# Proposed Standard Scale for Evaluating Aerobic Capacity ($VO_2max$ and VMA) Among Endurance Runners Aged 16–17 Years

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Date of transmission: 28/01/ 2026 date of acceptance: 04/03/ 2026

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**Abstract:**

The study aimed to develop a normative scale for assessing aerobic capacity ($VO_2max$ and VMA) among middle- and long-distance runners aged 16–17 years in the Wilaya of Batna, in order to improve the athlete selection process. A descriptive survey methodology was adopted, and the sample consisted of 48 athletes selected using the total population method. Statistical analysis included the mean, standard deviation, t-test, correlation coefficient, and standardized T-scores.

The results revealed statistically significant differences in $VO_2max$ and VMA in favor of the 17-year-old group compared with the 16-year-old group.

Furthermore, 21% of the sample demonstrated a good level of aerobic capacity, qualifying them for endurance events, while the majority of athletes were classified within the acceptable lev

**key words:** Standard Scale ; Aerobic Capacity ; Endurance ; $Vo_2Max$ ; Vma

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## Introduction:

The formation of a national elite and the selection of the most talented individuals from among a large number of practitioners begin with the stage of detection and selection, followed by the orientation phase, which directs the athlete toward the specialization in which they have the greatest potential for success. Talented or high-ability individuals exist in all fields; they are those who possess abilities that are clearly above average, allowing for the prediction of their potential to achieve a high level of performance in the short or long term. According to **Cazorla (2003)**, the selection process refers to choosing individuals who demonstrate the highest potential for excellence in a specific discipline or position from among a group of qualified athletes. **(Yahiaoui Benfares Latifa.2023.p689)**

Moreover, Higher levels of fitness among children have been associated with more favorable health outcomes, both in the present and in the future, including reduced risks of obesity, cardiovascular diseases, improved skeletal health, and even enhanced mental well-being, encompassing aspects such as depression, anxiety, mood state, and self-esteem. Health-related physical fitness (HRPF) refers to the fitness components that are closely linked to health outcomes or indicators. It is determined by a set of factors, including body weight status, cardiorespiratory fitness, musculoskeletal fitness, and motor fitness. Monitoring HRPF is therefore crucial for enhancing physical functional capacities. **(Christel Galvani ET all. 2024. p02).**

Cardiorespiratory fitness (CRF) is considered one of the most important functional indicators, often referred to as aerobic endurance, as it plays a crucial role in the development of other physical attributes. It also exerts significant health effects on both the heart muscle and the respiratory system. Aerobic endurance, in particular, plays a vital role in track and field events—especially in middle- and long-distance running disciplines.

Aerobic endurance is closely related to maximal oxygen uptake ($VO_2max$), which represents the maximum amount of oxygen an individual can transport from the environment to the lungs, and subsequently to the blood, muscles, and organs for the production of energy (ATP). $VO_2max$ is a direct indicator of cardiorespiratory efficiency (CRF) and is inversely associated with overall mortality and cardiovascular diseases. Furthermore, $VO_2max$ is one of the most critical determinants of endurance performance in athletes and is widely recognized as one of the most reliable predictors of race performance**. (Bryson Carrier ET all .2025. p02)**

The maximal oxygen uptake ($VO_2$max) is considered one of the most important determinants of performance excellence in the 800m and 1500m events, and it is a key parameter that most coaches emphasize during the selection process for such specializations. Therefore, professionals in the field of athletic training must establish precise selection standards to ensure that athletes reach high-performance levels and achieve competitive excellence. Continuous and long-term training demands considerable effort, which has led athletes and coaches to develop evaluation criteria to reduce this burden and ensure successful athletic progression.

In Western countries, coaches employ standardized rating scales and evaluation criteria to guide their athletes according to the specific requirements of each discipline, while taking into account the nature and characteristics of their societies. Unfortunately, such practices remain absent in Algeria, particularly in the field of athletics, which is the only sport that has earned the country the highest number of medals compared to other sports.

Indeed, Algeria's athletics record includes seven Olympic medals — four gold, one silver, and two bronze — representing the highest share among all sports disciplines. Athletics has thus been the sport that best represents Algeria internationally, particularly in endurance running, which accounts for most of these achievements.

