

Physiological Characteristics (Maximal Aerobic Speed) and Their Relationship with Numerical Achievement in Middle-Distance Running (1200 meters and 2000 meters) Among Athletically Talented Students.

بعض الخصائص الفيزيولوجية (السرعة الهوائية القصوى) وعلاقتها بالإنجاز الرقمي (1200 متر، 2000 متر) للتلاميذ الموهوبين رياضيا في نشاط الجري لمسافات متوسطة

Doulache Nacime¹ Guettaf Mohamed²

¹Ammar Thelidji University of Laghouat, Algeria n.doulache@lagh-univ.dz (PHD student),

²Ammar Thelidji University of Laghouat, Algeria m.gattaf@lagh-univ.dz
Laboratory of Dimensions of Knowledge and Practical Perceptions of Sports Training Sciences Multidisciplinary Visions and Approaches, Institute of Science and Technology of Physical Activities and Sports, University of Ammar Thelidji of Laghouat, Algeria.

Received: .../.../2024

Accepted: .../.../2024

Published: /.../2024

Abstract:

This study attempted to examine some physiological characteristics (maximal aerobic speed) and their relationship with performance in middle-distance running (1200 meters, 2000 meters) among athletically talented students. A descriptive research design was used, and the sample consisted of 39 athletically talented students engaged in middle-distance running (1200 meters, 2000 meters). The VAMEVAL test was administered to measure maximal aerobic speed, and the photo finish method was used to assess performance. The study found a statistically significant correlation between maximal aerobic speed and performance in both 1200 meters and 2000 meters among the study sample.

Keywords: maximal aerobic speed; numerical achievement; athletic talent; middle-distance running

Introduction:

Middle-distance running is considered one of the most important track and field sports in school athletics. To achieve titles and win competitions, a talented middle-distance runner must possess a set of physical and skill-based abilities, as well as physiological and morphological characteristics. This type of sport requires a significant physical effort that demands specific physical capacities, such as endurance and speed, which must be present at a high level in a talented athlete. It requires a combination of physical, physiological, and morphological characteristics for success (Irena Auersperger & M. Ulaga, 2009). Elite middle-distance runners exhibit intermediate biomechanical and physiological parameters between sprinters and long-distance runners (M. Thompson, 2017). These capacities provide the necessary energy to exert a high level of physical effort throughout the entire race.

Similarly, middle-distance running is also considered one of the most significant athletics sports in school-based physical education. To achieve titles and win competitions, a talented student in middle-distance running must possess a combination of physical and technical abilities, in addition to physiological and morphological characteristics. This sport also requires significant physical effort, necessitating specific physical capabilities that should be identified at an early age, such as endurance and speed. Research indicates that middle-distance events, such as the 800-meter and 1000-meter races, are integral components of national physical health tests for students, highlighting their importance in promoting exercise habits and health outcomes (Panova et al., 2020). Innovative teaching methods, such as direct feedback and scientific approaches, have been shown to enhance student performance in these events, leading to notable improvements in learning outcomes (Berthoin et al., 1995). Therefore, understanding the physical and physiological demands of middle-distance running is essential for optimizing educational programs and athlete development.

Maximal oxygen consumption ($VO_2\text{max}$) is considered one of the key indicators for enhancing overall fitness levels, particularly endurance. As a crucial predictor of middle-distance running performance, $VO_2\text{max}$ plays a significant role in determining an athlete's capability for endurance events like the 1500m and 3000m (Brandon & Boileau, 1992; Zacharogiannis & Farrally, 1993). Higher $VO_2\text{max}$ values indicate better endurance capabilities, essential for sustaining performance over middle-distance events (Zacharogiannis & Farrally, 1993). This highlights the importance of $VO_2\text{max}$ not only in training regimens but also in evaluating athletes' potential in competitive scenarios.

