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Original Article

A qualitative scale of the 6-minute race test to evaluate maximum aerobic speed in physically active people from 18 to 25 years

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Abstract. [Purpose] To create a qualitative scale for the 6-minute race test in physically active participants from 18 to 25 years old. [Participants and Methods] The sample was 299 healthy participants (254 males and 45 females). All the participants were instructed to perform the greatest possible distance in the 6-minute race test. To evaluate the reliability of the 6-minute race test, 30 participants performed the 6-minute race test for a second time. The variable was distance in meters. The qualitative scale was constructed with the percentiles <25, 50, 75, 90 and >90 for the criteria poor, fair, good, very good and excellent, respectively; the reliability was calculated with the coefficient of variation, intra-class correlation coefficient and the standard error of the mean. [Results] In the 6-minute race test, the mean was 1,607 and 1,364 meters for males and females, respectively. The coefficient of variation=4.08%, intra-class correlation coefficient=0.93 and standard error of the mean=11.46. [Conclusion] The creation of the qualitative scale of the 6-minute race test allows us to evaluate and classify the level and increase of maximum aerobic speed in physically active participants from 18 to 25 years old.
Key words: Maximum aerobic speed, 6-minute race test, Young adults

INTRODUCTION

Currently, several factors influence the physical performance and condition of the population, including the environmental situation, degree of training, and biomechanical, psychological, nutritional, and physiological status[1–3]. Specifically, one of the most representative variables of physical condition is maximum oxygen consumption (VO2max)[4]. This parameter has been associated with both sports' performance[5] and better standards of living[6]. In this context, the maximum VO2 value is evidenced from a plateau that occurs in an individual when subjected to an incremental test until exhaustion[7]. The kinetics of this variable is the maximum aerobic speed (MAS); this parameter corresponds to the minimum speed at which the VO2max is reached[8]. Furthermore, the MAS seems to be a superior predictor of VO2max and allows precise training plans to be prescribed within the aerobic–anaerobic transition zone[9]. In parallel, the aerobic–anaerobic transition zone has been considered a critical component for the improvement of aerobic capacity and aerobic power[10]. However, it is the prescription of individualized training loads that has proven to be most efficient in obtaining physical performance increases in the aerobic–anaerobic transition zone[9].

This background and the need to improve physical performance have led researchers to design and validate different tests to measure physiological parameters[11, 12]. Therefore, evaluation through gas analysis is the most reliable way to obtain VO2max and MAS (gold standard)[11]. These evaluations are performed, in most cases, in research laboratories or high-performance centers[12, 13], with professionals highly trained in gas analysis[14]. For these reasons, and due to their high cost,

these tests are difficult to access for the majority of the population[15]. Therefore, to provide valid and reliable tests, some other tests have been designed to evaluate both VO2max and MAS directly in the field[4, 12, 16, 17]. For example, the University of Montreal's Track Test allows the estimation of VO2max through a maximum, incremental, and continuous protocol up to fatigue[18]. The multistage 20-meter shuttle run test, mostly used because of its ease of preparation, allows the estimation of VO2max and MAS through a maximum, incremental, 20-meter protocol up to fatigue[16]. Another test used for indirect estimation of VO2max has been the 12-minute test (t-12 min)[19]. However, there is evidence that the t-12 min underestimates VO2max when compared to other field tests[4, 17]. On the other hand, other investigations have concluded that the estimation of VO2max does not require the application of tests as extensive as the t-12 min[20, 21]. Based on this background, shorter field tests have been created and validated[4, 12]; specifically, the 6-minute race test (6MRT) has been validated in school adolescents[22], naval personnel[4], and university middle-distance athletes[12]. However, the 6MRT does not present a qualitative scale to evaluate and classify the MAS of the participants, nor does it allow for checking the progress associated with the training programs. Consequently, this study's main purpose was to create a qualitative scale for the 6MRT in physically active participants from 18 to 25 years old.

PARTICIPANTS AND METHODS

Participants: A total of 299 healthy people volunteered to participate in this study (Table 1). For convenience, nonprobability sampling was used. All participants were cadets from the Chilean Naval Academy. All participants were informed of the study objective and possible risks of the experiment. In addition, all participants signed informed consent before the application of the protocols. The informed consent and the study were approved by the Human Research Committee of the University of Granada (registration number 493/CEIH/2018)[12] and conducted under the Declaration of Helsinki (WMA 2000, Bošnjak 2001, Tyebkhan 2003), which sets out the fundamental ethical principles for research with human beings.