This raises an important question:

**Why does Algeria not yet have a standardized performance scale for athletics?**

Despite the country's distinguished history in the sport, most national coaches still rely on foreign models and evaluation standards that do not reflect the specific characteristics of Algerian athletes. Others resort to non-scientific approaches, such as relying solely on experience and intuition during talent .In light of this, our study seeks to address the following general research question:

Does establishing a standardized evaluation scale for endurance running in athletics have a positive impact on guiding and selecting young talents effectively?

## 2. Research Hypothesis

Given that hypotheses represent one of the essential steps in conducting scientific research, and based on the theoretical framework and available empirical evidence, as well as the nature and objectives of the present study, we propose the following general hypothesis:

Establishing an evaluation scale for endurance running events can facilitate the selection of the best athletes and guide them toward the most appropriate specializations within athletics.

**3. Research Objectives**

- To provide a clearer understanding for coaches—particularly in athletics—of the importance of physical attributes through aerobic capacity ($VO_2max$) and its role in the talent identification and selection process.
- To offer guidelines and practical approaches for training young athletes in endurance disciplines within athletics.
- To collect theoretical data concerning the physiological and anthropometric characteristics of athletes aged 16–17 years.
- To present an overview of methods and tools for measuring the aerobic system.
- To determine the maximal oxygen uptake ($VO_2max$) for athletes aged 16–17 years.
- To identify the key physical characteristics of this age group.

**The practical chapter:**

**1. Research Methodology:**

The researcher adopted the descriptive method using the survey approach, as it is most appropriate for studies of this nature.

**2. Study Sample:**

**2.1. Research Population:**

The research population consisted of 48 athletes practicing in the athletics clubs of the Wilaya of Batna.

**2.2. Sample Characteristics:**

The entire research population was included using a purposive sampling method. The participants were cadet-level athletes (aged 16–17 years) from the athletics clubs of Batna during the 2024–2025 sports season. Given the specific focus of the study on this age category, other age groups were excluded. Thus, a comprehensive census of the study population was conducted, comprising a total of 48 athletes.

**3. The 5-Minute Briksy Dakkar Test:**

**3.1.Test Principle:**

This test closely resembles the 6-, 9-, and 12-minute running tests. According to its designers, five minutes is sufficient time to maintain an intensity close to the maximal aerobic power (PMA). Consequently, it enables the estimation of

maximal oxygen uptake ($VO_2$max) using the following equation developed for this purpose:

VO2max(ml/kg/min)=2.27 v v(km/h)+13.3 **(N. Dakkar et al., 1990)**

### 3.2.Test Objective:

To determine maximal oxygen consumption ($VO_2$max).

### 3.3.Equipment Used:

A stopwatch, whistle, and cones to mark the running field.

### 3.4.Performance Description:

The test is performed in multiple heats from a standing start. Upon hearing the start signal, the participants begin running and are allowed to walk if fatigued. The distance covered by each participant is recorded after the 5-minute period ends. Each participant remains in place to determine the distance between their final position and the starting line.

### 3.5.Scoring Procedure:

The total distance covered in 5 minutes is recorded. The number of laps completed is multiplied by the track length, and any remaining meters are added to calculate the total distance.

## 4. Pilot Study:

A pilot study was conducted on 10 athletes from the original population who were not included in the main sample, selected randomly. The pilot test was carried out between December 19 and 22, 2024, using the same physical test employed in the main study.

The objectives of the pilot study were to:

- Examine the seriousness and responsiveness of the pilot sample.
- Introduce necessary modifications to the test elements and instructions.
- Review the test to ensure that all dimensions of the measured attribute or ability were adequately represented.
- Identify and correct any weaknesses observed during implementation.
- Familiarize the assisting team with the nature of the test and its administration procedures.
- Ensure the validity, reliability, and objectivity of the test.

## 5. Psychometric Properties of the Test:

### 5.1. Test Reliability:

To assess reliability, the test–retest method was applied to 10 athletes from the research population who were later excluded from the main study. The first test was conducted on December 19, 2024, and the retest took place five days later,

on December 22, 2024, under identical conditions to the initial test to avoid any variables that could affect the results.

