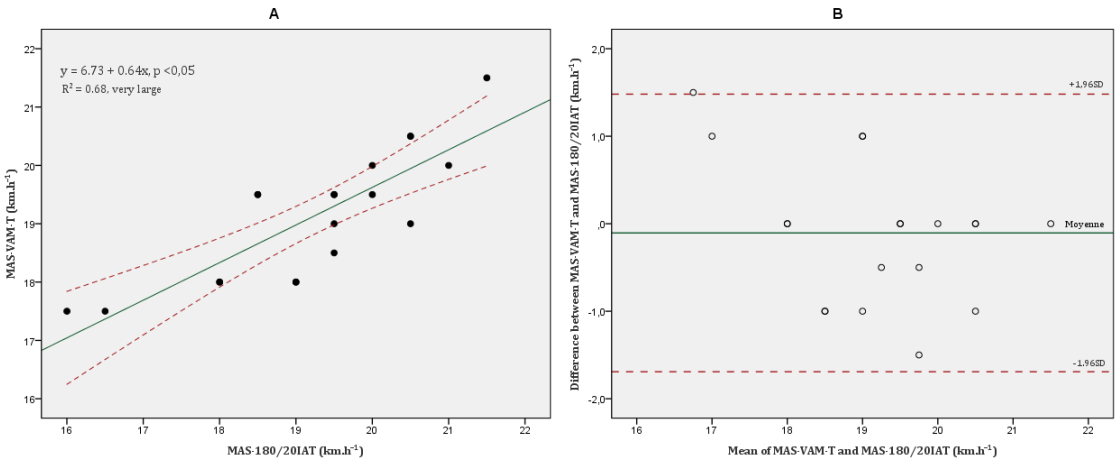

Figure 2. (A) Relationship between the maximal aerobic speed obtained from the VAM-EVAL test and the maximal aerobic speed obtained from the 180/20 intermittent athletic test. **(B)** Bland-Altman plot of the maximal aerobic speed obtained from the VAM-EVAL versus the maximal aerobic speed achieved during the 180/20 intermittent athletic test.

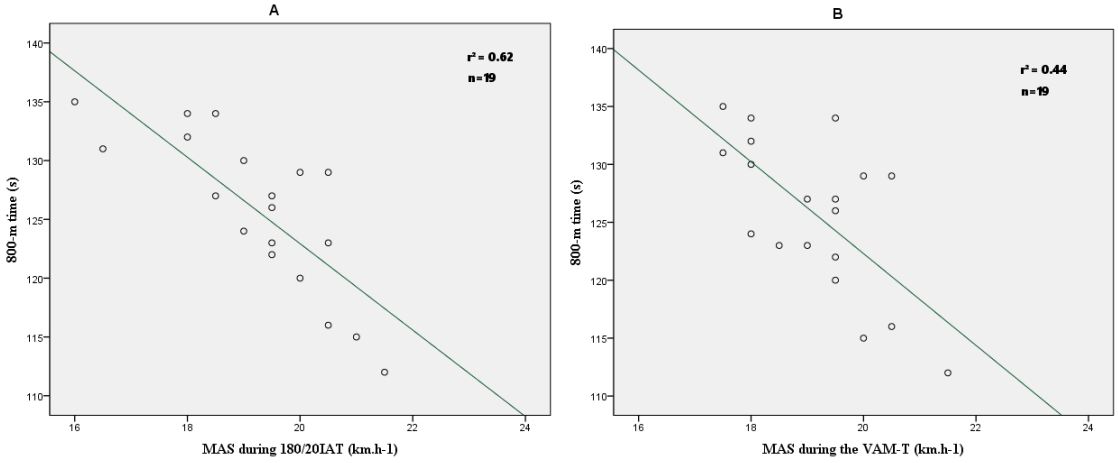

Figure 3. (A) Relationship between 800-m performance and MAS180/20IAT. (B) Relationship between 800-m performance and MASVAM-T.

distance for each stage (200m) has also been chosen because it been demonstrated that performance over a distance of 200m can be used to predict performance on 800m in middle-distance runners[6]. The results of the current study showed a similar MAS between an incremental continuous test commonly used (VAM-T) and a new incremental test with short intermittent exercise (which is supposed to be better meet the intermittent nature of the middle running distance discipline). These results confirm those found recently by Benhammou et al.[18]. Moreover, MAS during both tests were significantly correlated, and low systematic bias (-0.10km.h^{-1}) and limits of agreement (-1.69–1.48 km.h^{-1}) were noted. In other words, MAS is non-significantly underestimated by -0.5%, and among 100 new runners, 95 athletes would have at worst a MAS underestimated (not significantly) by -8.8% or overestimated (not significantly) by +7.7%.