Moreover, maximal aerobic speed (MAS) also influences the efficiency of the cardiovascular system, including the heart and arteries. MAS is a valuable measure of aerobic capacity and training intensity, with higher MAS levels associated with enhanced athletic performance across various sports (Casado et al., 2022; Balasekaran et al., 2023). Research shows that MAS can be improved through targeted training programs, emphasizing its role in optimizing cardiovascular efficiency and overall athletic performance (Berthoin et al., 1995). This connection underscores how MAS complements $VO_2\text{max}$ in contributing to an athlete's overall fitness and performance.

Furthermore, maximal aerobic speed (MAS) also enhances the efficiency of the respiratory system and the lungs. It has been shown that middle- and long-distance runners achieve higher MAS compared to non-running endurance athletes with similar $VO_2\text{max}$, possibly due to greater mechanical efficiency (Casado et al., 2022). MAS is closely related to other performance indicators such as velocity at lactate threshold and critical speed, which

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contribute to improved respiratory function and endurance (Balasekaran et al., 2023). This relationship illustrates how MAS impacts both cardiovascular and respiratory efficiency, further emphasizing its importance in athletic training and performance.

Time and distance are considered as measures and indicators of progress, with each athlete striving to achieve the shortest possible time for the distance covered in middle-distance running activities. This is known as the numerical achievement. Middle-distance running performance is evaluated through time and distance measures, with athletes aiming to achieve the shortest time for a given distance (Panova et al., 2020). Mathematical models have been developed to analyze the relationship between race distance and time, providing insights into performance across various running events (Ward-Smith, 1985). These measures are critical for assessing progress and setting performance benchmarks in middle-distance running.

To complete race distances in the shortest time and achieve a standard numerical performance, numerous studies have demonstrated a correlational relationship between numerical achievement and maximal aerobic speed (MAS) among middle-distance runners. The velocity at ventilatory threshold (VT) has been identified as a strong predictor of 3000m performance, and various tests such as time trials over distances between 1200-2200m can predict MAS (Bellenger et al., 2015; Renoux et al., 1999). These studies collectively highlight the importance of MAS in assessing aerobic performance and optimizing training programs for middle-distance runners (Benhammou et al., 2020). This connection between MAS and numerical achievement reinforces the significance of MAS in evaluating and enhancing middle-distance running performance.

Based on the previous discussion, the following questions arise:

1.2 Statement of the problem:

1.2.1 General Research Question

- Is there a statistically significant correlation between maximal aerobic speed and performance (1200 meters, 2000 meters) among the study sample?

1.2.2 Sub-questions

- Is there a statistically significant correlation between maximal aerobic speed and performance (1200 meters) among the study sample?
- Is there a statistically significant correlation between maximal aerobic speed and performance (2000 meters) among the study sample?

1.3 Research Hypotheses

1.3.1 General Hypothesis

- There is a statistically significant correlation between maximal aerobic speed and performance (1200 meters, 2000 meters) among the study sample.

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1.3.2 Sub-hypotheses

- There is a statistically significant correlation between maximal aerobic speed and performance (1200 meters) among the study sample.
- There is a statistically significant correlation between maximal aerobic speed and performance (2000 meters) among the study sample.

1.4 Objectives

The objectives of this study are twofold. First, it aims to explore the theoretical approaches to maximal aerobic speed (MAS) and its associated indicators, providing a comprehensive understanding of how MAS is conceptualized and measured. Second, the study seeks to examine the correlational relationship between MAS and numerical achievement over the 1200-meter and 2000-meter distances. By investigating this relationship, the study aims to elucidate how MAS influences performance outcomes in these specific distances, thereby contributing to the broader knowledge of endurance running performance.

1.5 Significance

The importance of the research lies in its study of the theoretical frameworks of maximal aerobic speed (MAS) as a physiological characteristic in middle-distance running, as well as its relationship with the numerical achievement of athletically gifted students in the 1200-meter and 2000-meter races.