**Table (01): Mean Values and Total Differences Between the First and Second Measurements for the Pilot Study Sample**

| Test | Sample Size | Significance Level | Correlation Coefficient Between First and Second Measurement |
|---|---|---|---|
| $VO_2max$ | 10 | 0.05 | 0.96 |

Table (01) shows that the correlation coefficient between the first and second measurements is 0.96, which is statistically significant and very close to 1, indicating a high level of reliability for the test.

### 5.2. Test Validity (Credibility):

To ensure the validity of the tests, the researcher used the intrinsic validity coefficient, which is calculated as the square root of the reliability coefficient.

$$\textbf{Intrinsic Validity} = \sqrt{\textbf{Reliability}}$$

### 5.3. Objectivity:

The objectivity of a test refers to the degree of consistency among evaluators in their judgment regarding a particular measurement or phenomenon. Since the test used in this study relies on objective instruments such as a stopwatch and a measuring tape, it is considered clear, precise, and free from subjective bias.

The physical test was conducted and adjusted in accordance with the recommendations and feedback of expert evaluators, ensuring that it was implemented under highly objective and standardized conditions. Thus, the test applied in this study can be deemed to have been administered with a high degree of objectivity.

### 5. Statistical Processing:

-Arithmetic Mean.

-Standard Deviation.

-Pearson Correlation Coefficient.

-Student’s t-Test.

-T-Score:

It is one of the most commonly used methods in physical education and sports research, particularly in physical performance tests. This method addresses the shortcomings of the previous method—the deviation score—which often results in negative values and small score ranges. The T-score has a mean of 50 and a standard deviation of 10, ensuring that all resulting values are positive. Therefore, this formula is used to convert raw scores into T-scores.

## 6-Result Evaluation Scale for the Test:

In this study, it was necessary to establish a grading scale to evaluate the participants' physical performance and assess their aerobic capacity. To this end, a five-level evaluation scale was developed based on the normal distribution (Gaussian distribution), as it is the most commonly applied model in the field of sports sciences. Most measured physical and physiological characteristics tend to approximate this distribution.

The normal distribution can be represented by a curve known as the *normal (Gaussian) curve*, which resembles an inverted bell shape extending infinitely in both directions, approaching the horizontal axis without ever touching it. The distribution is as follows:

- **Excellent level:** between ($\bar{X}$ + 2SD) and ($\bar{X}$ + 3SD), representing **2.14%**.
- **Good level:** between ($\bar{X}$ + SD) and ($\bar{X}$ + 2SD), representing **13.59%**.
- **Average level:** between ($\bar{X}$ + SD) and ($\bar{X}$ − SD), representing **68.26%**.
- **Weak level:** between ($\bar{X}$ − SD) and ($\bar{X}$ − 2SD), representing **13.59%**.
- **Very weak level:** between ($\bar{X}$ − 2SD) and ($\bar{X}$ − 3SD), representing **2.14%**.

Accordingly, standardized scores were adopted such that the upper limit corresponds to an evaluation score of 80, the arithmetic mean represents the average score of 50, and the lower limit corresponds to the minimum score of 20. **(Bluman, 2018)**

## Presentation and Analysis of Results:

**Table (02): Analysis of Physical Test Results and Normal Distribution for Males Aged 15–17 Years:**

| Age (years) | Weight (kg) | Height (cm) | $VO_2$max ($ml \cdot kg^{-1} \cdot min^{-1}$) | VMA ($m \cdot s^{-1}$) |
|---|---|---|---|---|
| Arithmetic Mean | 56.72 | 161.22 | 52.43 | 15.00 |
| Mode | 55.00 | 160.00 | 52.11 | 14.88 |
| Standard Deviation | 6.76 | 5.34 | 5.03 | 1.37 |
| Minimum Value | 47.00 | 151.00 | 41.63 | 12.28 |
| Maximum Value | 70.00 | 177.00 | 62.65 | 17.90 |
| Skewness | 0.56 | 0.82 | 0.18 | 0.34 |
| Kurtosis | -0.84 | 0.70 | -0.36 | 0.67 |

| | | | | |
|---|---|---|---|---|
| Shapiro–Wilk Value | 0.71 | 0.52 | 0.56 | 0.30 |
| Significance | (–) | (–) | (–) | (–) |
| Total Sample | 48 | 48 | 48 | 48 |

(–) = Not significant at the 0.05 level

From Table (02), it is observed that the skewness coefficients range between (±1), and all kurtosis coefficients are close to zero. The Shapiro–Wilk test results show no statistical significance ($p > 0.05$), indicating that the data follow a normal distribution pattern.

