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Perceptual and Cardiorespiratory Response to Progressive Running Test in Relation with Puberty and Weight Status

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Abstract

Puberty is a combination of physical, physiological and psychological changes with detectable alterations in physical growth, which is a determining factor for assessment of physical fitness. The aim of our study was to determine the influence of different stages of maturation, and weight status, on the respiratory and perceptual response of school adolescents in the city of Kenitra (Morocco). 1186 adolescents with a mean age of 15.65 ± 1.98 years (50% girls and 50% boys) performed 20 m shuttle run test with 1 min stages, on separate days. Age, height and weight were recorded for each adolescent. perceived exertion (RPE) was evaluated at the end of the test using an adapted version of the Borg scale (CR-10) modified by Foster. The results are expressed by their means and their standard deviations according to the pubertal classification and were analyzed by using ANOVA. The results also show a double rate of overweight girls (5.1%), compared to (2.8%) for boys, the urban area is judged to be overweight (4.3%) more than the rural area (3. 6%), also the qualifying level (4.1%), against (3.8%) for the college level, however the prevalence of overweight increases from the pre-pubescent stage (0.6%). The post-pubertal stage is the most represented in our sample with more than 50%, compared to 6% for the pre-pubertal stage and 34% for the pubertal stage. The best aerobic performance was obtained in the group with normal corpulence VO2max=48.21 ml.min^{-1} kg^{-1}, with the lowest level of perception of effort (5.9). The cardiorespiratory performance varies according to pubertal stage, a significant decrease in aerobic performance among adolescents can be observed in the city of Kenitra (Morocco).

Keywords: Cardiorespiratory, running test, puberty, weight status, Morocco

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1. Introduction

Adolescence is a period of transition between childhood and adulthood, characterized by important transformations during which physical and psychological capacities change exponentially, it is also marked by the acquisition of future modes of life, in particular the practice of physical activity (PA) [1], Chronological age is not a very good point of reference when analyzing biological data, particularly in children and adolescents, the consideration pubertal stages to analyze physical capacities, currently appears to be a necessity [2]. On a global scale, physical abilities tend to decrease since in 2016 according to the latest work [3], and indicate that 81% of adolescents were physically inactive, and do not meet the current recommendations of the World Health Organization (WHO) on practicing at least 60 minutes of moderate to vigorous physical activity (PA) 3 times per week, thus constituting a risk factor for several diseases.

In Morocco the rate of physical inactivity increased from 86.2% in 2001 to reach 87.3% in 2016 [3], factors such as the recent introduction and rapid proliferation of technology have made children and adults Moroccan adolescents more sedentary [4], other explanations suggest factors such as the hormonal change which characterizes this stage of puberty to which we also add the situation experienced on a global scale due to Covid-19 [5]. When diagnosing individuals' physical responses, it is necessary to take into account the level of aerobic fitness, one of the best indicators of the health-physical fitness relationship in young people [6-7]. The value of maximum oxygen consumption (VO2 max.) in relative terms (ml·kg−1·min−1), a recognized measure and accepted index of aerobic fitness [8], which since the pioneering work of Hill and Lupton in 1926, it became and remained "the gold standard" in exercise physiology to assess aerobic fitness, it is defined as the volume of oxygen used per unit of time during maximal

aerobic activity and is expressed, in particular, in liters of oxygen per minute relative to the unit of body mass (ml min-1 kg-1) [9]. However, since the 1970s, VO2max has tended to decrease with age in both sexes [10]. Which has repercussions on health in general, it has been shown that good aerobic performance has been associated with better levels of self-esteem [11], and also on the good physical health of young people when it is associated with body mass index BMI [12].

The study of the variation of VO2max during adolescence has been the subject of several publications, all of which have confirmed that VO2max remains constant in boys, and decreases in girls after puberty, and that this evolution in both sexes increase at puberty [13-17], others confirm that there are several factors that influence VO2max, including age, body composition [18], [19] Welsman et al [18], pointed out that the changes caused by the effects of age could be related to sexual maturation and fat percentage when he considered age as a factor affecting VO2max. Therefore, he recommended that factors such as body composition, age and sexual maturation be taken into account, especially for boys when assessing VO2max, along the same lines Werneck et al [20] believed that sexual maturation and rate of body fat were the reasons influencing VO2max.

