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Characterization of the anthropometric profile and physical activity levels of Portuguese adolescents

Abstract

Introduction: Adolescence is one of the most complex transitions in the life span. It is characterized by changes in body composition, dietary intake, physical activity and sedentary behavior. Anthropometry is of special importance during this period as it allows the monitoring and assessment of the changes in growth and maturation. Additionally, adolescent anthropometry provides indicators of nutritional status and health risk, being a crucial tool to diagnose obesity and to the evolution of caloric needs.

Objective: The objective of the present study was to describe Portuguese adolescents' anthropometric profile, Resting Metabolic Rate (RMR) and physical activity (PA) level.

Methods: The sample included 946 adolescents from 6 Portuguese schools aged 15-23 years. Weight, height and waist circumference were measured. Body Mass Index (BMI), waist-to-height ratio (WHTR) and Resting Metabolic Rate were calculated. Physical activity level was self-reported.

Results: In the present study 6 classes were developed to obtain a typology of the adolescents that would describe their anthropometric profile. Boys were significantly taller, heavier and had a significantly higher RMR than girls (p<0.01). The overall prevalence of overweight/obesity was 16.5% and 5.9%, respectively. Only 38.3% of the participants were engaging in "moderate", "intense" or "very intense" physical activity and boys were more likely than girls (50.1% versus 29.2%) to engage in these types of physical activity. No significant global association between age and physical activity was found.

Conclusion: These results are of concern due to obesity and physical inactivity health consequences, alongside with the high probability of both, obesity and physical inactivity to track into adulthood. Therefore, effective and evidence-based public health interventions to increase physical activity and prevent obesity during adolescence are needed.

Keywords: anthropometric profile, physical activity, obesity, adolescents

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Abbreviations:

RMR, resting metabolic rate; PA, physical activity; BMI, body mass index; WHTR, waist-to-height ratio; NHSC, National health and statistics

Introduction

Adolescence refers to the period of the transition from childhood into adulthood.[1] Historically, it has been defined as being between the ages of 12 and 18 years of age, which approximately corresponds to the time of puberty onset to guardian independence.[1] A recent work by some leading scholars has proposed that an expanded definition and timeframe of 10 to 24 years of age corresponds more closely to adolescent growth and general knowledge of this life period.[2]

Adolescence is one of the most complex transitions in the lifespan (National Research Council (US) and Institute of Medicine (US) Forum on Adolescence, 2017) and the most crucial phase of growth from birth to maturity.[3] Physically, the changes include a rapid increase in height and weight, the development of secondary sex characters and alterations in the quantity and distribution of muscle and fat.[4] These changes in body composition accompanied by changes in dietary intake, physical activity (PA) and sedentary behavior put adolescents at an increased risk of becoming overweight/obese and sustaining obesity throughout adulthood.[5] The latest results from the National Food and Physical Activity Survey, in 2015-2016, showed that 8.7% and 23.6% of the Portuguese adolescents were obese or pre-obese, respectively.[6] Maintaining a healthy diet alongside with practicing regular PA are thought to be essential factors for combating this trend.[7] However, the literature consistently suggests that a decline in PA levels is observed during adolescence[8] and only one third of European adolescents aged 11, 13 and 15 years of age are meeting the current PA recommendations.[8] Recent data from Portugal shows similar results, with only 35.6% of youth aged 15-21 years meeting the World Health Organization (WHO) PA recommendations.[6]

Anthropometry is the biological science that studies the measurable characteristics of human morphology[10] and is the most universally applicable, inexpensive and non-invasive method available (Physical status: Technical Report Series, 1995).[11] Anthropometry is of special importance during adolescence as it allows the monitoring and assessment of the changes in growth and maturation that occur during this period. Additionally, adolescent anthropometry provides indicators of nutritional status and health risk, being a crucial tool to diagnose obesity (Physical status: Technical Report Series, 1995).[11]

Therefore, the purpose of the cross sectional study was to describe Portuguese adolescence anthropometric profile and resting metabolic rate. So, we selected the variables weight, height, waist diameter, age and gender to construct the body mass index (weight/height x height), the prediction of RMR variable and the WHTR variable to get a better diagnosis of the amount of abdominal fat. Our clinical experience suggests that this anthropometric variable is more specific than the waist/hip ratio assessment. Finally the categorical variable PA was selected in line with the World Health Organization (WHO) recommendations regarding the need for exercise in adolescence, a determining factor for a healthy life.

Methods

Study sample

The present study included 946 participants from the 9th to the 12th grade and was conducted in 6 Portuguese schools (Lisboa, Palmela, Portalegre, Santo Tirso, Olhão and Tomar) (Table 1), that were available to participate. Adolescents undergoing nutritional counselling or with special educational needs and disabilities were excluded. Ethical approval was received from the Ethical Committee of Centro Hospitalar da Cova da Beira (Covilhã, Portugal) and written informed consent was obtained from all participants.

Procedures

The selected anthropometric variables for the analysis were body weight, height, BMI, WHtR and RMR. Body weight was measured to the nearest 0.1kg with light clothes and no shoes, using a SECA 803 (Hamburg, Germany) scale.