According to the present data, the 180/20$_{IAT}$ was correlated with the other indicators of maximal capacity of aerobic metabolism. The results showed that the 180/20$_{IAT}$ produced values of HRpeak and [La] comparable with those of VAM-T. These results are in agreement with values obtained by other authors[5,15]comparing intermittent protocols to other continuous incremental field exercises. The homogeneity of the HRpeak and [La] values at the end of the tests allowed to confirm maximal exertion at the end of the 180/20$_{IAT}$ and the major contribution of anaerobic metabolism, when an athlete reaches her/his MAS. Supporting this idea, previous studies reported a major anaerobic participation during intermittent exercise[19,20]. As maximal oxygen uptake (VO_2max) is considered to be the best indicator of maximal capacity of aerobic metabolism and that VO_2max is routinely evaluated during incremental exercise tests[21,22], the future studies could compare VO_2max between continuous test and 180/20$_{IAT}$.

Previously, several studies have demonstrated a strong relationship between middle-distance performance and the MAS[23,24]. Indeed, Ingham et al.[23] have previously observed large relationship between MAS measured on treadmill during incremental intermittent running test and 800-m running performance in 15 male 800-m runners (r= 0.53), and 16 female 800-m runners (r= 0.82). The current study confirms this because MAS determined from the VAM-T was significantly related to 800-m performance time (r= -0.66 considered as large, p<0.01).However, a better significant correlation between 800-m running performance and MAS achieved during 180/20$_{IAT}$ was noted (r= -0.78 considered as very large, p<0.01). So, MAS achieved during 180/20$_{IAT}$is a better predictor of 800-m performance than MAS obtained from the VAM-T. These results may be considered as a consequence of the intermittent form of 180/20$_{IAT}$which simulates daily training of middle-distance runners.

In conclusion, the results of the current study showed that 180/20$_{IAT}$may be considered as a valid

test to assess the MAS in middle-distance runners. Moreover, the MAS obtained during this filed test was significantly correlated to the 800-m running performance. Consequently, the 180/20$_{IAT}$appears as an interesting and practical alternative to a classic incremental continuous tests and seems as accurate for determine a reference velocity for intermittent training prescription in middle-distance athletes. Given the interest of the MAS determination in middle-distance runners, further researches examining the effect of training program including short intermittent exercises on the MAS$_{180/20IAT}$ are to be conducted in order to evaluate the sensibility of 180/20$_{IAT}$.

This study has some limitations that should be noted. The number of samples was relatively small. In addition, no women have performed this test. The need for familiarization with the sound signals to adjust running pace. A comparison with other MAS determination protocols is also recommended. Despite the very good correlations, perfect agreement and low bias observed in this investigation, future studies should replicate this research but using a portable gas analyzer in the field.

Practical applications

Evaluation of the MAS is essential for middle-distance runners and coaches, but they have to choose the specific test. The current study showed that athletes and coaches can use the 180/20$_{IAT}$ because it lead to a particular MAS that takes into account various qualities solicited during intermittent training of middle-distance runners, i.e., aerobic metabolism performance, and the ability to recover between intermittent exercises. Moreover, the 180/20$_{IAT}$ were very largely correlated with the 800-m running performance suggesting that it could therefore be a very helpful tool to individualize a reference velocity for intermittent training in middle-distance athletes.

Authotship. All the authors have intellectually contributed to the development of the study, assume responsibility for its content and also agree with the definitive version of the article. **Conflicts of interest.** The authors have no conflicts of interest to declare. **Funding.** XXXXX **Acknowledgements.** 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). An audio beep (designed at the 180/20IAT) is available free of charge from the first author upon request. **Provenance and peer review.** Not commissioned; externally peer reviewed. **Ethical Responsabilities.** *Protection of individuals and animals:* The authors declare that the conducted procedures met the ethical standards of the responsible committee on human experimentation of the World Medical Association and the Declaration of Helsinki . *Confidentiality:* The authors are responsible for following the protocols established by their respective healthcare centers for accessing data from medical records for performing this type of publication in order to conduct research/dissemination for the community. *Privacy:* The authors declare no patient data appear in this article.

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