Puberty is affected by other factors such as obesity, which is considered one of the most crucial public health issues of the 21st century worldwide [21]. Studies have shown that childhood obesity presents a wide range of health complications, including precocious puberty, accelerated pubertal rhythm, increased cardiovascular risk, sex hormone disturbances, hepatic and orthopedic problems, and psychosocial comorbidities [22–24]. Over the last decade and due to the accelerated increase in adolescent obesity rates, the two independent variables, VO2max and BMI, have been the focus of studies together [25], which have noted strong correlations in general between VO2max and anthropometric measurements such as weight, height and BMI [26-29]. Other studies have suggested the absence of a difference in weight, height and mass fat between both sexes until the age of 12-13, the period of onset of puberty [30]. Taking into account the above with consideration, that the pubertal classification is more favorable than the traditional classification by age in the study of physiological and morphological aptitudes in the period of adolescence [31-33]. The aim of our study was to determine the influence of different stages of maturation, and weight status, on the respiratory and perceptual response of school adolescents in the city of Kenitra (Morocco).

2. Materials and Methods

2.1. Participants

We conducted this study with a sample of students enrolled in 3 year levels of secondary education of the college and also the 3 levels of qualifying secondary education, the residential setting according to the presence of the establishment in a administrative territory of municipalities (urban or rural). The exclusion criteria were: a chronological age (year, month) less than 11.00 years or more than 18.11 years, also having an exemption in physical education and sports, and being an internal resident (adolescents of (rural commune origin pursuing their studies in an urban commune).

Based on the Tanner 1962 classification [34], participants were asked to compare themselves to the drawings and to inform their perception of the similarity of their own development, and asked about the age at which Ramadan became obligatory for them, we have determined 3 stages: S1 corresponds to the pre-pubescent stage, S2 corresponds to the pubescent stage, S3 corresponds to the post-pubescent stage.

2.2. Anthropometric characteristics

The height in cm of the participants was taken in a standing position using a vertical measuring rod, and the weight in kg was determined using an electronic personal scale (Korona 5818077 KFW 8077 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 weight (in kg) to the square of stature (in m^2), this index is strongly correlated with the level of total fat [35-36], and corresponded best to growth [37], for this reason the WHO considers BMI as a standard for evaluating corpulence, in clinical and research [38]. Then the BMI is reported on the reference curves of the International Obesity Task Force (IOTF) [39], from the IOTF thresholds we can evaluate the corpulence of adolescents, remember that when taking anthropometric measurements, the shoes are removed.

- ***Assessment of aerobic fitness and perception of effort***

The evaluation of VO2max, via the 20 m shuttle run test with 1 min stages [40]. This test remains an international reference in terms of evaluating physical condition in adolescents [41], the participant must complete as many back and forth trips as possible between two lines, spaced by a distance of 20 meters, and synchronize their running speed to the rhythm of an increasingly frequent sound signal, the initial speed corresponds to 8, 5 km/h, and gradually increases by 0.5 km/h every minute, the last level reached corresponds to the maximum aerobic speed (MAS), during our study this speed is converted into a linear running speed[42], it was shown that the maximum speed reached at the end of this event was lower than the speed measured during a track running test, the following equation proposed by Léger et al., 1993[43], can predict this problem:

$$VMA = -8{,}18 + 1{,}82 * MAS \text{ (shuttle)}$$

VO2max (ml min-1 kg-1) is calculated from an equation including the maximum speed reached during the test, gender and weight [44] recommended by (Batista et al., 2013) [45].

$$VO2max = 25{,}8 - (6{,}6 * sex) - (0{,}2 * Weight) + (3{,}2 * MAS).$$

In order to ensure that an individual has reached VO2max, the adolescents' perception of effort "Ranting of Perceived Exertion" (RPE) was also evaluated at the end of the test using an adapted version of the Borg scale (CR-10) modified by Foster in 1996[46], (scored from 0 to 10 with 10 representing a maximum effort which cannot be sustained and the need to interrupt the test).

2.3. Statistical analysis

The results are expressed by their means and their standard deviations according to the pubertal classification. We carried out analyzes of variance (ANOVA) to better express the variation of the different parameters studied according to the different stages of pubertal growth, followed by post-hoc analyzes. A correlational analysis with

Spearman's rank order correlation test between VO2max and BMI, to check the level of relationship that may exist in each growth stage. The significance threshold was set at $p<0.05$.