The research had a quantitative focus, exploratory-descriptive scope, and a non-experimental design of the predictive cross-sectional type[23]. For the creation of the qualitative scale of the 6MRT, the model of Ojeda et al.[24] was followed; during the study, four sessions separated by 48 hours were executed: session 1) briefing, signing of the informed consent and anthropometric evaluation; sessions 2 and 3) familiarization with the warm-up exercises and the 6MRT; session 4) application of the 6MRT. For the evaluation of the reliability of the 6MRT, 30 participants were invited to perform the test for the second time; this second performance was after 48 hours of rest.

Procedures: As a first action, all participants who voluntarily accepted to be part of the study (nonprobabilistic sample) were invited and gathered. In the informative talk, the purpose and procedures of the study were indicated. The inclusion criteria were that all participants should be healthy, physically active[25], and between 18 and 25 years old. In contrast, the exclusion criteria were the prevalence of musculoskeletal injuries, pre-existing cardiac pathologies, abnormal respiratory and cardiac responses during the familiarization period, and inability to perform 6MRT. All participants were asked to refrain from physical activities that generate nervous or musculoskeletal fatigue 48 hours before the measurements, and to refrain from ingesting caffeine or any substance that could increase their metabolism during the assessment[24]. Finally, only those participants who signed informed consent were subjected to the 6MRT.

Anthropometric measurements: the height (cm) was evaluated using a stadiometer from the feet to the vertex (Frankfort plane). Weight (kg) was evaluated through a Tanita Inner Scan BC-554® digital scale. Weight and height were evaluated with the participants barefoot, in shorts, and wearing a lightweight T-shirt. The body mass index (BMI) was measured according to anthropometric standards for evaluating nutritional status[26].

Standardized warm-up: the warm-up included 10 minutes of jogging, 5 minutes of ballistic movements of the lower limb (adduction, abduction, flexion, and extension of the hip, and flexion and extension of the knee and ankle), and three 80-meter sprints. After this warm-up and before running the 6MRT, there was a 5-minute rest.

6-minute race test: The evaluation of the 6MRT was carried out on a 400-meter athletic track. A maximum of 15 participants were assigned to each evaluator, which allowed precise control of the distance performed by the participants. Also, the participants were instructed to perform the maximum distance possible in the 6 minutes of the test; for this, during the application of the test, the participants received verbal encouragement from the researchers. With the distance achieved in the 6MRT, plus the BMI and gender, the VO2max was obtained through the following equation[22]:

Table 1. Characterization of the participants

	Female (n=49)	Male (n=254)	All (n=299)
	mean ± SD (min–max)	mean ± SD (min–max)	mean ± SD (min–max)
Age (years)	19.78 ± 1.41 (18–23)	20.04 ± 1.51 (18–25)	20 ± 1.50 (18–25)
Weight (kg)	61.94 ± 6.82 (46.8–82)	73.57 ± 7.89 (54–94)	71.82 ± 8.78 (46.8–94)
Height (cm)	165.1 ± 0.06 (160–180)	176 ± 0.06 (160–200)	174.4 ± 0.07 (160–200)
BMI (kg/m^2)	22.71 ± 2.14 (18.3–28.3)	23.75 ± 2.04 (17.4–30.2)	23.59 ± 2.09 (17.4–30.2)

kg: kilograms; cm: centimeters; m^2: square meters; SD: standard deviation; min: minimum; max: maximum.

$$\text{VO2max (mLO}_2\cdot\text{kg}^{-1}\cdot\text{min}^{-1})=41.946 + 0.022 * 6MRT -0.875 * BMI + 2.107 * gender$$

female gender=0, male gender=1, 6MRT=covered distance in meters, BMI= kg/m^2.