Table 1 Number of students segregated by school and grade

School Grade	9th grade	10th grade	11th grade	12th grade	Total
Professional School Gustave Eiffel *(Lisboa)*	0	59	29	2	90
Secondary School Palmela *(Palmela)*	62	18	1	26	107
Secondary School S. Lourenço *(Portalegre)*	0	4	24	2	29
Secondary School Tomaz Pelayo *(Santo Tirso)*	33	82	51	40	206
Secondary School Dr. Francisco F. Lopes *(Olhão)*	1	93	112	96	302
Secondary School Santa Maria do Olival *(Tomar)*	20	47	67	79	212
Total	**116**	**303**	**284**	**245**	**946**

Height was measured to the nearest 0.1 cm, using a SECA 213 (Hamburg, Germany) stadiometer. BMI was calculated as weight divided by height squared (kg/m^2). Overweight and obesity were determined using BMI according to age- and sex-specific cut-off points proposed by Cole et al.[12] adapting to the participants 18 years old or younger according to standard to the Portuguese reality using the BMI percentile curves by age of National Health and Statistics (NHSC). BMI categories of 25.0–29.9 (overweight) and 30.0 or more (obese) (World Health Organization Technical Report Series, 2000)[13] if participants were over 19 years old. Waist circumference was measured at the umbilicus level (Multi-ethnic Study of Atherosclerosos-MESA,[14]; Ross et al.,[15]) to the nearest 0.1 cm, using a SECA 201 (Hamburg, Germany) tape. WHtR was calculated by dividing the waist circumference by height. The Harris-Benedict equations[16] were used to estimate RMR (kcal/day). Complementarily, two self-reported auxiliary variables of a qualitative nature were also considered: gender (male and female) and PA level (very light, light, moderate, intense and very intense). PA was assessed by a multiple-choice question with the following 5 options: (i) very light exercise (little or casual exercise); (ii) light exercise (light exercise 2-3 times every week); (iii) moderate exercise (moderate exercise 4-5 times every week); (iv) Intense exercise (intense exercise 5-6 times every week) and (v) very intense exercise (very intense exercise, 2 times a day, every week).[17]

Statistical analysis

Firstly, a univariate analysis of the anthropometric variables was performed, through measures of location and dispersion (absolute and relative), order statistics and the asymmetry coefficient. Also, a Box Plot analysis was done to provide a visualization of the empirical distribution of each variable and allow the identification of moderate and severe outliers. Secondly, we performed a bivariate visualization of the data using Scatter-Plots and calculated the Pearson's correlation *coefficient* to measure the statistical linear relationship between two continuous variables (e.g., weight *vs*. BMI).

Then, a Principal Component Analysis (PCA) was performed to identify a small number of latent variables (principal components), linear combinations of the initial centered variables likely to explain a significant part of the total inertia of the anthropometric data. The two retained factors that better describe the linear correlation coefficients between each of the principal components and the variables being studied were elected by examining the Factor Loading matrix. The simple structure of data explained by the first two factors was applied for the construction of an adolescent's typology using the Euclidean distance matrix between any pairs of subjects. In the next step we performed an ascending hierarchical classification by the Ward method for class aggregation. This approach gave us a highlight concerning the number of classes to be considered. Finally cluster analysis by the K-means methods was used to obtain a sample partition into 6 classes, a number that corresponds to the different obesity or pre-obesity risk classifications proposed in the literature. The Wilks' λ test was used to confirm the significant separability of the groups ($p<0.001$). A Chi-square test was also applied to assess the significance of the association between age and physical activity.

All statistical analysis was conducted with *SPSS*, version 24.0 (IBM® Corp., Armonk, NY, USA).

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Results

A univariate analysis of the quantitative variables was performed and can be found in Table 2.

The Box Plot analysis (Figure 1) provides a visualization of the empirical distribution of each variable, its degree of symmetry as well as the identification of moderate and severe outliers according to the following criteria: (a) moderate outliers if x <Q1 – 1.5(Q3 – Q1) or x >Q3 + 1.5(Q3 – Q1) and (b) severe outliers if x <Q1 – 3(Q3 – Q1) or x >Q3 + 3(Q3 – Q1).

The inclusion of severe outliers in the bivariate or multivariate analysis could affect the results, skewing the estimates. Therefore, we decided to exclude at this stage 19 observations where at least one severe outlier was identified. In Table 3 the univariate analysis of the censored sample (n=927) can be found. We not that relative variability of variables weight, BMI and RMR are greater. Using the measure IQR/Median, the variable RMR presented the second highest relative dispersion.

In a second step, we performed a bivariate visualization of the data using Scatter-Plots – this analysis anticipates the fact that only two pairs of variables reveal a weak correlation: BMI versus height and WHtR versus height. For the remaining variables the linear correlation (Pearson) (Table 4) is positive and particularly significant ($p<0.01$).