1.6 Definition of Key Terms

1.6.1 Athletic Talent: According to Weinek, athletic talent is defined as a set of distinctive general abilities and aptitudes of an athlete, including high-level performance techniques and skills that are characterized by maximal development through continuous pedagogical observation and follow-up. It is also an exceptional state characterized by superior technical performance compared to other cases. (Jurgen Weinek, 1999, p. 89)

1.6.2 Numerical Achievement: It is divided into two words: "achievement," which refers to performance and exerting maximal effort, and "numerical," which is related to the time in which the achievement is accomplished, that is, performing the effort in the shortest possible time. (Ben Si Qaddour Habib, 2020, p. 441)

1.6.3 Maximal Aerobic Speed (MAS) is the speed at which maximal oxygen uptake (VO₂max) is achieved during an incremental exercise test, serving as a reliable indicator of aerobic capacity and endurance in athletes, and is closely related to performance in aerobic-based physical activities (Wilmore & Costill, 2004). MAS reflects the functional capacity of the cardiorespiratory system and is crucial for evaluating physical fitness and the body's ability to sustain prolonged effort (Lauzon, Dallaire, & Leblanc, 2016). Determined during an incremental exercise test on a treadmill or track, MAS is identified as the speed at which oxygen consumption plateaus, signaling the attainment of maximal aerobic capacity (Pyke, 2021). This measurement is widely used for monitoring and programming athlete training, particularly in endurance sports.

1.7 Literature review

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Maximal Aerobic Speed (MAS) is a critical parameter in evaluating middle-distance running performance and optimizing training regimens. Previous studies have provided insights into how MAS correlates with performance outcomes, offering valuable information for enhancing athletic training. This literature review examines key studies related to MAS and its impact on running performance, focusing on various experimental approaches and findings.

The study of Thomas et al. (2004) examined the physiological responses of runners during an 800-meter race and their implications for training. They reported that runners reach their VO_{2max} within the first 45 seconds and maintain it for approximately 33 seconds before experiencing a decrease in VO_2 during the final stretch. This finding is relevant to understanding the role of physiological measures in middle-distance running. Understanding these physiological responses can help in developing targeted training strategies to improve performance in middle-distance events.

In a related study, Bellenger et al. (2015) investigated various methods for determining MAS and their implications for endurance training. They found that time trials over distances between 1200-2200 meters effectively predict MAS, with the 2000-meter distance being particularly optimal. This supports the discussion about the importance of accurately measuring MAS to enhance training programs for middle-distance runners. The study also emphasized that improved MAS is associated with enhanced performance outcomes, highlighting the critical role of MAS in achieving high levels of endurance performance.

In their study, Hamzaoui et al. (2021) aimed to investigate the effect of a proposed training program for developing anaerobic endurance on the numerical achievement level of 800-meter runners. The researchers employed an experimental design with a sample consisting of 15 runners from CAAT Tiaret Club, Algeria, aged between 18 and 19 years. Pre-tests were administered, followed by an 8-week training program, after which post-tests were conducted. The results of the post-test revealed statistically significant differences in favor of the post-test, indicating that the training program had a positive effect on the runners' numerical achievement level. This supports the importance of targeted training interventions in enhancing performance, as highlighted in discussions about improving middle-distance running performance through specific training programs.

Zerouki Ali and Kaisari Ali (2024) conducted a study aimed at examining the correlational relationship between maximal aerobic speed (MAS) and the numerical achievements of short- and middle-distance runners in the U20 category. The researchers employed an experimental design with a sample of seven runners from the Athletic Club Ouled Mohamed. Maximal aerobic speed (MAS) tests were conducted using the VAMEVAL test. The results revealed a weak correlation between MAS and the numerical achievements of short-distance runners, and an inverse weak correlation between MAS and the numerical achievements of middle-distance runners. These findings underscore the complex relationship between MAS and performance metrics, suggesting that while MAS is a valuable measure, its predictive power varies across different running distances.

2. METHODOLOGY

2.1 Exploratory Study

Corresponding author:, E-mail:

Researchers of this study conducted an exploratory study with a sample consisting of 6 talented students in middle-distance running (1200 meters and 2000 meters) to test the data collection tools and assess the responsiveness of the sample to these tools.