3. Results and Discussions

A representative sample of 1186 adolescents with a mean age of 15.65 ± 1.98, and presenting a balanced sex ratio (50% girls and 50% boys), was selected from 4 public secondary education establishments (each environment is represented by 1 middle school & 1 high school), in general our population is distributed proportionally according to sex, environment, and level of secondary education (table 1), the post-pubertal stage is the most represented in our sample with more than 50%, compared to 6% for the pre-pubertal stage, adolescents are distributed according to chronological ages between 5%, and more than 18% for age 16+ between 16.00 and 16.11 (the age chronological represents the exact age at the time of the survey, obtained by the difference between the date of the survey and the date of birth).

The distribution of corpulence, showing a prevalence of obesity of 1%, that of overweight of 7.9%, that of underweight of 6.3%, and that of normal was 84.4%. According to table 2, the prevalence of obesity is very significant in urban areas with (6%), compared to (0.3%) found in rural areas, depending on pubertal stages and chronological age it does not exceed 1%. The results also show a double rate of overweight girls (5.1%), compared to (2.8%) for boys, the urban area is judged to be overweight (4.3%) more than the rural area (3. 6%), also the qualifying level (4.1%), against (3.8%) for the college level, however the prevalence of overweight increases from the pre-pubescent stage (0.6%), pubescent (3, 4%), reaching (4%) at the post-pubescent stage, and it is around 2% between a chronological age of between 13-16 years.

underweight is high among boys (3.7%), compared to (2.6%) among girls, in rural areas (3.5%), compared to (2.8%) in urban areas, and by (4.4%) for college education versus (1.9%) for qualifying education, puberty is the stage most affected by underweight (3.7%), versus 3.7% for post-pubescent and less than 1% for pre-pubescent, depending on chronological age it is between 12 and 14 years old by more than 1%, and less than 1% for other ages. The difference was statistically significant (P.=0.028). The prevalence of overweight was 8.25% for girls and 7.15% for boys, but the difference was not statistically significant (P.=0.37). The prevalence of obesity was higher among girls (3.96%) than boys (2.86%), but again the difference was not significant (P. = 0.19). According to table 3, the pre-pubescent stage is more represented by girls (4%), than boys (2%), the same thing for the urban environment with a rate of (4.2%), against (1 .8%) in the Rural environment, however this stage is absent at the level of qualifying education in our sample.

Puberty is well represented by girls (22.7%), as well as boys (20.5%), the same thing for the college level of education with (37.1%), against (6.1%) for the level of qualifying education, however this stage is equally distributed between rural and urban areas. The post-pubertal stage is well presented by boys (27.5%), as well as girls (23.4%), the same percentages were found according to the environment in favor of the rural environment, while the level of qualifying education (43.3%) is the most present at this stage than the college level (7.5%).

Table 4 presents the anthropometric characteristics of the sample according to weight status, all measures increase starting from obesity, towards the form of underweight, while height increases in the opposite direction, the best aerobic performance is obtained in the group with normal corpulence VO2max=48.21 ml min-1 kg-1, with the lowest level of perception of effort (5.9), overweight or obese corpulence presents the highest performance lower (44.8 ml min-1 kg-1), and a high perception of effort (7.73), while the underweight form presents performances between the obese or overweight and the normal with a VO2max=46.52 ml min-1 kg-1), a perception of (6.85). A very statistically significant difference noted in the t-test, in terms of all anthropometric measures, respiratory and perceptual response.

The results in table 5 show an increase in all anthropometric measurements, moving from one stage to another, in the same direction the respiratory response evolves, thus the peak of better performance is found at the post-pubertal stage with 48, 61(ml min-1 kg-1) with a high perception of effort 6.14, followed by puberty with 47.10(ml min-1 kg-1), and a perception of 6.33, and finally the pre-pubertal stage with a performance of 45.63(ml min-1 kg-1), and a perception of effort of 5.27, the ANOVA in terms of all variables showed the presence of a strong significance between Pubertal stages of terms of age, height, weight, BMI, maximum oxygen consumption, and level of perceived physical exertion. Monitoring the intersex evolution of the respiratory and perceptual response during the pubertal stages (figures 1and 2) showed an increase in VO2max in both sexes from the pre-pubertal stage towards puberty with a 4% difference in performance, then a decrease in girls between puberty and the post-pubertal stage the peak of VO2max is at the puberty stage, however the VO2max in boys continues to increase to reach the peak at the post-pubertal stage with more than 37% difference with the performance of girls, the same evolution of the level of perception as that of VO2max in both sexes the only difference is from the pre-pubertal stage the VO2max of boys is high until the post-pubertal stage compared to that of girls, while the level of perception during the pre-pubescent stage is in favor of girls.