Table 2 Univariate analysis of the study variables for 946 observations

	No. of observations	Mean	SD	Coef. of Variation	1st quartile	Median	3rd quartile	IQR	Asymmetry coef.
Weight	946	61.157	12.692	0.208	53.000	59.000	67.800	14.800	1.493
Height	946	167.041	9.095	0.055	160.000	167.000	174.000	14.000	0.060
BMI	946	21.848	3.815	0.175	19.500	21.100	23.500	4.000	2.169
WHtR	946	0.446	0.060	0.135	0.409	0.436	0.468	0.059	1.238
RMR	946	1551.209	216.775	0.140	1384.900	1494.400	1693.925	309.025	1.064

SD, Standard Deviation; IQR, Interquartile range

Table 3 Univariate analysis of the study variables for 927 observations

	No. of observations	Mean	SD	Coef. of Variation	1st quartile	Median	3rd quartile	IQR	Asymmetry coef.
Weight	927	60.488	11.385	0.188	52.950	59.000	67.000	14.050	0.875
Height	927	167.072	9.123	0.055	160.000	167.000	174.000	14.000	0.217
BMI	927	21.596	3.222	0.149	19.400	21.000	23.400	4.000	1.102
WHtR	927	0.443	0.049	0.110	0.409	0.435	0.466	0.058	0.788
RMR	927	1543.694	206.243	0.134	1384.100	1488.200	1683.550	299.450	0.864

SD, Standard Deviation; IQR, Interquartile range

In a third step we performed a PCA to identify a small number of latent variables (principal components), linear combinations of the initial centered variables likely to explain a significant part of the total variability of the data. Principal components are new variables that restore a principal part of the initial variability of the data in descending order and exhibit the property of being uncorrelated variables.[18] Therefore, the new matrix constructed by this method can provide an interpretation of the data in a reduced dimension space, minimizing the overall loss of variability on the initial data. In the current situation the anthropometric variables are expressed in different units which shows that the analysis is based on the correlation matrix. So the total variance of the standardized data is equal to 5, the number of variables. The PCA outputs show that the variance of the first component is λ_1=3.19, which means that the first principal axis of inertia accounts for 63.8% of the total inertia. On the other hand, the second principal component has a variance of λ_2=1.45, and therefore the second principal axis explains 28.9% of the total inertia. Thus, the two first principal axis of inertia explain 92.7% of the total inertia and so we consider that is relatively irrelevant to retain any additional axis. The examination of the Factor Loading matrix (Table 5) is crucial for the interpretation of the two retained factors that describe the linear correlation coefficients between each of the principal components and the variables being studied.

Analyzing table 5 we conclude that the first factor is a *"size factor"* positively correlated with all variables. Therefore, the first axis essentially opposes the adolescents with reduced scores in these variables or at least with scores lower than the global average in all or in part of the study variables, to individuals with relatively high values in the set of variables or at least with scores above the global average in all or in part of the study variables. In addition, the second principal axis of inertia essentially opposes adolescents with smaller height and higher WHtR, to adolescents with higher height and lower WHtR, the second factor is a "shape factor". The table 5 allows to represent the study variables in the first principal factorial plane, in the so-called "correlation circle" (Figure 2) where the coordinates of each variable relative to factors 1 and 2 are just the linear correlation coefficients between the variables and the two first principal components.

