RESEARCH ARTICLE

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Gender and Body Mass Index Difference in Aerobic Capacity: A Study in Moroccan High School Students

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ABSTRACT

Different tests are used to evaluate the aerobic capacity of a person. This study aims to investigate the gender and Body Mass Index (BMI) difference in aerobic capacity measured by using shuttle and Spartacus test.

The study was conducted on 230 high school students (135 girls and 95 boys) followed their study in public establishment in kenitra city (Morocco). All participants were classified according to their gender (male vs. female) and their BMI (normal weight vs. overweight-obese) and performed the both test of shuttle and Spartacus. Running speed at the last completed stage, run time, maximum heart rate (max HR) max HR and perceived exertion were measured and analyzed. For each test, VO2max was estimated by using the proposed equation.

There was significant BMI difference in the measured parameters ($p<0.001$). Difference in VO2max between male and female remained significant with high-speed level in boys. A significant difference between males and females ($p < 0.001$) was observed in shuttle test. Participants with normal weight or physical activity had good aerobic capacity. Compared to the Shuttle test, the Spartacus provides a 11.5% higher final speed (11.2 vs. 9.7km/h) and a total test time 2.3 times longer (11.3vs. 4.9 min) ($p < 0.001$).

Our study underlines the interest of the Spartacus test and is preliminary. Indeed, these results must now be replicated in a larger sample of obese adolescents

Keywords: Aerobic capacity, Moroccan high school, gender, body mass index, Kenitra, Morocco.

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INTRODUCTION

The ability to perform long-duration exercise or aerobic fitness has a powerful indirect effect on the good physical health of young people when it is associated with the body mass index "BMI"[1] and with a good mental health since good cardiorespiratory performance presents better levels of self-esteem[2].

One of the main determinants of aerobic fitness is maximal oxygen consumption (VO2max), which is the maximum amount of oxygen the body is able to use per unit time ($ml.min^{-1}.kg^{-1}$) during physical effort, this parameter in the school environment constitutes an interesting educational support for physical education and sports teachers, it makes it possible to calibrate a precise programming of learning sessions according to the physiological possibilities of learners, thereby promoting appropriate productive motor engagement time.

The assessment of VO2max is generally carried out on the basis of two tests is indirectly, the most popular of which is the 20-meter shuttle run test, progressive with a continuous protocol, widely practiced in schools and designed for children aged 6 to 18 by[3], it presents an international reference for the assessment of physical condition in children[4], The last level reached by this test determines the last Maximum Aerobic Speed (VMA) reached and by extrapolation the VO2max, is the parameter most used to characterize aerobic fitness in populations of children and adolescents[5].

But this estimate is very difficult in overweight or obese adolescents, for several psychological and physiological reasons, studies have shown that an increasing number of Braking-Re-Acceleration (PFR) phases is at the origin muscle fatigue[6], thus leading to an exaggerated increase in energy cost in overweight young people, with joint inflammation which affects the motor skills of these young people. It has been shown that the speed at the end of the shuttle test is negatively correlated with overweight[7].

In order to circumvent the constraints encountered during a continuous protocol test such as the 20m shuttle run, and to make aerobic tests less monotonous for adolescents[8],developed a test on the maximum intermittent running course alternating periods of running and rest called the Spartacus Test or 15-15, the latter was validated in obese adolescents by two studies[9,10],the intermittent nature to be specified[9] shows an advantage in terms of physiological and perceptual responses in adolescents, they observed that the maximum aerobic speed is 20% higher with the Spartacus compared to an adapted 20m shuttle run test in adolescents obese, despite similar heart rates and perceived exertion, which proves a delay in the onset of muscle fatigue[10], Within the framework of establishments of the aftercare and rehabilitation type for adolescents, the evaluation of the global level of aerobic capacity is generally carried out by means of indirect tests (i.e., achievable within establishments and allowing several children to be tested simultaneously). These evaluations aim to better individualize the management by endurance activities and to quantify the effects both during this management and at the end of it.

The objective of the present study is to measure the interest of the Spartacus test, comparing the following parameters (Maximal Oxygen Consumption [VMA], Perceived Exertion [PE], and Heart Rate [HR] affected), of this population during two tests with different graduated protocols, and to verify the feasibility of this test as an alternative to the school environment.