The aim of our study was to verify the influence of different stages of maturation, and weight status, on the respiratory and perceptual response of school adolescents in the city of Kenitra, the first objective of our hypothesis was to verify since, the ANOVA did present a very significant difference in terms of all variables, this significance for the VO2max values verified by post hoc occurs between S1 and S3, and S2 and S3, absent between S1 and S2 ($p>0.05$) , depending on sex there is a very significant difference between boys and girls, due to the fact that boys are more physically active than girls [24], the evolution of VO2max during the pubertal stages shows a peak of performance in girls at puberty at the age of 13, similar to Norwegian girls [25], in boys this peak coincides with the start of the post-pubertal stage at the age of 16, the difference in V02max between the both sexes increased from 4% at puberty to reach 14.8% at the post-pubertal stage, these results agree with other studies which estimated the difference in 50% [5], 37% [9], at the age of 16, this difference between the two sexes is related to variations in body composition, boys showing a greater percentage of lean mass during the pre-pubertal years [17], also to the habits of their physical activities and hemoglobin concentration [9].

Table 1: Demographic and anthropometric characteristics of the participants (n= 1186)

		Number (%)
Gender	Male Female	593(50%) 593(50%)
Origin	Rural Urbain	599(50,5%) 587(49,5%)
Level study	Middle school High school	600(50,6%) 586(49,4%)
Pubertal stages	Pre-Pubertal Pubertal Post-Pubertal	71(6%) 512(43,2%) 603(50,8%)
Age classes	11+ 12+ 13+ 14+ 15+ 16+ 17+ 18+	66(5,6%) 144(12,1%) 164(13,8%) 184(15,5%) 195(16,4%) 216(18,2%) 122(10,3%) 95(8, %)
Weight status	Obese Overweight Normal wieght Weight insufficiency	11(1%) 94(7,9%) 1006(84,8%) 75(6,3%)

Table 2: Distribution of weight status of population according to sex, origin, level study, pubertal stages and chronological age

Parameters		**Weight status**			
			Overweight (n=94)	**Normal (n=1006)**	**Insufficiency (n=75)**
Sex	Male Female	6(0,5%) 5(0,4%)	33(2,8%) 61(5,1%)	510(43%) 496(41,8%)	44(3,7%) 31(2,6%)
Origin	Rural Urban	3(0,3%) 8(6%)	43(3,6%) 51(4,3%)	511(43,1%) 495(41,7%)	42(3,5%) 33(2,8%)
Study level	Middle school High school	5(0,4%) 6(0,5%)	45(3,8%) 49(4,1%)	489(42%) 508(42,8%)	52(4,4%) 23(1,9%)
Pubertal stages	Pre-pubertal Pubertal Post-pubertal	1(0,1%) 5(0,4%) 5(0,4)	7(0,6%) 40(3,4%) 47(4%)	57(4,8%) 423(35,7%) 526(44,4%)	6(0,5%) 44(3,7%) 25(2,1%)
Age classes	11+ 12+ 13+ 14+ 15+ 16+ 17+ 18+	1(0,1%) 2(0,2%) 1(0,1%) 0 3(0,3%) 2(0,2%) 1(0,1%) 1(0,1%)	7(0,6%) 9(0,8%) 12(1%) 19(1,6%) 7(0,6%) 21(1,8%) 9(0,8%) 10(0,8%)	52(4,4%) 116(9,8%) 137(11,6%) 152(12,8%) 179(15,1%) 186(15,7%) 104(8,8%) 80(6,7%)	6(0,5%) 17(1,4%) 14(1,2%) 13(1,1%) 6(0,6%) 7(0,6%) 8(0,7%) 4(0,3%)

Table 3. Distribution of pubertal stages according to sex, origin, and level study

Parameters		Pubertal stages		
		Pre-pubertal (n=71)	**Pubertal (n=512)**	**Post-pubertal (n=603)**
Sex	Male Female	24(2%) 47(4%)	243(20,5%) 269(22,7%)	326(27,5%) 277(23,4%)
Origin	Rural Urban	21(1,8%) 50(4,2%)	255(21,5%) 257(21,7%)	323(27,6%) 280(23,6%)
Study level	Middle school High school	71(6%) 0	440(37,1%) 72(6,1%)	89(7,5%) 514(43,3%)