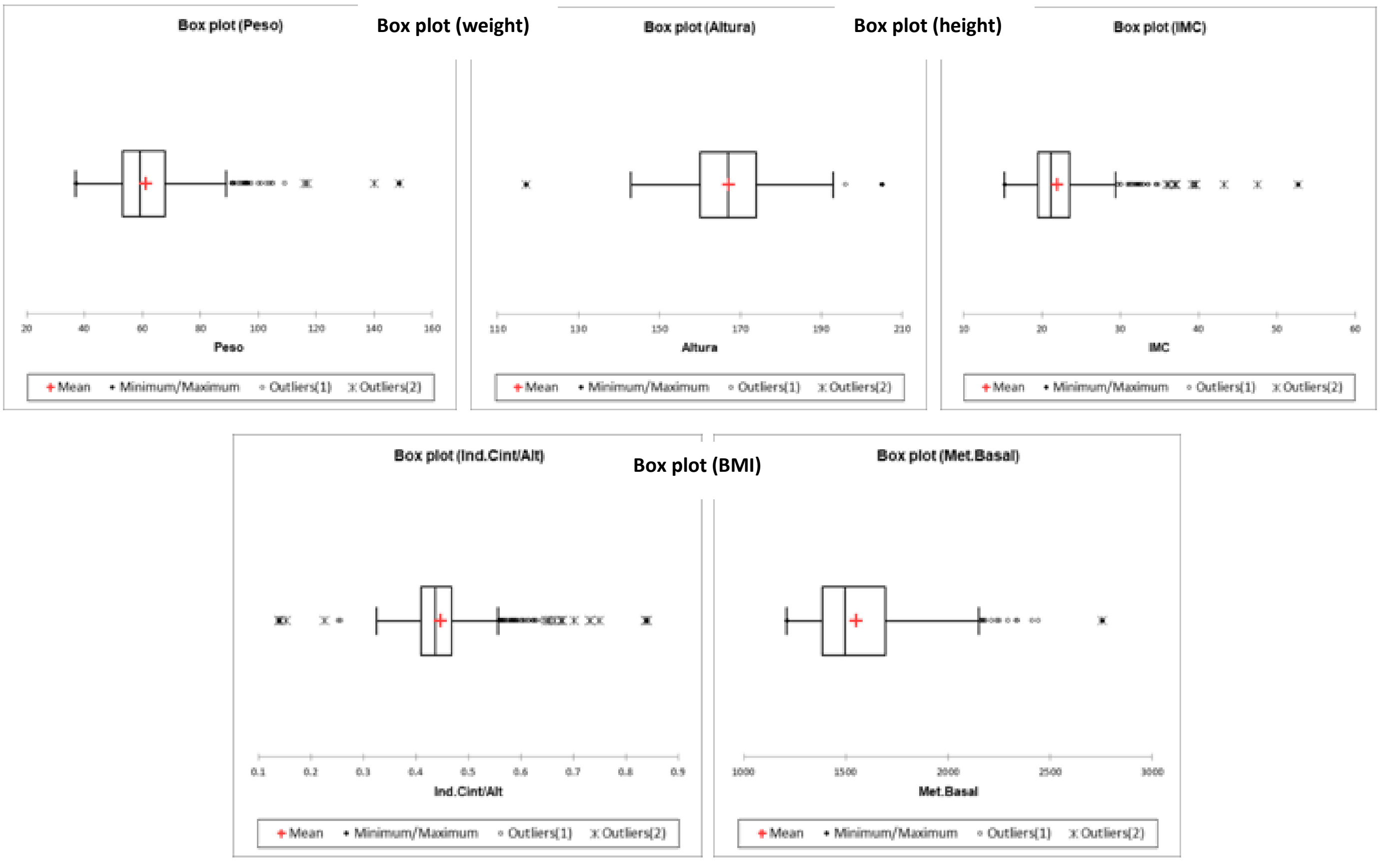

Figure 1 Box Plots of the study variables for 946 observations.

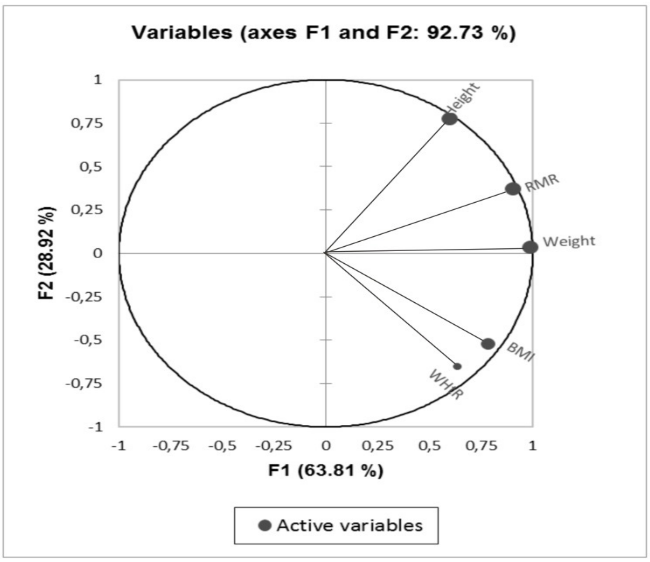

Figure 2 Correlations circle – Representation of the variables on first principal plan.

In fact, all the variables represented here satisfy the condition: r^2(variable, F1) + r^2(variable, F2) ≤ 1, where the first member of this inequality has the following statistical interpretation: it's the part of the variance of each variable in the study (Table 6) explained by the first two factors. In fact, table 6 reveals that two first axes gave a quite completely description of variability inherent to each variable at least 82.8%.

Considering the objectives initially proposed for the statistical characterization of the adolescent population in Portugal attending the 9th, 10th, 11th and 12th grades, we used the characterization of the adolescents explained by the first two factors for the construction of the Euclidean distance matrix between any pairs of adolescents.

From this matrix $D_{927x927}$ we performed an ascending hierarchical classification (Figure 3), taking the Ward method for class aggregation in each interaction of the method.

The dendrogram shows several possibilities of sample partitioning in a number of classes. Considering that we want to obtain a typology of the adolescents that explains their anthropometric profile, possibly identifying different groups at risk of obesity or pre-obesity, we propose 6 classes, according to the specific analysis of the dendrogram (Figure 3, horizontal line).

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Table 4 Linear correlation between variables, ns= non statistical significant

Variables	Weight	Height	BMI	WHtR	RMR
Weight	1	0.60566 p<0.01	0.80730 p<0.01	0.54647 p<0.01	0.89117 p<0.01
Height	0.60566 p<0.01	1	0.02744 ns	-0.06050 ns	0.80753 p<0.01
BMI	0.80730 p<0.01	0.02744 ns	1	0.73182 p<0.01	0.51460 p<0.01
WHtR	0.54647 p<0.01	-0.06050 ns	0.73182 p<0.01	1	0.33636 p<0.01
RMR	0.89117 p<0.01	0.80753 p<0.01	0.51460 p<0.01	0.33636 p<0.01	1

Table 5 Factor Loading of the variables being studied for the retained factors

Variables	F1	F2
Weight	**0.986**	0.035
Height	**0.599**	**0.775**
BMI	**0.796**	**-0.530**
WHtR	**0.635**	**-0.652**
RMR	**0.907**	0.371

Table 6 Reconstituted variance

Percentage of the variance explained by the first two factors	
Weight	97.4%
Height	96.0%
BMI	91.5%
WHtR	82.8%
RMR	96.0%