The table above also presents the statistical analysis of height, weight, $VO_2max$, and VMA measurements for athletes aged 15–17 years, showing the following:

**Weight:** The mean value is 56.72 kg, with a maximum of 70 kg and a minimum of 47 kg. Most values cluster around the mode of 55 kg.

**Height:** The mean value is 161.22 cm, with a maximum of 177 cm and a minimum of 151 cm. Most values concentrate around the mode of 160 cm.

**$VO_2max$:** The mean value is 52.43 $ml \cdot kg^{-1} \cdot min^{-1}$, with a maximum of 62.65 $ml \cdot kg^{-1} \cdot min^{-1}$ and a minimum of 41.63 $ml \cdot kg^{-1} \cdot min^{-1}$. Most values align with the mode of 52.11 $ml \cdot kg^{-1} \cdot min^{-1}$.

**VMA:** The mean value is 15 $m \cdot s^{-1}$, with a maximum of 17.9 $m \cdot s^{-1}$ and a minimum of 12.28 $m \cdot s^{-1}$. Most values are consistent with the mode of 14.88 $m \cdot s^{-1}$.

### -Comparison Tests Between the 16- and 17-Year-Old Groups

When comparing two or more groups, the researcher must use appropriate statistical tests to determine whether the differences between arithmetic means, standard deviations, or percentages are statistically significant. Among these .tests, the t-test is one of the most commonly used methods

**Table (03): Differences in Height and Weight Between the 16- and 17-Year-Old Groups:**

| Variable | 16 years | 17 years | Variable | 16 years | 17 years |
|---|---|---|---|---|---|
| Mean (Weight) | 54.75 | 58.70 | Mean (Height) | 159.04 | 163.40 |
| Sample Size | 24 | | Sample Size | 24 | |
| Significance Level | 0.05 | | Significance Level | 0.05 | |
| Levene’s Value | 1.32 | | Levene’s Value | 2.76 | |

| | | | |
|---|---|---|---|
| Levene's Sig. | 0.25 | Levene's Sig. | 0.103 |
| t-test Sig. | 0.015 | t-test Sig. | 0.034 |
| Significance | (+) | Significance | (+) |

- (+) = Significant at the 0.05 level
- From the results (03) , it can be stated that there is homogeneity and equivalence between the two groups, as the Levene's significance value is greater than 0.05, confirming equality of variances.

However, analysis of Table (13) reveals statistically significant differences in both height and weight between the 16- and 17-year-old athletes ($p < 0.05$). This indicates that 17-year-old athletes are taller and heavier than those aged 16 years, reflecting normal physical growth and maturation.

**Table (04): Differences in $VO_2$max and VMA Between the 16- and 17-Year-Old Groups:**

| Variable | 16 years | 17 years | Variable | 16 years | 17 years |
|---|---|---|---|---|---|
| Mean ($VO_2$max) | 49.90 | 54.96 | Mean (VMA) | 14.32 | 15.68 |
| Sample Size | 24 | | Sample Size | 24 | |
| Significance Level | 0.05 | | Significance Level | 0.05 | |
| Levene's Value | 1.01 | | Levene's Value | 1.82 | |
| Levene's Sig. | 0.319 | | Levene's Sig. | 0.183 | |
| t-test Sig. | 0.002 | | t-test Sig. | 0.012 | |
| Significance | (+) | | Significance | (+) | |

- (+) = Significant at the 0.05 level
- As shown in Table (04), there is homogeneity and equivalence between the two groups, as indicated by the Levene's test ($p > 0.05$).