Table 4. Anthropometric characteristics and respiratory response in relation to weight status

Parameter	**Weight status**				**P-value**
	Obese (n=11)	**Overweight (n=94)**	**Normal (n=1006)**	**Insufficiency (n=75)**	
Age (years)	15,59±2,24	15,73±2,07	15,69±1,95	14,98±2,03	*
Height (m)	1,60±0,08	1,62±0,10	1,65±0,1	1,66±0,1	**
Weight (Kg)	76,27±8,16	67,29±9,73	53,79±9,31	40,70±7,41	***
BMI (kg/ m²)	29,64±1,61	25,46±1,65	19,56±2,14	14,62±1,16	***
VO2max ($ml.min^{-1}.kg^{-1}$)	45,09±4,71	44,52±6,69	48,21±6,75	46,52±4,82	***
RPE	8,55±0,82	6,93±1,15	5,90±1,27	6,85±1,27	***

BMI =Body mass index; VO2max= maximum O2 consumption; RPE= perceived exertion
*: P < 0,05; **: P < 0,01; ***: P < 0,001; NS: not significant

Table 5. Anthropometric characteristics and respiratory response in relation to pubertal stages

Parameter	**Pubertal stage**			**P-value**
	Pre-pubertal (n=71)	**Pubertal (512)**	**Post-pubertal (n=603)**	
Age (years)	11,94±0,33	14,23±0,88	17,28±1,02	***
Height (m)	1,57±0,08	1,62±0,09	1,68±0,1	***
Weight (Kg)	45,03±8,28	50,37±9,96	58,63±9,57	***
IBMI (kg/ m²)	18,17±2,98	18,98±3,11	20,71±2,76	***
VO2max ($ml.min^{-1}.kg^{-1}$)	45,63±4,43	47,10±6,33	48,61±7,11	***
RPE	5,27±1,45	6,09±1,16	6,14±1,41	***