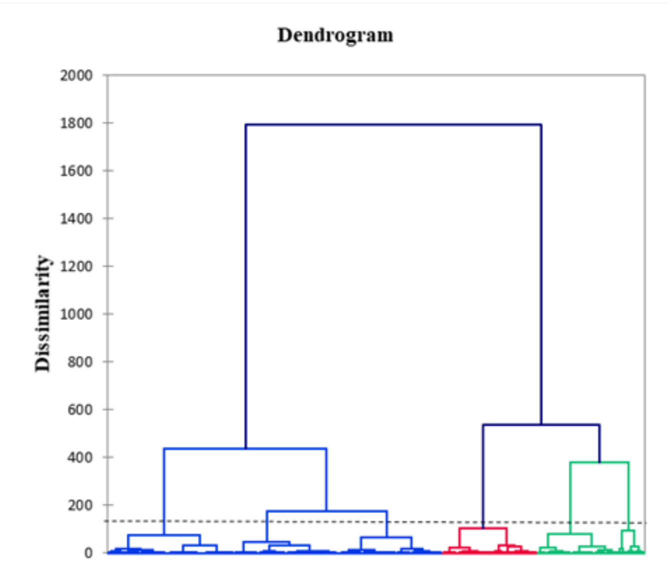

Figure 3 Dendrogram for class definition.

The next step in the cluster analysis is to obtain a sample partition into 6 classes, using the k-means method. The results of this partition are suboptimal and conditioned to the initialization fixed in 6 classes. So, our procedure followed Diday[19] recommendations, validating the stability of results from several initializations of *K-means* clustering. The final solution will be a *local optima* for the within-group variability (maximizing group homogeneity and the between-group variability) that is, the local optima for the separability of the groups. Table 7 characterizes each class through the "gravity center" of the associated sub-cluster.

Using the Wilks' λ test we confirm the significant separability of the groups, that is, the following hypothesis: $H_0 : \mu_1 = \mu_2 = ... = \mu_j$ where μ_i represents-in the target population-the mean of the five-dimension variable j , is rejected with p<0.001. From the analysis of the previous we identify: - Class 1 is composed by 211 adolescents that present a RMR mean value (1349.8 kcal/day) much lower than the overall sample mean, in conjunction with the lowest mean height (1.61m), lower mean weight and a BMI within normal values.

- Class 2 is composed by 222 adolescents that display balanced values for all the variables, with a height significantly higher than the overall mean and a WHtR significantly lower than the overall mean.
- Class 3 is a small group of 42 adolescents who are notable by presenting the highest mean values for all anthropometric variables. This class will include situations of pre-obesity or even obesity.
- Class 4 is composed by 199 adolescents with the lowest mean height and a lower RMR than the overall sample.
- Class 5 is composed by 105 adolescents with a relatively high BMI (25.7kg/m^2) along with a mean height significantly lower than the overall mean and a WHtR that slightly exceeds the internationally recommended limit value (0.5).[20] Even though their RMR is balanced, it represents a group with a potential risk of obesity.
- Class 6 is composed by 148 adolescents with the highest height (1.78m), a balanced mean WHtR (0.449), a relatively high RMR mean value and a relatively balanced mean BMI.

In patients within classes 3 and 5 characteristics, clinical practice should be based in the study of the specificity of each one where multiple factors compete, namely at the genetic level. Rigorous assessment of caloric needs at rest (RMR) and through controlled physical activity can be important steps in the fight against overweight/obesity or at the prevention clinical procedures.

Complementary, class 4 has the second highest WHtR which suggest further clinical study on abdominal fat accumulation.

Table 7 Gravity centers for the clusters

Class	Weight	Height	BMI	WHtR	RMR
Class 1	48.691	161.209	18.727	0.402	1349.777
Class 2	59.655	173.333	19.882	0.418	1591.447
Class 3	89.712	173.571	29.845	0.550	1955.088
Class 4	54.839	159.080	21.668	0.455	1396.334
Class 5	67.621	162.314	25.694	0.504	1547.036
Class 6	72.802	178.318	22.914	0.449	1827.550

The previous brief statistical characterization does not consider gender segregation. Hence, in table 8 we can find each of the 6 classes stratified by gender, allowing us to make the following observations: (i) classes 1, 4 and 5 are mainly composed by females; (ii) on the contrary, classes 2 and 6 are mainly composed by males; (iii) this double situation confirms the level of homogeneity in the partition into 6 classes generated by the k-means method; (iv) class 3 has the highest gender balance, despite two thirds of the group being females. Except for WHtR, there is a significant difference in the remaining anthropometric variables, as it would be expected.

The gender differentiation evidenced in the factorial plane is explained by the significant difference of the mean weight ($p<0.01$), mean height ($p<0.01$) and RMR ($p<0.01$), with the mean values being significantly higher in males. Regarding BMI and WHtR there is no significant difference between the mean values of these anthropometric variables in these two sub-populations.