Statistical analysis: descriptive data are presented as means and standard deviations. The normal distribution of data was confirmed by the Shapiro-Wilk test (p>0.05). For the creation of the qualitative scales, the percentile distribution was used with the following criteria: ≤25%: poor; ≤50%: fair; ≤75%: good; ≤90%: very good; and >90%: excellent. The reliability of the 6MRT was evaluated through the coefficient of variation (CV), the intra-class correlation coefficient (ICC), the standard error of the mean (SEM), and the corresponding 95% confidence interval (CI). Acceptable reliability was determined as a CV<10% and a ICC>0.85[27]. The t-tests for related samples and the Bland-Altman technique were used to evaluate the concordance between the test and retest of the 6MRT[28]. All other statistical analyses were performed with SPSS software version 25.0 (SPSS, Chicago, IL, USA). The significance level for all statistical analyses was p<0.05.

RESULTS

To create the qualitative scale of the 6MRT, we used the distance covered in meters by the 299 participants of the study (test). The different ranges and criteria are reported in Table 2.

With regard to the mean distances, men covered 1,607.5 ± 101.0 m, while women reached 1,364.4 ± 75.6 m. Minimum, maximum, 95% CI, and SEM values are reported in Table 3.

For the reliability of the 6MRT, 30 of the 299 participants were evaluated in two instances separated by 48 hours (test and retest). The variable used to determine the reliability of the 6MRT was the distance traveled in meters. In analyzing the 30 cases, a CV of 2.69 and an ICC of 0.93 were observed. The reliability results are reported in Table 4 and Fig. 1.

DISCUSSION

In terms of the main objective of the study, once the qualitative scale of 6MRT has been created, it will be possible to categorize the young adult population from 18 to 25 years old. These categories are poor, fair, good, very good, and excellent according to the distance made in the 6MRT. Recent studies have shown that the 6MRT is a valid and reliable test for estimating VO2max and MAS in the population[4, 12, 22]. It seems that 6MRT does not underestimate VO2max when compared to

Table 2. Qualitative scale for the 6MRT

	Distance in 6MRT (m)				
	Poor	Regular	Good	Very good	Excellent
Male	≤1,550	1,551–1,610	1,611–1,670	1,671–1,730	≥1,731
Female	≤1,310	1,311–1,360	1,361–1,410	1,411–1,460	≥1,461

6MRT: 6-minute race test; m: meters; min: minutes.

Table 3. Distances of the 6MRT (n=299)

	6MRT				
Participants	mean ± SD	Min–Max	95% CI (Low Lim–Upp Lim)	SEM
Male (n=254)	1,607.5 ± 101.0	1,330–1,960	1,595.0–1,620.0	6.34
Female (n=45)	1,364.4 ± 75.6	1,220–1,530	1,341.7–1,387.1	11.27
All (n=299)	1,570.9 ± 130.8	1,220–1,960	1,556.1–1,585.8	7.56

6MRT: 6-minute race test; SD: standard deviation; m: meters; Min: minimum; Max: maximum; CI: confidence interval; Low Lim: lower limit; Upp Lim: upper limit; SEM: standard error of measurement.

Table 4. Reliability of the 6MRT (n=30)

	Test (mean ± SD)	Re-Test (mean ± SD)	Δ (95% CI)	SEM (95% CI)	CV (95% CI)	ICC (95% CI)
6-minute test (m)***	1,618.5 ± 169.6	1,680.0 ± 142.9	61.5 m 38.0–84.9	44.3 35.3–59.8	2.69% 2.14–3.62	0.93 0.85–0.96

6MRT: 6-minute race test; m: meters: SD: standard deviation; CI: confidence interval; Δ: variation delta; CV: coefficient of variation; ICC: intra-class correlation coefficient; ***: <0.001.
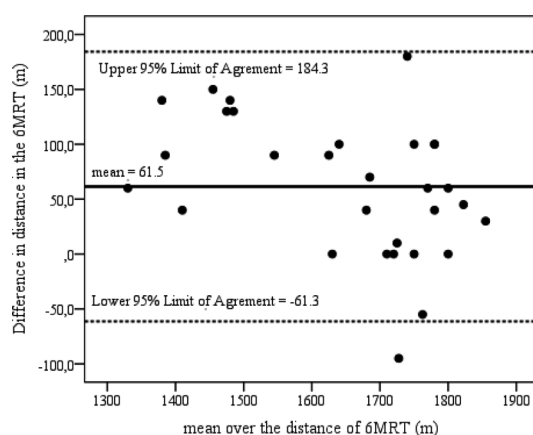
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Fig. 1. The solid line represents the mean difference between the test and re-test of the 6MRT (meters). The segmented lines represent the upper and lower 95% confidence limits.
6MRT: 6-minute race test; m: meters.