This study aims to measure the interest of the Spartacus test and to compare it to the shuttle test as an indirect evaluation test of the overall level of aerobic capacity of obese adolescents through the maximum performance values (speed, heart rate) and perceived exertion. We hypothesize that the Spartacus intermittent test should promote better performance (higher values) of adolescents compared to the shuttle test in measures of maximum speed and heart rate.

MATERIALS & METHODS

Population

A sample of 230 Moroccan high school students (135 girls and 95 boys), followed their study in a public establishment (Kenitra city) for 5 months, participated in this study. Their demographic and anthropometric characteristics are presented in Table 1. The adolescents were distributed in three groups according to their Body Mass Index (BMI) of each young person and according to the thresholds proposed by the "International Obesity Task Force" according to their age and gender (eg, obesity thresholds of 28.6 and 27.6 kg/m2 respectively, for 14-year-old girls and boys)[11].

The inclusion criteria were an age between 14 and 18 years old, and a Body Mass Index (BMI), thus defining the weight category "normal corpulence", and respectively "overweight or obese".

The exclusion criteria were age over 18 and a BMI defining underweight when plotted on reference curves (IOTF).

Measures and procedures

The height (to the nearest 0.01 mm) of the participants was taken in a standing position using a vertical measuring board, and the weight in kg was determined using an electronic personal scale (Korona type, precision of 0.1 kg German), the body mass index (BMI) is thus calculated from these two variables, and corresponds to the ratio of the weight (in kg) to the square of the stature (in m^2), remember that when from the taking of the anthropometric measurements, the shoes are removed.

Evaluation of corpulence: according to the thresholds proposed by the International Obesity Task Force "IOTF" according to their age and sex[11], We speak of obesity when (BMI >IOTF-30), overweight when (IOTF-25 < BMI < IOTF-30), and of normal weight when (3rd percentile < BMI < IOTF-25).

Table 1: Age and anthropometric characteristics of participants (N=179).

	Total (n = 230)	Girls (n = 135)	Boys (n = 95)
Age (yers)	15,6 ± 1,0	15,4 ± 1	15.9 ± 1.1
Height (cm)	168 ± 0,8	163 ± 5.8	175.8 ± 8.1
Weight (kg)	62.8 ± 12,2	60.6 ± 11	66,2 ± 13,4
BMI	22,2 ± 4	22.7 ± 4	21.3 ± 3.8

BMI: body mass index.

a significant difference between girls and boys at $p < 0,05$.

The two tests, Shuttle Run- 20m and Spartacus (15/15), took place respectively according to the protocols recommended by[3], and the recommendations of [8]on the physical education and sports platform with an interval of one week between the first and the second test, setting the same time, to keep similar climatic conditions in temperature and humidity.

For each of these tests, the parameters evaluated by extrapolation VO2max from the speed reached at the end of the test (expressed in km/h), the total duration of the effort expressed in minutes (min), and the maximum heart rate (HRmax) expressed in beats per minute (b/min) measured at the end of effort.

Perceived exertion values were reported by all students immediately after exercise cessation. They were measured using "Rating Scale of Perceived Exertion" (RPE)[11], validated with adolescents[12]. The latter assesses the sensation of dyspnoea from 1 ("not at all") to 10 ("maximum"). These perceived exertion values were measured immediately after the end of the course test.

The evaluations were carried out at 8 weeks after the admission of the students to the high school. They took place in the morning (that is, between 9 a.m. and 12 p.m.), and under similar climatic conditions in temperature and humidity. The two tests were carried out one to three weeks apart and the order of the tests was randomly counterbalanced between the adolescents. Each of them was already familiar with the shuttle test, which is systematically organized at the very beginning of their stay. The Spartacus test protocol begins at a slow speed of 7 km/h, to allow children to quickly adjust their effort to the successive phases of 15 s of running and 15 s of rest. Just like in the warm-up phase of the shuttle test, these first three minutes made it possible to provide some individualized race management advice to teenagers. Subsequently, the shuttle test was administered according to the recommendations of[13]. Using equation proposed by[14] actually recommended by[15].

VO2max = 24.2–5.0*sexe – 0.8*age+3.4*Vmax

And for the Spartacus test according to the recommendations of[8].