Table 8 Gravity centers stratified by class and gender

Class	Gender	N	Weight	Height	BMI	WHtR	RMR
	F+M	211	48.691	161.209	18.727	0.402	1349.777
1	F	180	48.635	160.667	18.826	0.401	1333.370
	M	31	49.013	164.355	18.152	0.405	1445.042
	F+M	222	59.655	173.333	19.882	0.418	1591.447
2	F	55	60.318	170.418	20.784	0.417	1462.580
	M	167	59.436	174.293	19.585	0.418	1633.889
	F+M	42	89.712	173.571	29.845	0.550	1955.088
3	F	14	87.000	166.357	31.450	0.551	1709.300
	M	28	91.068	177.179	29.043	0.550	2077.982
	F+M	199	54.839	159.080	21.668	0.455	1396.334
4	F	183	54.869	158.929	21.718	0.454	1387.446
	M	16	54.494	160.813	21.100	0.459	1497.988
	F+M	105	67.621	162.314	25.694	0.504	1547.036
5	F	88	67.339	161.511	25.839	0.505	1513.052
	M	17	69.082	166.471	24.947	0.502	1722.953
	F+M	148	72.802	178.318	22.914	0.449	1827.550
6	F	4	72.750	178.250	22.900	0.428	1595.200
	M	144	72.803	178.319	22.914	0.449	1834.004

Additionally the difference between the mean RMR for boys in classes 1 and 3 was quite significant ($p<0.01$) and within the girls subpopulation the difference between the mean RMR for the classes 1 and 3 was also significate ($p<0.01$).

In the final step of this study we performed a PCA where each class is represented by its center of gravity and where the qualitative variables "gender", "PA" and "age" are supplementary elements projected on the first factorial plane. As expected, the first two axes explain almost all total variance (99.7%), with the first principal axis contributing with 72.4% and the second axis with 27.3% (Figure 4).

The first axis hierarchizes the groups according to the intensity of the anthropometric values, separating the G1, G2 and G4 groups from the G3, G5 and G6 groups. The representation of the 6 classes in the first factorial plane and the modalities of the "gender" and "PA" variables shows the gender disparity in PA, with most girls practising "light" or "very light" PA.

In fact, the positioning of the modalities of the "gender" and "PA" variables on the principal plane 1-2, reveals the very distinct behavior of the 2 genders in PA practice. Table 9 quantifies this differentiation - 70.8% of girls practiced "light" or "very light exercise", whereas 49.9% of boys practiced these types of exercise; girls were much less likely (29.2%) than boys (50.1%) to practice "moderate, intense" or "very intense" exercise.

Complementarily, the reading of the factorial plane 1-2 does not seem to show a significant effect of the factor *age* in the practice of PA, particularly in the "very light", "light" and "moderate" categories. To understand the nature of the association between age and PA, a contingency table (Table 10) and the respective profiles table of the age classes regarding the categories of PA (Table 11) were constructed.

This table shows that the differentiation between the age classes profiles is relatively localized: in the class of adolescents with at least 20 years of age, 41.3% of these adolescents' practice "very light" exercise, as opposed to the other classes where this percentage does not exceed 28.1%. But this class has also the highest percentage of adolescents who practice "intense" exercise (15.2%), as opposed to the remaining classes that practice between 12.2% and 13.6% of this type of exercise. Additionally, in the class of adolescents aged 15 or 16 years, 40.7% practice "light" exercise, in contrast with the remaining classes where the practice of this type of exercise varies between 25% and 36.5%.

Table 9 Type of PA segregated by gender

	Very Light	Light	Moderate	Intense	Very intense
Girls	30.0%	40.8%	21.2%	7.1%	1.0%
Boys	23.3%	26.6%	26.8%	20.8%	2.5%
Total sample	27.1%	34.6%	23.6%	13.1%	1.6%

Table 10 Contingency table between age and PA

	Very Light	Light	Moderate	Intense	Very intense	Total
≤ 16	29	50	27	15	2	123
17	54	77	61	28	5	225
18	68	97	64	34	3	266
19	62	74	51	30	4	221
≥ 20	38	23	16	14	1	92
Total	251	321	219	121	15	927

Table 11 Age classes profiles

	Very Light	Light	Moderate	Intense	Very intense
≤ 16	0.236	0.407	0.220	0.122	0.016
17	0.240	0.342	0.271	0.124	0.022
18	0.256	0.365	0.241	0.128	0.011
19	0.281	0.335	0.231	0.136	0.018
≥ 20	0.413	0.250	0.174	0.152	0.011

Considering now all the sample (n=946) and using the BMI Portuguese percentile curves by age from National Centre for Health and Statistics (NCHS), the prevalence of overweight and obesity segregated by gender is summarized in Table 12. In this sample, 18.0% of girls and 14.6% of boys were overweight/obese.

Table 12 Prevalence of overweight and obesity segregated by gender.

	Overweight	Obese	Overweight/obese
Girls (n=534)	62 (11.6%)	34 (6.4%)	96 (18.0%)
Boys (n=411)	38 (9.3%)	22 (5.4%)	60 (14.6%)
Total (n=946)	100 (10.6%)	56 (5.9%)	156 (16.5%)

Results are expressed as number of individuals and (percentage).