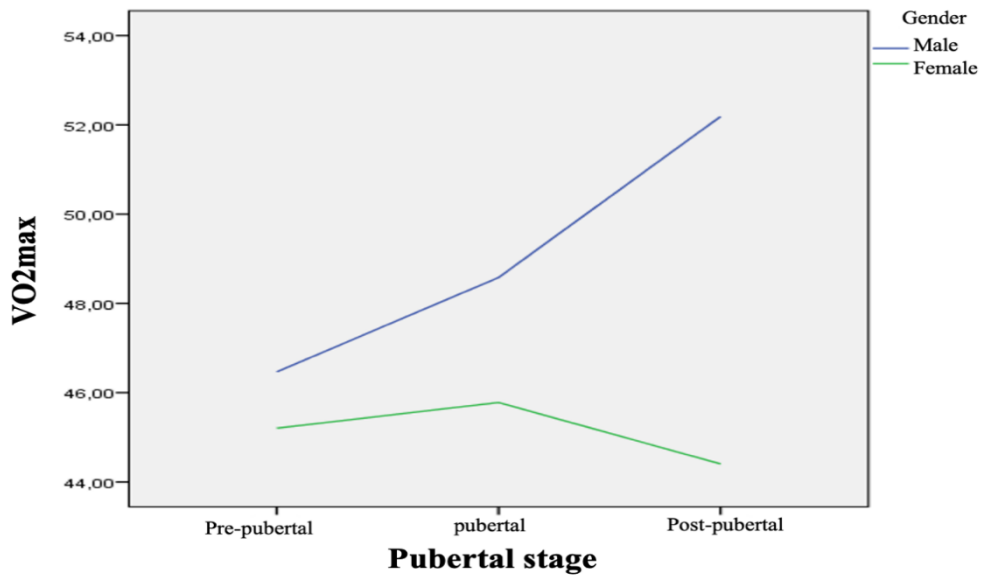

Figure 1: Evolution of VO2max according to pubertal stages in males and females

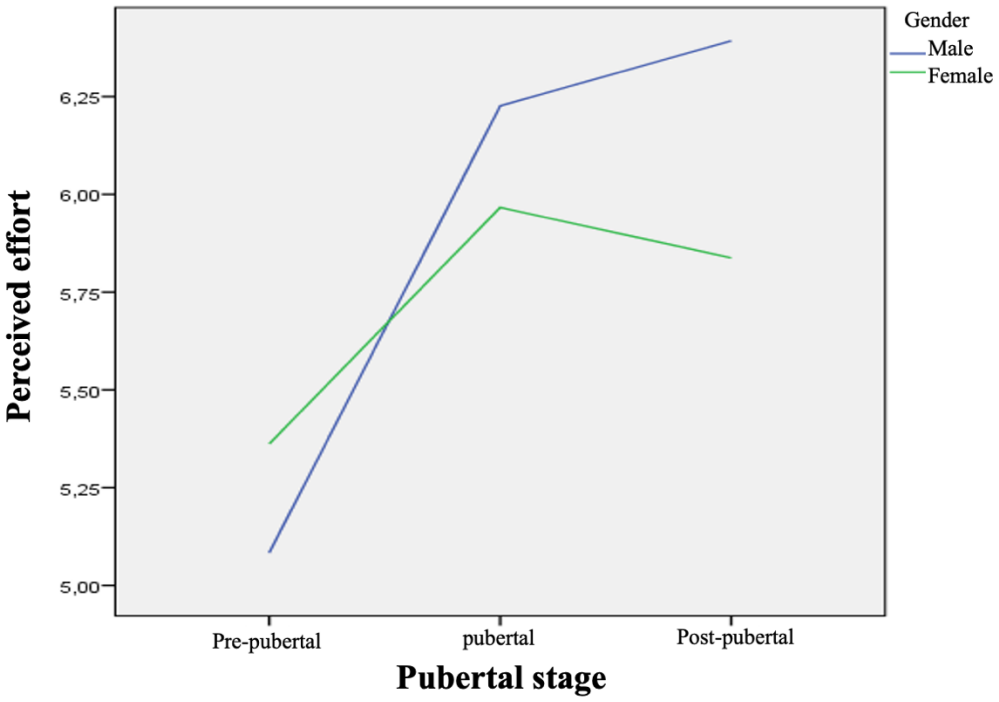

Figure 2: Evolution of effort perception according to pubertal stages in males and females