2.2 Research Methodology

A descriptive research methodology was employed in this study. This approach involves describing the phenomenon under investigation, analyzing the data collected, and interpreting the findings.

2.3 Study Population and Sample

The research population consists of all athletic talented students engaged in middle-distance running (1200 meters, 2000 meters). A purposive sample of 39 students from the fourth year of middle school was selected, distributed across 11 middle schools in Algiers, Boumerdes, and Aïn Defla cities.

2.4 Scopes of the Study

The study was conducted within the following scope:

2.4.1 Setting: his study was conducted with 39 athletically talented students participating in clubs (JSOH, CRBR, OB, DSN, SMB, OCAM, NKA, CRBTZ, JSMBA, OCR, NMA) in Algiers, Boumerdes, and Aïn Defla cities.

2.4.2 Timeframe: The study extended from March 7, 2024, to June 23, 2024.

2.5 Study Variables

The study employed two primary variables:

2.5.1 Independent Variable: Maximal Aerobic Speed (MAS).

2.5.2 Dependent Variable: Numerical achievement in the 1200-meter and 2000-meter races.

2.6 Research Instruments

The VAMEVAL test was administered to measure maximal aerobic speed (MAS). The data collection tools were subjected to scientific standards.

2.7. Statistical Tools:

We performed a series of statistical analyses using the Statistical Package for the Social Sciences (SPSS) 2020, and selected the following statistical methods: mean, standard deviation, simple and multiple linear regression, and coefficient of determination.

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3. RESULTS AND DISCUSSION

We performed a series of statistical analyses using the Statistical Package for the Social Sciences (SPSS) 2020, and selected the following statistical methods: mean, standard deviation, simple and multiple linear regression, and coefficient of determination.

3.1. Presentation of Results:

Table 1. Regression Coefficients between the Independent Variable (Maximal Aerobic Speed) and the Dependent Variable (Performance in 1200 meters) for Athletically Talented Students in Middle-Distance Running.

Variable	B	Standard Error	Beta	T-test Value	Sig Value	Correlation Coefficient R	R-squared	Adjusted R-squared
Num-Time	501.37	45.59		11.00	0.00	0.69	0.489	0.475
MAS	17.31	2.91	-0.70	-5.95	0.00			

Source: Prepared by the researchers based on SPSS output, 2020.

Theoretical Conditions:

Referring to the regression model that shows the correlation between the independent variable (Maximal Aerobic Speed) and the dependent variable (Performance in 1200 meters) for athletically talented students in middle-distance running, we get the following model:

$$Y = 17,31X_1 + 501,37$$

From this model, we can conclude the following:

- The intercept B0 has a positive value (501.37) and is not equal to zero.
- The slope of the regression line B1 has a negative value (17.31).

Model Interpretability:

The interpretability of the regression model is assessed by the Adjusted R-squared value, as shown in Table 1. The estimated Adjusted R-squared value is 0.475, which means that the variables included in the regression model explain 47.5% of the effect of the independent variable (Maximal Aerobic Speed) on the dependent variable (Performance in 1200 meters) among the study sample. Therefore, 47.5% of the variation in the dependent variable (Performance in 1200 meters) can be attributed to the independent variable (Maximal Aerobic Speed) among the study sample, while 52.5% is due to other factors. These results justify the validity of the selected variables for the study and their ability to explain the results of the regression model.

Partial Significance of the Model:

In the previous step, it was found that at least one of the regression coefficients differs from zero. To measure the significance of the regression coefficients, a T-test was conducted. Based on the results shown in Table 1:

- The intercept B0 has a T-test value of (11.00) with a significance value (0.00), which is less than (0.05), indicating that the intercept in the regression model is significant.
- The slope of the regression line B1 for Maximal Aerobic Speed has a T-test value of (-5.95) with a significance value (0.00), which is less than (0.05), indicating that the slope in the regression model is significant.