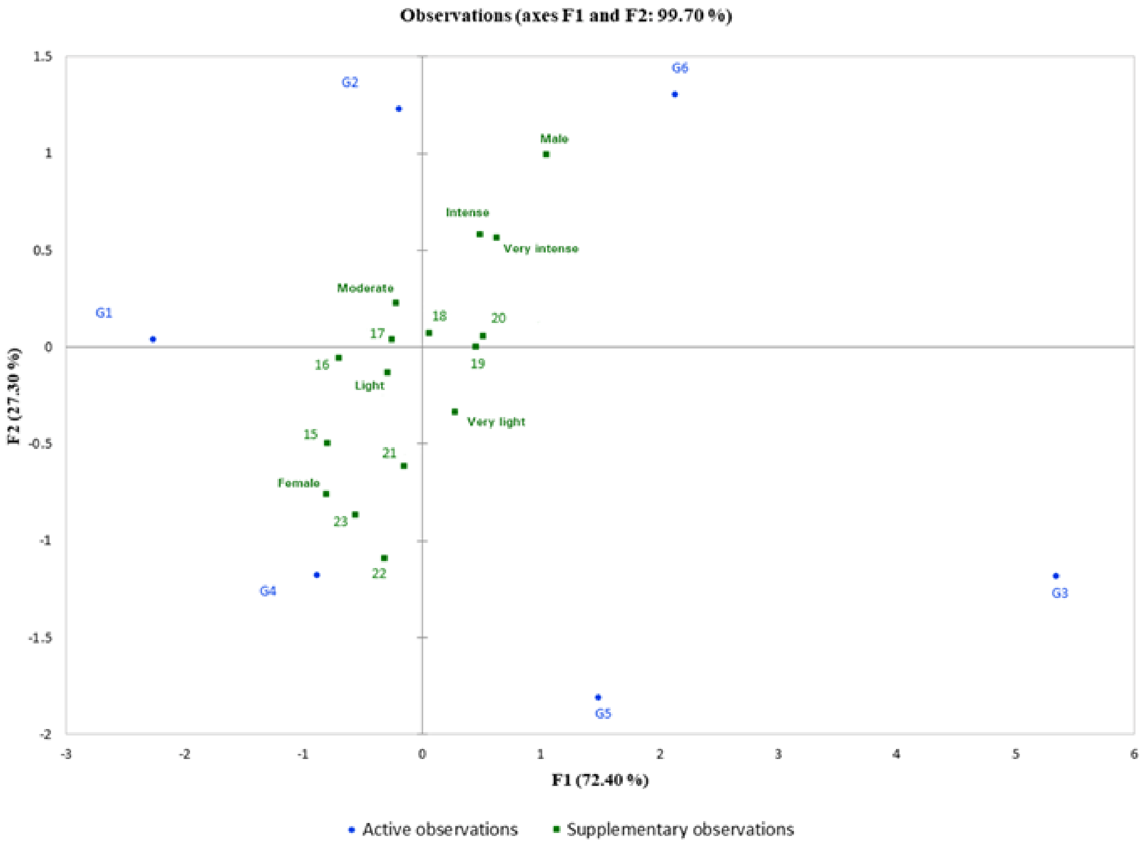

Figure 4 First factorial plane: 6 classes, 7 modalities and age.

Discussion

The objective of this cross-sectional study was to describe Portuguese adolescents' anthropometric profile (weight, height, BMI and WHtR), RMR and PA level.

Most of the variables were positively correlated ($p<0.01$) except for BMI versus height and WHtR versus height (accounted for in the analysis). This was anticipated since adolescents with a high BMI/waist circumference can be either tall or short. Boys were significantly taller, heavier and had a higher RMR than girls ($p<0.01$), whereas no significant differences in mean BMI and WHtR were found between genders. In order to obtain a typology of the adolescents that explained their anthropometric profile, 6 classes were developed. Classes 1, 4 and 5 were mainly composed by females, classes 2 and 6 being mainly composed by males and class 3 (composed by 42 adolescents with the highest mean values for all anthropometric variables) with the highest gender balance, even though two thirds of the group were females.

The overall prevalence of overweight obesity and obesity was 16.5% (girls=18.0%; boys=14.6%) and 5.9% (girls=6.4%; boys=5.4%), respectively. In what concerns PA, only 38.3% of the subjects were engaging in "moderate", "intense" or "very intense" PA and boys were more likely than girls (50.1% versus 29.2%) to engage in these types of PA. There was no significant global association between age and PA.

During puberty, as a result of the anabolic effect of growth hormones, a significant increase in height is observed.[4] Testosterone has a stronger anabolic effect in comparison with the Estrogen group of hormones, explaining a more significant peak height velocity in boys. This difference explains the average height difference between males and females.[4] During adolescence, boys gain between 19 to 20 kg and get 25 to 28 cm taller on average, whereas girls gain 16 to 17 kg and get 20 to 25 cm taller. In girls weight gain occurs largely in the form of fat stores and in boys it occurs in the form of muscle and skeleton mass.[4] This explain the results conveyed here regarding the differences in height and weight observed between boys and girls, which are supported by the literature.[21,22]