An equation can be proposed to estimate VO2max based on the performance obtained during the Spartacus test. This equation integrates "age", "gender", "BMI" and "VMA" (r=0.68): VO2max estimation equations:

Girls: VMA*153.4433 +BMI*58.64534+age*−2.701522–921.2878

Boys: VMA*153.4433+320.1583+BMI*58.64534+age*−2.701522–921.2878

For each of these tests, the parameters evaluated are: the speed reached at the end of the test (expressed in km/h), the duration of the effort (in minutes), and the maximum heart rate (HRmax, expressed in beats/min) recorded at the end of exercise.

Statistical analysis of data

Values are described as mean ± standard deviation. Differences between boys and girls in terms of age, height, weight and BMI were assessed using a Student's t-test for independent samples. Differences between adolescents according to "type of test", according to "sex" and according to "BMI" were evaluated for HRmax, max speed, and perceived exertion, based on a multivariate analysis of variance (Manova). When the Manova was significant, a two-way Anova was conducted for each of the variables. In case of significant effect of the ANOVA, a post-hoc test of "Student-Newman-Keuls" (SNK) was used ($p < 0.05$). The relationships between the maximum speed (VMA) and HRmax values reached during the two tests were analyzed using the "Bravais-Pearson" test.

RESULTS

Age and anthropometric data are presented in Table 1. The Student's t results show no significant difference between girls and boys for age values [t(230)=2.66; p=0.008] and BMI [t(230)=2.28; p=0.024]. The Manova shows a significant relationship (Wilks'=0.09; F[5.78]=158.27; p<0.001) between the "type of test" main effect and the variables studied (HRmax, WMA and perceived exertion).

The different Anovas highlight a significant difference between the two tests in terms of running speed at last completed stage (F[1.82]=22.56; p<0.001), total test duration (F[1, 82]=155.88; p<0.001) and the running time (F[1.82]=34.53; p<0.001) Table 2. Post-hoc SNK tests performed on these three parameters show a significantly higher speed at the end of the test Table 2 and total and net running times Table 2 respectively 3.3 and 1.67 times longer in the Spartacus test. compared to the shuttle test ($p < 0.001$).

On the other hand, no significant difference was observed between the two tests in terms of HRmax (F [1.82]=0.60; p=0.44) and perceived exertion (F [1.82]=0.07; p=0.80)

Table: 2 Shuttle and Spartacus test results.

Tests	BMI class	Speed (km/h)	Run time (min)	Max HR (bpm)	Perceived exertion (Borg 0-10)
Shuttle	Normal	12.17 ± 0.17	5.8 ± 2.9	147.0 ± 16.3	7.3 ± 1.3
	Overweight	10.48 ± 0.38	3.5 ± 2.1	141.8 ± 22.1	6.7 ± 1.3
	Obese	9.34 ± 0.59	2.0 ± 0.7	121.0 ± 13.2	6.6 ± 1.0
Spartacus	Normal	13.79 ± 0.32	12.3 ± 4.3	148.3 ± 16.0	5.0 ± 1.4
	Overweight	12 ± 0.51	9.3 ± 3.0	148.0 ± 15.0	5.5 ± 1.5
	Obese	9.91 ± 0.79	5.0 ± 1.6	140.7 ± 14.9	4.6 ± 0.8

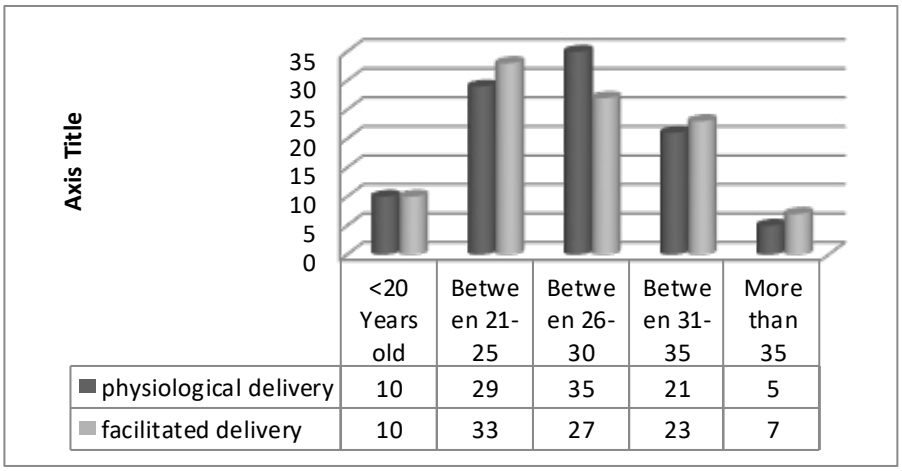

Figure 1: Frequency of patients in two groups by age.