However, the independent samples t-test revealed statistically significant differences at the 0.05 level ($p < 0.05$) for both $VO_2$max and VMA. This indicates that 17-year-old athletes demonstrated higher $VO_2$max and VMA values compared to those aged 16 years, confirming an improvement in aerobic capacity and running performance with age.

Standard Scale

Establishing a Standard Scale for the 16-Year-Old Age Group

**Ranking of Test Results by Average Score for 16-17 Year-Old Athletes:**

The table below presents the ranking of the best-performing athletes based on the total points obtained from all tests. The average score reflects each athlete's overall performance level, while the performance percentage column indicates the corresponding percentile ranking for each level.

**Table (05): Ranking of $VO_2max$ and VMA Test Results:**

| Rank | Age | VMA | VO2MAX | Total | Average Score | Percentile |
|---|---|---|---|---|---|---|
| 1 | 17 | 67 | 67 | 134 | 67 | |
| 2 | 17 | 67 | 67 | 134 | 67 | |
| 3 | 17 | 65 | 65 | 130 | 65 | |
| 4 | 16 | 62 | 67 | 129 | 65 | |
| 5 | 16 | 62 | 67 | 129 | 65 | |
| 6 | 16 | 62 | 67 | 129 | 65 | 21% |
| 7 | 17 | 62 | 62 | 124 | 62 | |
| 8 | 17 | 62 | 62 | 124 | 62 | |
| 9 | 16 | 53 | 69 | 122 | 61 | |
| 10 | 16 | 53 | 69 | 122 | 61 | |
| 11 | 17 | 58 | 59 | 117 | 59 | |
| 12 | 17 | 58 | 59 | 117 | 59 | |
| 13 | 16 | 55 | 60 | 115 | 58 | |
| 14 | 17 | 55 | 55 | 110 | 55 | |
| 15 | 17 | 53 | 53 | 106 | 53 | |
| 16 | 17 | 53 | 53 | 106 | 53 | |
| 17 | 17 | 55 | 55 | 106 | 53 | |
| 18 | 16 | 50 | 50 | 100 | 50 | |
| 19 | 16 | 50 | 50 | 100 | 50 | |
| 20 | 16 | 50 | 50 | 100 | 50 | %66.7 |
| 21 | 16 | 45 | 55 | 100 | 50 | |
| 22 | 16 | 45 | 55 | 100 | 50 | |
| 23 | 16 | 44 | 56 | 100 | 50 | |
| 24 | 17 | 48 | 48 | 96 | 48 | |
| 25 | 16 | 48 | 48 | 96 | 48 | |
| 26 | 16 | 48 | 48 | 96 | 48 | |
| 27 | 17 | 48 | 48 | 96 | 48 | |
| 28 | 16 | 48 | 48 | 96 | 48 | |
| 29 | 16 | 48 | 48 | 96 | 48 | |
| 30 | 17 | 47 | 47 | 94 | 47 | |
| 31 | 17 | 47 | 47 | 94 | 47 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 32 | 16 | 44 | 45 | 89 | 45 | |
| 33 | 16 | 44 | 45 | 89 | 45 | |
| 34 | 17 | 44 | 44 | 88 | 44 | |
| 35 | 17 | 44 | 44 | 88 | 44 | |
| 36 | 17 | 44 | 44 | 88 | 44 | |
| 37 | 17 | 44 | 44 | 88 | 44 | |
| 38 | 17 | 37 | 48 | 85 | 43 | |
| 39 | 17 | 42 | 42 | 84 | 42 | |
| 40 | 17 | 40 | 41 | 81 | 41 | |
| 41 | 16 | 39 | 41 | 80 | 40 | |
| 42 | 16 | 39 | 41 | 80 | 40 | |
| 43 | 16 | 39 | 41 | 80 | 40 | |
| 44 | 16 | 36 | 38 | 74 | 37 | |
| 45 | 16 | 42 | 30 | 72 | 36 | %11 |
| 46 | 17 | 35 | 36 | 71 | 36 | |
| 47 | 17 | 33 | 34 | 67 | 34 | |
| 48 | 32 | 31 | 33 | 64 | 32 | |

**General Discussion:**

After presenting and analyzing the results obtained, using graphical representations and various statistical treatments of the collected data, which were based on evaluating each athlete individually for each physical test, followed by ranking the results of both physical tests according to the total points scored by each athlete (Table 05), our study, which aimed to propose a scoring scale for evaluating aerobic capacity (VMA and $VO_2$max) among 16–17-year-old endurance runners, reached the following conclusions:

We found that, for optimal guidance in endurance races, 21% of the sample—equivalent to 10 out of 48 athletes—demonstrated a good level, showing capabilities that significantly distinguish them from the rest of the sample. According to Hakimi, citing Prus (1988), an individual whose physical test results fall between the mean and two or three standard deviations above it can be considered potentially capable of reaching high levels of athletic performance in the future.