RMR is the energy required by the body in a resting condition[23] and is the largest component of daily energy expenditure, ranging from 50% of the total energy expenditure in physically very active individuals and 70% in sedentary individuals.[24,25] As expected, boys' RMR was significantly higher than that for girls. This results are supported by a systematic review conducted in 351 sex-specific publication estimates, showing that the RMR of females (0.839 kcal·kg−1·h−1; 95% CI=0.825–0.853) was lower than that for males (0.892 kcal·kg−1·h−1; 95% CI=0.872–0.912). Since RMR is largely dependent on the amount of metabolically active tissue in an individual, some of the differences found between genders can be in part related to the fact that muscle mass is lower in females than in males.[23] Our research confirmed such difference and additionally revealed quite significant difference between mean RMR within boys groups and within girls groups, comparing classes 1 and 3. Even so, we should emphasize the significant difference in the different groups obtained, almost 500kcal from classes 1 to classes 6. So if we consider the multiplier factor of PA we will widen these differences. This reflection reinforce the markedly individual character of caloric needs, independently of gender, and suggest innovate approaches to evaluate predictive RMR in adolescence obesity classes or with risk of obesity. So, the practical clinical is increasly concerned with the accuracy of such evaluation in order to define a quite adapted individual strategy to fight against overweight/obesity, complementing other potential factor risks previously identified.

Obesity prevalence during childhood and adolescence has increased substantially in the past 3 decades, particularly in developed countries. Nevertheless, a rise in the prevalence of obesity in developing countries has also been observed.[26] In our sample, the overall prevalence of overweight/obesity was 16.5%. Furthermore, obesity/overweight prevalence was 18.0% among girls and 14.6% among boys. The prevalence of overweight/obesity was lower than that reported in other Portuguese studies in adolescents, [6,27,28] where overweight/obesity prevalence ranged from 16% to 27.6% and 21% to 36.7% among girls and boys, respectively. Obesity arises from a complex interaction of a wide-range of non-genetic and genetic factors,[29] which are not yet fully understood. However, nations where obesity rates are the highest are simultaneously, the ones that show the lowest compliance with PA recommendations.[30] A systematic review conducted by Pate et al.[31] in 2013 concluded that there is enough evidence to support the association between low PA and excessive fatness in children and adolescents.

Despite the extensive evidence that PA provides numerous benefits to adolescents' physical, mental and social health, epidemiological studies still show that more than half of the young people worldwide are not meeting the current PA recommendations of at least 60 minutes of moderate to vigorous PA per day. [31,32] International European studies place Portugal amongst the countries that have a low level of compliance of the PA guidelines during adolescence.[27] A recent cross-sectional study involving 276 adolescents (56.9% girls) between 12-15 years of age from a public school in the city of Vila Real, concluded that the PA levels of Portuguese adolescents is undoubtedly insufficient, with only 17.8 % of the adolescents meeting the WHO recommendations (girls 10.83 % and boys 26.89%).[34] Data from the latest National Food and Physical Activity Survey collected using the short version of International Physical Activity Questionnaire, showed that only 35.6% of the youth with 15-21 years were meeting the WHO recommendations.[6] Similarly, in our study less than half (38.3%) of the adolescents were engaging in "moderate", "intense" or "very intense" PA, and probably meeting the WHO recommendations. Moreover, differences were observed between boys and girls, with girls being less likely than boys to engage in "moderate", "intense" or "very intense" PA. This is a persistent finding in the literature[6,21,27,30] and a relatively recent systematic review that described the variation of PA levels in the population, in cross-European Countries showed that generally, boys were more active than girls independently of the measurement method or reported outcome variables used across the 30 studies included in the review.[35]

Establishing healthy patterns of PA during adolescence is of extreme importance, as PA tracks from adolescence to adulthood, however PA levels appear to be declining among young people.[27] In Portugal, a 10-year trend analysis of two cross-sectional cohorts of adolescents aged 12-18 years, using identical methods, reported a considerable decline in the total levels of PA between 2006 and 2016 (-10.8%), as well as a small and declining proportion of adolescents that were meeting the international PA recommendations (10.7% in 2006 versus 8.1% in 2016).[32] The previous findings reflect the fundamental changes in society that have taken place in the last decades leading to a reduced demand for PA and simultaneously presenting barriers that reduce PA.[36] This more sedentary lifestyle results from reductions in active transport, increased use of technology and the restructuring of the home/family environment. In addition, increased concern about crime has reduced outdoor playing (Institute of Medicine (US) & National Research Council (US); Pate et al.,).[36-38] Even though these changes may represent major challenges to promote PA in adolescents, the literature indicates that PA levels can be increased.[39] However, increasing PA at the community level will require the implementation of effective public health programs that can reach a large number of adolescents.[36]

Conclusion

In the present study six classes were developed to obtain a typology of the adolescents that would describe their anthropometric profile. Boys were significantly taller, heavier than girls (p<0.01) due to the anabolic effect of males' growth hormones. Boys also had a significantly higher RMR than girls (p<0.01) due to differences in body composition and therefore, in the amount of metabolically active tissue.

Analyzing these classes we observe maximum mean RMR differences of the order of 500 kcal which highlights the importance of individual assessment of caloric needs.

In this sample the overall prevalence of overweight/obesity was 16.5% and only 38.3% of the participants were engaging in "moderate", "intense" or "very intense" PA. Boys were more likely than girls (50.1% versus 29.2%) to engage in these types of PA. These results are unsettling due to obesity and physical inactivity health consequences, alongside with the high probability of both obesity and physical inactivity to track into adulthood. Therefore, effective and evidence-based public health interventions to increase physical activity and prevent obesity during adolescence are needed.

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