Table 2. Furthermore, the Manova shows that there is no significant relationship between the variables studied (i.e., speed at the end of the test, total and net duration of the race, HRmax and perceived exertion) and the "gender" main effect (Wilks'=0.94; F [5.78]=01.06; p=0.39) or the "test type X gender" interaction effect (Wilks=0.94; F [5.78] =1.06; p=0.39).

Finally, the "Bravais-Pearson" correlation tests carried out between the two tests show a moderately significant relationship for the VMA values (r=0.75, p<0.05), perceived exertion (r=0.3, p<0.05) and HRmax (r=0.55, p<0.05).

In this study, VO2max was significantly less in obese group as compared with no obese group in both the genders Figure 1. The correlation factor for association of BMI and VO2max was negative and it was statistically significant.

DISCUSSION

The objective of this study was to measure the interest of the Spartacus protocol, as a progressive and maximum intermittent test for indirect evaluation of the overall aerobic level of obese adolescents. To this end, the 15-15 type intermittent test, known as Spartacus, recently developed in schools[16] was compared to the shuttle test[4]. The latter was selected as the reference test because it is internationally valid[3] and commonly used with this type of population, particularly within the SSR welcoming young obese subjects.

Obese adolescents have reduced aerobic capacities when walking and running, which is illustrated by a faster state of exhaustion compared to healthy subjects[1,17]. This situation is explained by a lower anaerobic threshold, a higher HR in submaximal effort, a higher percentage of VO2max and a higher perceived effort than for a healthy population when performing an exercise relative identical[18]. The review by[6] considers motor efficiency more than cardiovascular parameters as the main factor limiting aerobic-type activities in obese young people. The globalization of the use of the shuttle test allows us to compare our data with those from the meta-analysis of[19]. This study brings together the results obtained in this test by young boys and girls (of different weight categories) from 37 countries. The results of the present study show that obese adolescents have performances close to the lowest values reported by[19], for both girls and boys in their age group (9.2 ± 1.8 vs. 11.4 ± 1.6 km/h and 9.9 ± 1.1 vs. 11.8 ± 1.9 km/h, respectively), but with no difference in performance between the sexes. These results are original, because they differ from this meta-analysis which revealed significantly different performances between boys and girls of the same age. However, they deserve to be tempered with regard to the small number of boys who make up the sample of the present study.

About run time, the results showed that the load of the effort or the total duration of the race measured during the Spartacus test is very large than that encountered during the shuttle run test, this can be explained by the nature of the protocol in both tests, it is intermittent in the Spartacus and continuous in the shuttle, we should also note that this (the duration of the race) evolved with the degree of the perception of the effort of the adolescents

in a comparable way between the two tests, thus indicating that RPE measurements were higher during the continuous protocol compared to the intermittent protocol 15-15.

Our study has limitations, the low heart rates are not well measured because of a lack of knowledge of the method by the students, the use of a frequency meter is necessary and useful in a future article, also the estimation of VO2max via equations from the 20m shuttle run test[14], or Spartacus test[20], we have presented a VO2max from the shuttle test higher than those found from the Spartacus test despite the VMA of the first test(shuttle test over 20m) is lower than that of the Spartacus test, this can be explained by the parameters taken into consideration when developing the 2 equations[14], in the shuttle test took into account the age and sex, whereas[20] in the Spartacus test, proposed an equation based on age, sex and BMI.

CONCLUSION

The major result of this study is that even with high intensities and long running times during a test with the Spartacus intermittent protocol, the RPE remains lower than that encountered during a continuous protocol.

Our study underlines the interest of the Spartacus test and is preliminary. Indeed, these results must now be replicated in a larger sample of obese adolescents, and they should be compared to a direct observation of maximal oxygen consumption (VO2max). VO2max measurements at the pulmonary level can be useful for a better understanding and validation of the "Spartacus" test compared, for example, to the "shuttle" test. They would thus make it possible to assess the validity of the end-of-exercise speeds of the Spartacus as a maximum aerobic value of the intermittent type.

CONFLICT OF INTEREST

The authors report no conflicts of interest.

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