other field tests[4], nor does it show significant differences when compared to laboratory tests (VO2max laboratory 3.46 ± 0.80 vs. VO2max field 3.75 ± 0.89 LO-min-1; p>0.05)[12]. As a background, when comparing the VO2max obtained in a 12-minute run with the VO2max of the multistage 20-meter shuttle run test (Course Navette Test), a significant difference is obtained between both results (p<0.05)[17]. Similarly, it seems that the 6MRT allows us to obtain a more precise MAS than a running test over 6 minutes[4, 12, 22]. Independent of that, before choosing a test to evaluate physical parameters, the participants' sport level should be considered[8].

Simultaneously, the creation of qualitative scales will make it possible to monitor the increase in MAS associated with physical training programs. In this regard, Huerta et al.[29] characterized the dose–response relationship of interval training associated with MAS in adolescents; at the end of the study, the researchers showed a significant increase (p<0.01) in VO2max and MAS in the intervention group. Simultaneously, the same researchers stated that an 8-week training period, which included two sessions per week with an intensity between 95 and 115% of the MAS, was an efficient methodology to improve VO2max and MAS. Swaby et al.[30] concluded that rugby players with higher MAS covered a greater distance on the pitch. This background supports the notion that MAS is a superior predictor of VO2max and allows for accurate training plans to be prescribed[9].

On the other hand, and considering that exercise intensity is the fundamental axis around which the metabolic predominance of physical exercises revolves[31], the convergence between execution time and distance covered in the 6MRT places the test at the extreme right of the aerobic–anaerobic transition zone[10], which shows that this test allows the estimation of VO2max and MAS. This background is supported by other studies that have established a time frame of 6 to 8 minutes for the estimation of VO2max and MAS[20, 32]. In turn, the results reported in this study indicate that the 6MRT has a high degree of reliability (CV: 2.69%; ICC: 0.93; SEM: 11.46)[27].

The literature mentions that the reliability of the tests used to evaluate the different parameters of the physical condition depends on the biological differences presented by the participants[33], as well as on the variations that the instrument itself may have[34]. Thus, the statistical analyses reported in some studies show that the instruments' reliability is assured with an ICC value of over 90% between two or more evaluations[34]. Simultaneously, the differences between participants can be reduced with a period of familiarization with the test before data collection[35, 36]. Thus, the reliability achieved in the present study is due to two fundamental reasons: On the one hand, the accuracy of the 6MRT min for estimating VO2max and MAS as opposed to other field tests[4]; and, on the other, the familiarization process that the participants underwent before data collection[35, 36]. Thus, it is essential that when replicating this protocol, participants have at least two familiarization sessions with the 6MRT.

For those applying the 6MRT, it is recommended that there is a familiarization period before applying the test, which should include: a) standardized warm-ups; and b) approach sessions with intensities close to the MAS, but with stimulus times of less than 6 minutes. During the execution of the 6MRT, it is recommended that participants are verbally encouraged to run as far as possible.

For the interpretation of the results of the 6MRT, the qualitative scale enables us to estimate the physical condition of healthy adults between 18 and 25 years old, according to the distance covered, through the VO2max and the MAS. This last aspect could indicate the guidelines for a possible fitness-oriented physical training program, specifically to improve the parameters in the aerobic–anaerobic transition zone. For example, if a participant needs to control body mass, reducing body fat, he must run at 60–65% of VO2max[37] and the 6MRT allows to quantify the running time for each km (see practical applications).

At the same time, the creation of the qualitative scale enables the evaluation of the level of, and increase in, MAS in physically active participants from 18 to 25 years old. In addition, the 6MRT proved to be reliable for assessing MAS in this population.

A practical application of the 6MRT is as follows: if a participant performs 1,600 m on the 6MRT (qualitative scale: good), it means that his MAS is equivalent to 4.44 m·s^{-1} or 3 min 45 s (225 s) every km. If the participant needs to train at an intensity equivalent to 65% VO2max[37], he must perform the following calculation: 225 * 1.35=303.7 s (5 min 3.7 s) every km[38].

A limitation of the 6MRT for the quantification of training load is that all participants have different ways of responding to the intensity of effort. Therefore, in addition to 6MRT, physiological and psychological aspects must be considered in load control.

Conflict of interest

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