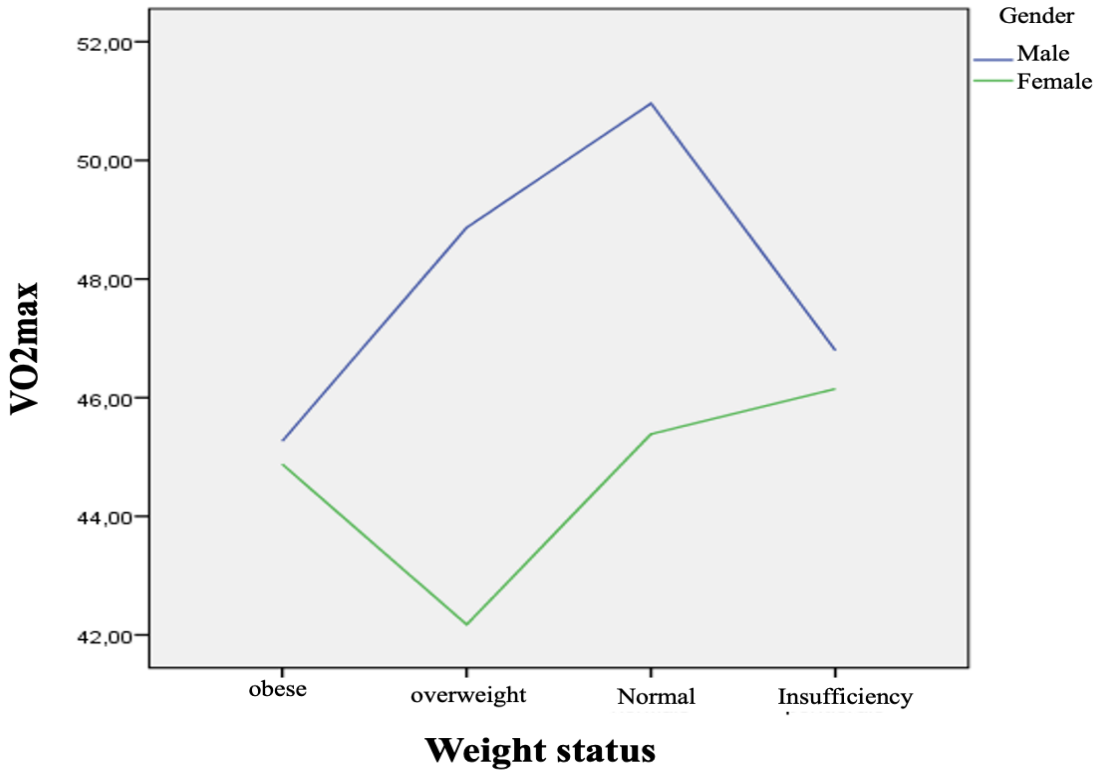

Figure 3: Evolution de la VO2max according to weight status in males and females

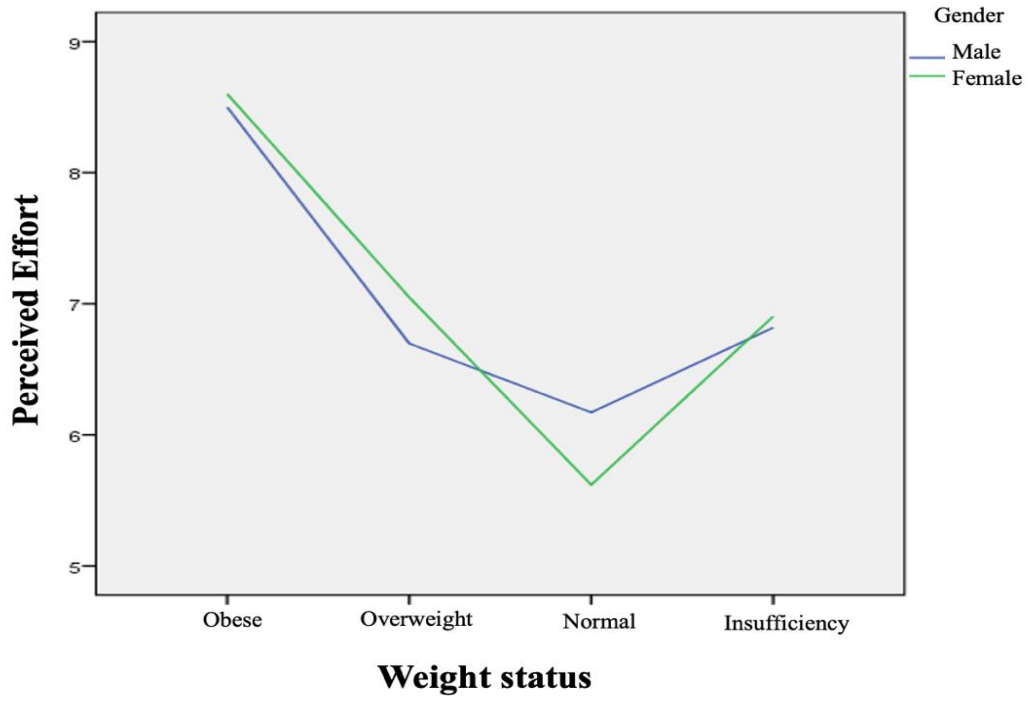

Figure 4: Evolution de la perception de l'effort according to weight status in males and females

The aim of our study was to verify the influence of different stages of maturation, and weight status, on the respiratory and perceptual response of school adolescents in the city of Kenitra, the first objective of our hypothesis was to verify since, the ANOVA did present a very significant difference in terms of all variables, this significance for the VO2max values verified by post hoc occurs between S1 and S3, and S2 and S3, absent between S1 and S2 ($p>0.05$) , depending on sex there is a very significant difference between boys and girls, due to the fact that boys are more physically active than girls [24], the evolution of VO2max during the pubertal stages shows a peak of performance in girls at puberty at the age of 13, similar to Norwegian girls [25], in boys this peak coincides with the start of the post-pubertal stage at the age of 16, the difference in V02max between the both sexes increased from 4% at puberty to reach 14.8% at the post-pubertal stage, these results agree with other studies which estimated the difference in 50% [5], 37% [9], at the age of 16, this difference between the two sexes is related to variations in body composition, boys showing a greater percentage of lean mass during the pre-pubertal years [17], also to the habits of their physical activities and hemoglobin concentration [9].