Table 2
Regression Coefficients Between the Independent Variable (VO2max) and the Dependent Variable (2000m Performance) for Athletically Talented Students in Middle-Distance Running

Variables	B	Standard Error	Beta	t-test Value	Sig Value	Correlation R	R ²	Adjusted R ²
Num-time	920.54	55.62		16.55	0.00	0.82	0.68	0.67
VO2max	-32.03	3.55	-0.83	-9.02	0.00			

Source: Prepared by the researchers based on SPSS outputs, 2020.

Theoretical Conditions

Referring to the regression model obtained, which illustrates the correlation between the independent variable (VO2max) and the dependent variable (2000m performance) for athletically talented students in middle-distance running, the model can be expressed as:

$$Y = -32,03X_1 + 920,54$$

From this model, we can infer the following:

- The intercept B0 is positive and not equal to zero (920.54).
- The slope B1 has a negative value of -32.03.

Model Interpretability

The interpretability of the regression model is evaluated using the Adjusted R² value, as shown in Table 2. The Adjusted R² value is 0.67, indicating that the variables in the regression model explain 67% of the variance in the dependent variable (2000m performance) attributed to the independent variable (VO2max) among the sample. This means that 67% of the variation in the 2000m performance is explained by VO2max, while 33% is due to other factors. These results support the validity of the selected variables for the study and their capacity to explain the regression model results.

Partial Significance of the Model

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In the previous step, we identified that at least one of the regression coefficients differs from zero. To assess the significance of the regression coefficients, we conducted a partial significance test using the t-test. According to the results in Table 2:

- The intercept B_0 has a t-test value of 16.55 with a p-value of 0.00, which is less than 0.05, indicating that the intercept in the regression model is significant.
- The slope B_1 for VO_{2max} has a t-test value of -9.02 with a p-value of 0.00, which is less than 0.05, indicating that the slope in the regression model is significant.

Analysis and Interpretation of Results:

The statistical analysis of the study results clearly shows the correlation between the maximal aerobic speed (MAS) of talented students and their performance in 1200m and 2000m races. This is illustrated in Table 1 and Table 2. Students with higher MAS achieve better numerical results and complete the 1200m and 2000m distances in less time and with higher efficiency. The impact of MAS on running performance occurs in various ways, as indicated by Billat and Koralsztein (2001), who state that "an increase in MAS is associated with improved performance in middle-distance running. MAS reflects the ability to produce energy through the aerobic system, which is the primary determinant of running performance over distances ranging from 800m to 5000m" (Billat & Koralsztein, 2001). This aligns with the findings of Bellenger et al. (2015), who reported that MAS is a critical measure of aerobic performance and is closely related to endurance outcomes in middle-distance running.

An increase in MAS reflects the efficiency of the aerobic system in transporting oxygen from the lungs to the working muscles responsible for generating movement. This includes the heart's pumping ability, the lungs' efficiency in gas exchange, and the muscles' ability to extract oxygen. In the context of middle-distance running, this is confirmed by Midgley and Carroll (2007), who found a strong correlation between MAS and the time recorded in the 3000m race (Midgley & Carroll, 2007). Similarly, research by Thomas et al. (2004) highlights how VO_{2max} , which is related to MAS, impacts running performance by influencing how efficiently oxygen is utilized during high-intensity efforts.

MAS also contributes to maintaining performance speed without fatigue, known as "critical speed," for middle-distance runners. Billat and Koralsztein (2003) noted that improvements in MAS are reflected in increased critical speed, which represents the highest speed a runner can sustain for a period, leading to enhanced running performance (Billat & Koralsztein, 2003). This is consistent with the findings of Zerouki Ali and Kaisari Ali (2024), who observed that while MAS shows weak correlations with short-distance performance, it plays a crucial role in middle-distance events, emphasizing its importance in sustaining higher speeds over longer distances.

Furthermore, MAS is associated with maximal oxygen consumption (VO_{2max}), a key determinant of performance in aerobic-based races. Noakes (2001) suggests that developing VO_{2max} leads to improvements in MAS, positively impacting middle-distance running performance (Noakes, 2001). This is supported by the study conducted by Hamzaoui et al. (2021), which demonstrated that targeted training programs designed to improve anaerobic endurance positively affected runners' performance levels, indirectly underscoring the relationship between MAS and VO_{2max} .