This finding is also consistent with the study conducted by Hicham Zeroual and Slim Ghmoura (2013), which identified 9 athletes, including 4 females, with high aerobic capacity, making them suitable for endurance events, provided the evaluation criteria are applied.

Additionally, 66.7% of the sample, equivalent to 33 athletes, achieved an acceptable level, indicating sufficient general abilities to engage in physical

activity. Conversely, 11% of the sample—equivalent to 5 athletes—demonstrated a weak level, indicating that their physical readiness does not qualify them for endurance-specific activities. These individuals may be excluded from this specialty due to their low results.

This finding is also consistent with the study conducted by Mertat Mohamed (2011/2012) the findings revealed statistically significant differences among students aged 12 to 15 years in most of the tests, indicating the existence of different performance levels and age-specific scoring scales when assessing male middle school students.

Based on the study and the analyzed data, it can be concluded that nearly all athletes in the studied sample, except for those lacking the requisite physical readiness, have the potential to achieve future success. Our field study of 16–17-year-old athletes and the results obtained indicate that this sample shows promising endurance capacities for future participation.

Although $VO_2max$ reflects the maximal functional capacity of the circulatory system, which is a key factor in endurance sports relying on aerobic energy, possessing a high $VO_2max$ does not automatically guarantee superior performance in endurance sports. Other factors, such as motivation and tactical skills, and tecnicl ….. play an equally important role

**Conclusion:**

From our theoretical and field study, and after analyzing the literature and interpreting the results through statistical indicators, it is evident that 16–17-year-old athletes achieved generally acceptable results. Specifically, 87.7% of the sample (43 out of 48 athletes) displayed physical readiness and capabilities above the sample mean, enabling them to engage in sports activities generally and in endurance races in particular.

This study resulted in the development of a selection and evaluation scale for 16–17-year-old athletes in Batna province, enabling the collection of detailed information about this age group based on $VO_2max$ and VMA tests. This scale may help identify future factors contributing to high-level performance in endurance events and characterize morphological, physiological, and psychological traits.

Achieving high-level results requires a progressive approach, beginning with selection based on matching an athlete’s capabilities to the appropriate specialty, supplemented with the necessary training program to develop physical qualities according to each age group.

From our observation of the training field, we noticed that many coaches, particularly in athletics, do not use scientific methods to guide their athletes toward the appropriate specialties. Instead, they rely on traditional observation and experience, which are insufficient given the current level of athletics development. This is particularly relevant for Batna, which has considerable talent in national endurance competitions.

Our study, therefore, aimed to emphasize the importance of using physiological indicators to guide athletes toward endurance specialties, especially for the 16–17-year-old age group, considered a critical stage for specialization. This approach contributes to creating a scientific criterion to pave the way toward a better athletic future.

**Recommendations:**

The goal of selection is to guide athletes toward the most appropriate specialty and design a suitable training program for the preparatory stage to achieve high-level results. Accordingly, we recommend:

1. Coaches should emphasize general endurance, given its importance in developing other physical qualities.
2. Conduct comprehensive selection processes for young athletes.
3. Periodically evaluate athletes to monitor physical progress.
4. Conduct physiological tests to assess energy system characteristics and track relevant changes and developments that help guide training.
5. Consider all aspects in selection; it should not be limited to a single factor while neglecting others.

**Key Findings:**

- Most of the sample were distributed across the acceptable and good levels.
- 10 athletes (21%) achieved a good level, exceeding the normal distribution curve.
- 33 athletes (66.7%) achieved an acceptable level, slightly below the normal distribution curve.

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