The decrease in VO2max observed in girls between puberty and the post-pubertal stage is affected by the relationship that exists between age, the quantity of body fat (the accumulation of subcutaneous fat mass during the peri-pubertal years), physical activity, cardiovascular function and perhaps also morphological changes such as reduction in muscle mass [26]. Along the same lines, Welsman and Armstrong [11] compared VO2 max. pre-pubescent girls and boys with groups of pubescent and adult individuals. Their results confirm the increase in VO2 max from pre-pubertal age to adulthood in boys and its decrease between pre-puberty and puberty in girls. This sexual dimorphism is further accentuated at puberty when the quantity of hemoglobin (O2 transporter) is significantly lower and the quantity of fat mass higher (estrogens) in girls. In boys, androgens are responsible for an increase in muscle mass (a large energy consumer). It turns out that in all long-term activities where it is a question of carrying body mass, boys perform better on average than girls.

The results of our study reveal that the perception of effort increases with the intensity of aerobic exercise, the multiple comparison between the pubertal stages showed that the significance of the Anova occurs between S1 and S2 and also S1 and S3, while it is absent between S2 and S3, these data can be explained by the similar psychological state which reigns between puberty and the post-pubertal stage, this difference could be explained by psychological determinants, since the perception of Effort is explained by 66% by physiological determinants (respiratory frequency, maximum oxygen consumption) the rest can be linked to psychological factors [27]. A study have shown that the maximum increase in VO2max occurs during the year that corresponds to the height growth peak in girls coincides with 13 years and boys 16 years and it the girls' growth peak is observed early during adolescence and later in boys [28].

However, the evolution of VO2max in both sexes depending on the pubertal stages showed that in boys the VO2max is constant according to the different stages while in girls it decreases from one stage to another our results seem similar to the studies [21], on the other hand in another study, Welsman and Armstrong [11] compared VO2 max. pre-pubescent girls and boys with groups of pubescent and adult individuals. Their results confirm the increase in VO2 max from pre-pubertal age to adulthood in boys and its decrease between pre-puberty and puberty in girls. This is explained by showing a greater percentage of lean mass during the pre-pubertal years [7]. Due to the metabolic changes occurring during the adolescent period, however obesity, puberty influences aerobic responses [24]. During this period can lead to early signs of puberty in girls and pubertal delay in boys, in This study, the prevalence of obesity was 1%, 7.9% are overweight, and 6.3% are overweight, a prevalence of 7.2% in overweight (obesity included) was revealed among adolescents attending school in Marrakech [3], in Fez overweight adolescents was 7.29%, and that of obesity was 3.41% [25].

Also emphasizing the overweight is double in girls than in boys (5.1% against 2.8%; $p< 0.05$), This difference is observed in a study on Moroccan adolescents but with a large percentage (12, 50% versus 7.81%; $p < 0.05$) [5], also note that the urban area is more obese 6%, than the rural area 0.3%, similar results were found in a study in Morocco [5] , this difference between sex and environment is explained on the one hand, that boys are more active than girls, and by the use of means of transport to go to school, d others share through growth since, after the pre-pubertal stage, there is an increase in fat mass in girls while that of boys decreases. This explanation is confirmed by the evolution of excess weight which increased from 0.7% at the pre-pubertal stage, 3.8% at puberty, to reach 4.4% at the post-pubertal stage. This is explained by the morphological characteristics which increase significantly, during adolescence, particularly at the time of the growth peak [28,30]. higher BMI is associated with earlier maturation.

4. Conclusions

In the context of physical education, teachers should be careful in using thresholds. The evaluation of aerobic fitness thus proves to be a key and essential element, to modify, correct, adjust, select and/or guide the preparation of the young athlete in a way more adapted to his potential. But, instead of Having an increase in VO2max during this period, it is worrying to see the significant decrease in aerobic performance among adolescents in the city of Kenitra, which will undoubtedly have repercussions on the health of our adolescents and especially among girls.

Declaration statement

Ethical approval and consent to participate

The education direction in Kenitra agreed to the study for pedagogical researches. The students who met the inclusion criteria were informed about the objectives of the study and the conditions of participation. Their consent was obtained before beginning the study. The respect of anonymity and confidentiality of information was rigorous. The collected data entry of the students does not contain their identity.

Consent for publication

Not applicable.

Availability of supporting data

The collected data were entered into statistical processing software, and the database of all parameters are available from the author.

Competing interests

The authors declare that they have no competing interests.

Contributions des auteurs

All authors contributed to the acquisition, analysis and interpretation of the data; writing the article, critically revising its content and final approval of the version to be published. All authors contributed to the conduct of this work.

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