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This explains the 66% impact of physiological factors (MAS) on performance in the 1200m and 2000m races, making it a fundamental determinant for middle-distance runners. However, other factors accounting for the remaining 34% include running technique and biomechanics, running economy, psychological factors (e.g., self-confidence, motivation), and mental factors (e.g., focus, mental strength). The comprehensive understanding of these factors is essential for optimizing training programs and improving overall performance in middle-distance running.

4. RECOMMENDATIONS

Enhance MAS through Targeted Training: Given the study's findings on the correlation between maximal aerobic speed (MAS) and performance in 1200m and 2000m races, it is recommended to implement training programs that specifically target the improvement of MAS. Incorporate high-intensity interval training (HIIT), tempo runs, and endurance intervals into the training regimen to effectively boost MAS and enhance overall race performance.

Integrate MAS Testing into Training Regimens: Regularly assess MAS using validated testing methods such as the 2000m time trial or the 150-50 Intermittent Test (150-50IT). This will provide athletes and coaches with critical data on their aerobic capacity, allowing for more precise adjustments to training loads and strategies. Monitoring MAS can help track progress and identify areas that need further development.

Optimize Running Efficiency and Technique: The study highlights the role of MAS in improving running performance efficiency. To maximize this, focus on refining running technique and biomechanical efficiency. Incorporate drills that enhance running form, optimize stride mechanics, and reduce vertical stiffness, as these factors can significantly impact performance and efficiency in middle-distance races.

Address Psychological and Tactical Aspects: Given that psychological factors play a role in performance, incorporate mental training techniques to improve focus, motivation, and race strategy. Develop pre-race routines and mental preparation strategies to help athletes manage race day stress and execute their tactics effectively.

Focus on Comprehensive Training Approaches: In addition to improving MAS, ensure that training programs address other performance factors such as running economy, technique, and psychological readiness. A holistic approach will help athletes not only improve their MAS but also enhance their overall competitive edge.

Provide Personalized Training and Support: Since MAS affects individual performance differently, customize training programs to fit the specific needs and current levels of each athlete. Offer personalized feedback and adjustments based on MAS test results and performance metrics to optimize individual training outcomes.

Emphasize Recovery and Nutrition: Ensure that athletes have a structured recovery plan and access to proper nutrition to support the demands of intense training. Effective recovery strategies and balanced nutrition are crucial for maintaining performance levels, preventing injuries, and facilitating overall athletic development.

5. CONCLUSION

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To conclude, the investigation into the relationship between maximal aerobic speed (MAS) and performance in middle-distance running has provided valuable insights into the factors influencing athletic success in this discipline. The study's findings underscore the critical role of MAS in enhancing running performance, as evidenced by the significant correlation between MAS and the numerical achievements in 1200-meter and 2000-meter races. This aligns with previous research demonstrating that MAS is a robust indicator of aerobic capacity and endurance (Billat & Koralsztein, 2001; Midgley & Carroll, 2007). The results indicate that athletes with higher MAS levels are able to complete these distances more efficiently, reflecting improvements in both speed and endurance.

Moreover, the study highlights the multifaceted nature of middle-distance running performance, where MAS contributes substantially but is not the sole determinant. While physiological factors such as MAS account for a significant portion of performance variance, other elements like running technique, biomechanics, psychological factors, and mental strength also play crucial roles. This comprehensive understanding can guide future training programs by emphasizing the development of MAS while also addressing other relevant performance factors.

In conclusion, enhancing MAS through targeted training interventions can lead to substantial improvements in middle-distance running performance. Future research should continue to explore the interplay between MAS and other performance determinants to further refine training approaches and optimize athletic outcomes. The integration of MAS with a holistic view of performance factors will be essential for developing well-rounded athletes capable of excelling in competitive middle-distance running.

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Corresponding author:, E-mail: