ORIGINAL ARTICLE

Body composition analysis for non-athlete urban schoolgirls in the pubertal stage

George Danut Mocanu[1ACDE], Madalina Gabriela Postelnicu[1ABE], Andreea Maria Adam[1ABE], Gabriel Murariu[2ACE], Vladimir Potop[3,4ADE]

[1] *Faculty of Physical Education and Sport, "Dunarea de Jos" University of Galati, Romania*
[2] *Faculty of Sciences and Environment, "Dunarea de Jos" University of Galati, Romania*
[3] *Department of Physical Education and Sport, University of Pitesti, Romania*
[4] *State University of Physical Education and Sport, Republic of Moldova*

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Abstract

Background and Study Aim
Body composition analysis by bioimpedance is a modern investigation method that provides additional and relevant information, compared to the classical assessment, based only on BMI levels. The purpose of the research is to compare body composition parameters for secondary school girls, according to the stages of puberty and to identify the differences that appear between these stages.

Material and Methods
The investigated group was made up of 115 non-athlete girls from the urban environment, divided into two distinct age categories: 10-12 years/55 cases (Under 12 with age=10.97±0.40, BMI=19.53±3.71, percentiles BMI=65.52± 25.78) and 12-13 years/end of puberty/60 cases (Over 12 with age=12.30±0.30 BMI=20.72±3.62, BMI percentiles=66.13±28.23). The assessment carried out with Inbody 720/Biospace (Korea).

Results
Reporting to the percentile ranges indicates the absence of Underweight cases for the Over 12 group and only 7.27% of the Under 12 group falls within these values. In both groups, the Normal Weight class dominates (67.27% for Under 12 and 63.34% for Over 12), and the percentages of Overweight and Obese cases are higher for Over 12 (23.33% and 13.33%, respectively). The distribution according to body composition indicates the slim type for about a quarter of the students of both groups, but also the placement of a large number of subjects in the Chubby/normal type category (29.10% for Under 12 and 20% for Over 12). According to the percentage of mass fat, the Over 12 group has a double percentage of Obesity for high level, compared to Under 12 group (23.33% vs. 10.90%). The Over 12 group has statistically higher values ($P<0.05$) for body fat mass (BFM), Skeletal lean mass (SLM), fat free mass (FFM), total body water (TBW), Skeletal Muscle Mass (SMM) and has a much higher number of cases reporting abdominal obesity/ waist-to-hip ratio (WHR) (33.34% vs. 14.55%).

Conclusions
The analysis of body composition by bioimpedance allowed the precise identification of the ratio between the main components of the body, clearly highlighting the cases with problems related to the very high percentage of fat mass. In this sense, for many girls who fell according to the BMI percentiles in the Normal Weight category, the low percentage of muscle tissue and the excessive amounts of fat generated the reclassification in the Chubby/normal type or Obese/excessive fat type categories. The results confirm the increase in percentages of overweight and obese children for the last stage of puberty.

Keywords: students, puberty, body composition, obesity, fat mass, lean mass, fitness score

Introduction

The onset of puberty varies according to individual characteristics, this stage (with an average duration of 3-4 years) being defining in terms of secondary sexual characteristics, changes in body composition, functional changes and psychological transformations [1, 2]. Children grow rapidly in height and weight at puberty, but the evolution of these transformations is variable, and there can be large individual differences between these variables for the same chronological age [3]. During puberty, the defining elements of body composition (lean mass (LM), fat mass (FM), bone mineral content (BMC), etc.) provide relevant information regarding the nutritional status and potential conditions/ diseases of future adults. The metabolic changes influence the growth and the development of the body, sexual dimorphism at puberty being obvious [4]. The manifestation of early onset of puberty in obese children of both sexes may also be influenced by adipokines, which influence the HPG/ hypothalamic-pituitary-gonadal axis [5].

Obesity in young generations is a phenomenon that has gained momentum in recent years and is seriously affecting the long-term health of future

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adults. The earlier onset of puberty for overweight and obese (especially girls) supports the idea that body fat influences neuroendocrine processes more rapidly compared to lean children [6, 7]. The manifestation of obesity during childhood and adolescence signals an imbalance between high caloric/energy intake and energy expenditure deficit. This problem is influenced by a complex of genetic, biological, hormonal, environmental, dietary, cultural, etc. factors. Young people's preference for sedentary activities involving modern technologies and the considerable limitation of physical activities explain why in the US 6% of adolescents suffer from severe obesity [8]. For overweight and obese children, a faster and earlier growing up was found compared to the thin/lean children, they present higher values of height and FM, aspects that require their monitoring, in order to prevent the metabolic and cardiovascular diseases to which they are exposed [9]. Lean mass (LM) and fat mass (FM) influence bone health in children and adolescents, but the influence of Lean mass (LM) on bone parameters is stronger than that of fat mass (FM). Even for overweight and obese youth, improvements in bone parameters would be primarily due to LM and not to the increases in FM, according to Sioen et al. [10]. The disadvantages of obesity on muscle performance are obvious: lower antigravity muscle strength values, agonist muscle damage, functional limitations, poor relative muscle strength results [11]. Soft lean mass (SLM) at the level of body mass is dependent on the quantity and quality of proteins, body composition values in children being a relevant indicator of long-term health [12]. For children of both sexes, higher fat free mass (FFM) values are associated with lower risks of early onset of puberty, compared to cases where these values are lower, and rapid increases in anthropometric values indicate higher risks of early onset of puberty [13].

Young Danish women descended from women with gestational diabetes mellitus (GDM) have higher risks of having higher values of weight, BMI; waist-to-hip ratio (WHR), low percentages of muscle mass, high percentages of body fat, as well as an early onset of puberty [14]. For young girls in 6 provinces in China (ages 9-19), early onset of puberty is associated with being overweight or childhood obese [15]. Analyzes of Danish children found that high BMI values and being in the overweight and obese categories are associated with earlier puberty for both genders, according to Brix et al. [16]. The evolution of anthropometric parameters and BMI values for Spanish children at puberty/Barcelona is analyzed for each year separately. In this way, 5 stages of puberty are determined in girls, in the range of 8-13 years: very early maturity (8-9 years, early maturity (9-10 years), intermediate maturity (10-11 years), late maturity (11 –12 years) and very late maturity (12–13 years). BMI values show a slight increase or even stagnation for the first 4 years, then an obvious increase: 17.5, 17.7, 17.6, 17.8, 18.4, respectively, according to Carrascosa et al. [17]. Body composition analysis for adolescent girls in Spain (14-17 years, Madrid) revealed that high percentages of body fat are associated with sedentary behavior and low values of cardiovascular and muscular fitness. By comparison, these performances are better in subjects with low fat mass percentages, but for girls, physical activities, diet and physical fitness level explain only 17% of the variance in body fat percentage [18]. The good quality of the diet during childhood in the Netherlands (up to 10 years) is correlated with higher values of FFM/fat free mass, weight and height, but also with lower FM, thus limiting the risk of adiposity [19]. A 3-year longitudinal study involving young Italians (11-14 years) revealed an increase in parameters associated with adiposity only for girls, and a decrease for boys. Even though there are fewer cases of overweight/ obesity among girls, their perception of body image indicates greater dissatisfaction than that of boys, according to Toselli et al. [20].

The assessment and prediction of the metabolic syndrome for obese young people is easier by calculating BMI values, even if this variant does not provide information related to the distribution of adipose tissue in the body, an aspect that is indicated in detail by the body composition analysis. Careful monitoring of body composition has an important role in placing subjects in the normal weight category, the role of physical effort for reducing body fat being important [21, 22, 23]. The constant involvement in physical activities of adolescents, athletes and other population categories during the Covid-19 Pandemic was important for ensuring a high value of FFM/fat free mass and reducing FM, with favorable effects on physical performance and health [24, 25, 26]. Reduced physical activity time in Australian children (11-12 years) is associated with increases in trunk and total body fat. Promoting moderate-vigorous physical activities (MVPA) is beneficial for body composition [27].

Even if the variant of using BMI presents the advantage of a non-invasive investigation, it has limitations regarding the identification and comparative analysis of the amount and percentages of muscle tissue vs. adipose tissue. In some situations, the increases in BMI associated with being in the overweight category can be generated by the presence of a high percentage of muscles. For this reason, bioimpedance body composition analysis provides additional details regarding FM, FFM/ and the distribution of muscle mass and fat across different body areas [28].

Purpose of the Study. Our study aims to identify the differences that appear between the stages of puberty in non-athletes urban girls, regarding the manifestation of obesity levels and body composition values, using the bioimpedance analysis technique.

Materials and Methods

Participants

The investigated group (115 females) was made up of non-athlete students, but medically fit for physical exertion, selected from 5 secondary schools in different districts of the city of Galati. 2 investigation groups were defined, the first consisting of 55 schoolgirls (10-12 years old) and the second of 60 schoolgirls from the last stage of puberty (12-13 years old). Average values related to age and anthropometric characteristics are summarized in table 1. All study participants had the consent of their legal guardians for involvement in this study. The Over 12 group has higher average scores for all parameters summarized in the table, so advancing in age generates increases in all anthropometric indicators.

Research Design

The research was planned between March 20th and April 7th, within the University Center of Physiotherapy and Medical Recovery within the Lower Danube University in Galati. Body composition analysis was performed with the Inbody 720/Biospace (Korea) device. The students were informed about the purpose of the research and all the rules related to the protection of personal data were respected [29, 30]. The main data provided by the analysis were selected: Protein(kg), Mineral(kg), BFM (kg), TBW (L), SLM (kg), FFM (kg), TBW (percent), Protein percent, Mineral percent, BFM (percent), SMM (kg), SMM ratio percent, BFM ratio percent, WHR. We also used the parameters associated with the distribution of lean mass by body zones and segments, as well as additional data: body cell mass (BCM, kg), BMC (kg), basal metabolic rate (BMR, kcal), arm muscle circumference (AMC, cm), arm circumference (AC, cm), Target weight (kg), Weight control (kg), Fat control (kg), Muscle control (kg), Fitness score (points).

Statistical Analysis

For the statistical calculation it was used SPSS Software (Statistical Package for the Social Sciences/ IBM Vers.24 Chicago, IL, USA. The normality of the data distribution was verified by the Kolmogorov–Smirnov test, in order to compare using parametric methods. Levene's Test for Equality of Variances, Independent Samples Test t and size effect expressed by Cohen's d values were used. The confidence interval was set at 95% [31, 32].

Results

The summary of the investigations is presented in tables 2-6, and for the clarification of the terms used and the easier understanding of the results, we have also included some graphs provided by the software. Charts 1-10 are provided through the software associated with the InBody 720 device. The methodology of its use is presented in its technical book [33].

Table 2 shows the divisions of the 2 groups according to the placement of the students in the 4 BMI levels (Under Weight, Normal Weight, Overweight, Extreme Overweight/Obese), but by calculating the percentiles and reporting the results at these intervals, according to World Health Organization data [34]. We noticed the small number of those in the Under Weight class for the Under 12 group and the fact that they are missing from the Over 12 group. In both groups, the Normal Weight category dominates, with over 60% of the participants. We highlight the increase in the percentage of Overweight and Obese

Table 1. Average values for age and anthropometric parameters for the two investigated groups

Group	Age	Height	Weight	BMI values	percentiles	Z score BMI
a. <12	10.97±0.40	153.30±8.15	46.30±11.02	19.53±3.71	65.52±25.78	0.45±1.05
b. >12	12.30±0.30	157.20±5.56	51.17±9.29	20.72±3.62	66.13±28.23	0.54±0.95

Table 2. Classification results for the Under 12 and Over 12 groups according to Obesity Degree by BMI percentiles

Levels	Percentiles interval	Group	Percentile Average/SD	BMI Average/SD	No cases	Percent
Underweight	< 5th	<12	0.70±0.34	13.20±0.00	4	7.27%
		>12	-	-	0	0%
Normal Weight	5th to < 85th	<12	62.50±15.44	18.50±1.31	37	67.27%
		>12	50.84±24.67	18.41±1.91	38	63.34%
Overweight	85th to < 95th	<12	88.07±2.31	21.20±0.92	8	14.56%
		>12	90.40±2.99	23.51±1.14	14	23.33%
Extreme Overweight/Obese	⩾ 95th	<12	97.30±1.28	27.86±2.79	6	10.90%
		>12	96.27±0.96	26.82±1.33	8	13.33%

cases for the Over 12 group, the end of puberty in girls generates an increase in the number of cases that exceed the optimal body mass values (36.6%), so at this stage one in 3 girls is overweight or obese, while for the Under 12 group only 25% of the girls are overweight or obese.

The body composition analysis provides more detailed information and the possibility of dividing the batches into several levels/qualifications (table 3), with the body fat/BF% values as a benchmark: (Slim type, Normal type, Chubby but normal type, Obese/ excessive fat type, Obesity for high level). It is noticed that the progressive transition from level 1/slim type to level 5 Obese is characterized by an increase in the average values from one level to another of the percentile, BF% and abdominal obesity/WHR, but also a decrease in protein%, where the highest values are those from the slim type and normal levels, and the lowest are those from the obesity level. Both groups have a little over 25% of participants in the slim type category, but for the Over 12 Group there is an obvious increase in cases of obesity and high-level obesity (approximately 40% of the entire group), while for the Under 12 group the value is lower (about 22%). It is interesting that 29% of girls under 12 and 20% of girls over 12 fall into the Chubby but normal type intermediate category, which indicates slight excesses of body fat. Interesting information emerges from the group comparison of WHR (which provides information related to abdominal adiposity). The Under 12 group has 33 cases (60%) in the normal category, while for the Over 12 group there is a decrease (26 cases – 43.33%). In the category Slight abdominal obese, the distribution is balanced (14 cases – 25.45% for Under 12 and 14 cases – 23.33% for Over 12). The values for the category Abdominal Obesity is lower in the case of the Under 12 group (8 cases -14.55%), while for Over 12 we found an obvious increase (20 cases - 33.34%), so one out of three girls has abdominal obesity at the end of puberty.

Figures 1-4 exemplify the patterns analyzed in tables 2 and 3, including data related to abdominal obesity, expressed by WHR.

Table 4 selects the main body composition data and their differences between the two groups. It is noticed that the Over 12 group has higher average values than the Under 12 group for most variables (BFM, SLM, FFM, TBW, WHR, protein, mineral), which indicates obvious accumulations at the end of the puberty stage. However, significant differences ($p<0.05$) are recorded only for BFM, TBW, SLM, FFM and SMM, but with weak size effect values ($0.2<$Cohen's $d<0.5$). The comparison between the percentage values, however, shows better values of protein%, TBW%, SMM%, for the Under 12 group, but without statistically significant differences ($p>0.05$). The only significant difference in favor of the Under 12 batch is for mineral%. We note higher values of BMF ratio% and WHR in the Over 12 group, which explains the higher percentages of overweight and obese in this group and these are highlighted in tables 2 and 3.

Figures 5 and 6 present the body composition for normal situations and deficit situations regarding the main constituents of the body composition, with the percentage reporting to the body composition ratio standards.

Figures 7 and 8 show the ratio between skeletal body mass and adipose tissue expressed as a percentage. In the first case we have a percentage deficit of fat mass by reference to the normal ratio, and in the second case a too high percentage of fat mass.

Table 5 shows the distribution of lean mass in the upper limbs, trunk and lower limbs. The individual graphs provided by the software also indicate the balance or imbalance manifested between segments (e.g. left and right arm) and between body areas (upper body and lower body). The Over 12 group

Table 3. Classification results for the Under 12 and Over 12 groups according to Obesity Degree by Body Fat

Levels	Group	Percentile Average/SD	BF% Average/SD	WHR Average/ SD	Protein% Average/SD	No cases	Percent
Slim type	a. <12	37.69±28.58	17.48±2.43	0.73±0.05	16.03±0.48	15	27.27%
	b. >12	27.11±17.10	20.05±2.88	0.75±0.02	15.56±0.62	16	26.67%
Normal type	a. <12	65.78±11.19	21.00±1.10	0.78±0.01	15.45±0.23	12	21.83%
	b. >12	57.7500±8.89	19.57±2.24	0.78±0.01	16.30±0.97	8	13.33%
Chubby/normal type	a. <12	71.00±10.94	25.90±1.40	0.79±0.01	14.45±0.29	16	29.10%
	b. >12	74.25±8.38	25.30±1.46	0.81±0.02	14.58±0.26	12	20.00%
Obese/excessive fat type	a. <12	88.20±2.93	31.30±0.99	0.81±0.03	13.36±0.22	6	10.90%
	b. >12	85.42±6.03	31.66±1.00	0.84±0.02	13.28±0.32	10	16.67%
Obesity for high level	a. <12	97.30±1.28	39.43±3.12	0.92±0.03	11.73±0.62	6	10.90%
	b. >12	94.78±2.29	37.57±5.02	0.89±0.02	12.18±1.00	14	23.33%

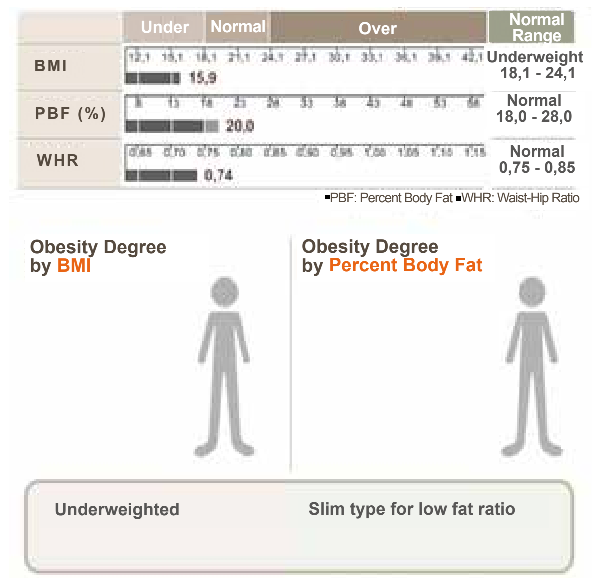

Figure 1. Female 12 years – Fitting in Underweight (BMI), respectively Slim type (percent body fat)

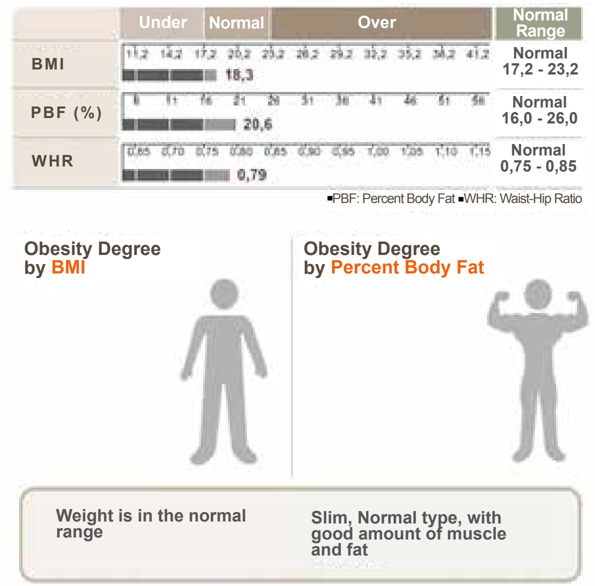

Figure 2. Female 11 years – Fitting in Normal Weight (BMI), respectively Normal type (percent body fat)

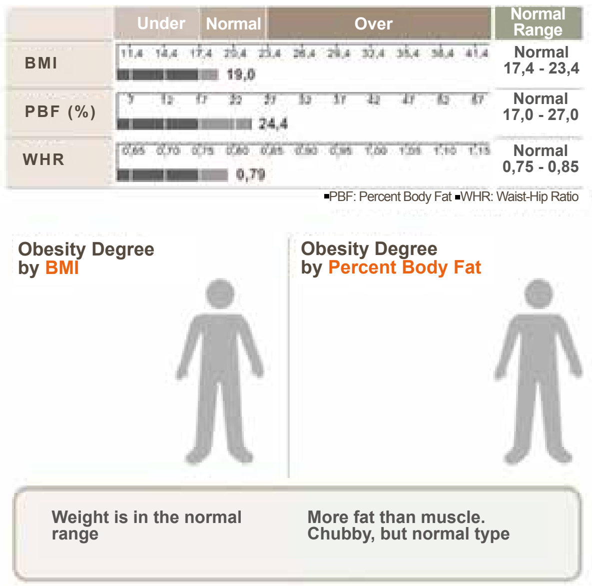

Figure 3. Female 11 years – Fitting in Normal Weight (BMI), respectively Chubby/normal type (percent body fat)

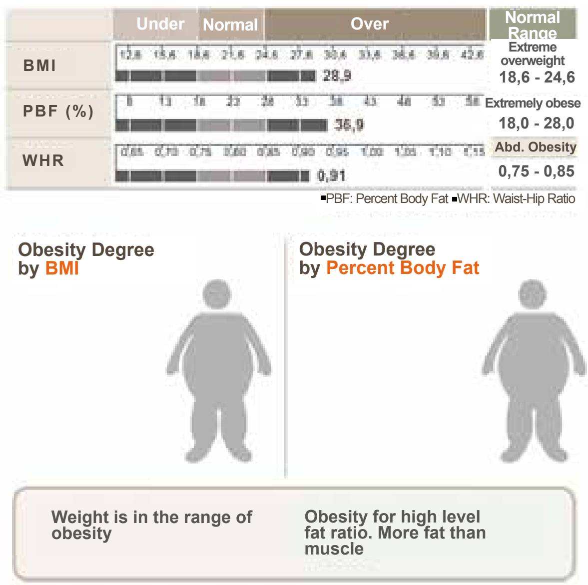

Figure 4. Female 13 years – Fitting in Obesity (BMI), respectively Obesity for high level type (percent body fat)

has (for the comparison in kg of lean mass) for all data pairs significant differences ($p<0.05$), but with strong size effect values only for the differences in the legs (Cohen's d >0.05). However, between the Under 12 and Over 12 groups, the Lean/Ideal lean % indicator shows a balance between the batches, all differences being in this case insignificant ($p>0.05$).

The level of body strength development for the Under 12 group indicates 43 cases (78.18%) of normal Upper body development and 34 cases (61.91%) of normal Lower body development. 8 students (14.55%) are included in the week strength category for Upper body and 16 (29.09%) for Lower body. The smallest number of situations are those of the developed level, with only 4 cases (7.27%) for Upper body and 5 (9.1%) for Lower body. For 23 cases (41.81%) we found the imbalance in strength development between Upper body and Lower body. The same analysis at the level of the Over 12 group indicates normal Strength in 44 cases (73.33%) for Upper body and 42 cases (70%) for Lower body. 10 students (16.67%) have week strength level for Upper body and 16 (26.67%) for Lower body. And for this batch there is a small number of cases with the qualification developed strength: 6 (10%) for Upper body and only 2 (3.33%) for Lower body. For 24 girls (40%), imbalances between Upper body and Lower body development are reported. For both groups, we identified a larger number of girls who have problems related to falling into the weak strength category at the Lower body level, compared to the Upper body, where their number is smaller.

Table 4. Synthesis of the main parameters of body composition and comparative analysis by age groups

Parameters	Group	Mean	Std. deviation	Std. error	a-b	Test t	Sig.	Cohen's d (df=113)
Protein(kg)	a. <12	6.707	1.291	0.174	-0.376	-1.713	0.090	0.322
	b. >12	7.083	1.059	0.136				
Mineral(kg)	a. <12	2.480	0.482	0.065	-0.152	-1.997	0.048	0.376
	b. >12	2.633	0.327	0.042				
BFM (kg)	a. <12	11.860	6.219	0.838	-2.500*	-2.136	0.035	0.401
	b. >12	14.360	6.314	0.815				
TBW (L)	a. <12	25.283	4.871	0.656	-1.689*	-2.175	0.032	0.409
	b. >12	26.973	3.383	0.436				
SLM (kg)	a. <12	32.363	6.225	0.839	-2.253*	-2.264	0.025	0.426
	b. >12	34.616	4.354	0.562				
FFM (kg)	a. <12	34.414	6.602	0.890	-2.395*	-2.270	0.025	0.427
	b. >12	36.810	4.615	0.595				
TBW (percent)	a. <12	55.290	5.231	0.705	1.827	1.777	0.078	0.334
	b. >12	53.463	5.754	0.742				
Protein percent	a. <12	14.685	1.395	0.188	0.388	1.363	0.176	0.256
	b. >12	14.296	1.640	0.211				
Mineral percent	a. <12	5.443	0.497	0.067	0.236*	2.621	0.010	0.493
	b. >12	5.206	0.472	0.060				
BFM (percent)	a. <12	24.601	7.085	0.955	-2.458	-1.769	0.080	0.332
	b. >12	27.060	7.757	1.001				
SMM (kg)	a. <12	18.227	3.865	0.521	-1.466*	-2.349	0.021	0.441
	b. >12	19.693	2.779	0.358				
SMM ratio percent	a. <12	62.200	8.613	1.161	2.680	1.604	0.112	0.301
	b. >12	59.520	9.249	1.194				
BFM ratio percent	a. <12	37.800	8.613	1.161	-2.680	-1.604	0.112	0.301
	b. >12	40.480	9.249	1.194				
WHR	a. <12	0.792	0.061	0.008	-0.024*	-2.173	0.032	0.409
	b. >12	0.816	0.057	0.007				

* The mean difference is significant at the 0.05 level

Figures 9 and 10 indicate variants of balanced and unbalanced distribution of lean mass at the level of the main segments. In the first case, we have a balance in development only between the right and the left arm, respectively between the right and the left leg, but a major imbalance between the development of the muscles between the upper body and the lower body.

Table 6 summarizes the additional data given by the software that provides important information regarding body composition variations between the two groups. The Over 12 group shows significantly better scores only in BCM, BMR, AMC and AC ($p<0.05$). For both groups we note the similar values of Muscle control/the amount of muscle that would be indicated to be added, and for the Over 12 group we note the higher values of the adipose tissue recommended to be eliminated. Also for this group we notice that the average value of Weight control is positive and lower than that of the Under 12 group. The average values of the Fitness score are close and do not indicate significant differences between the groups ($p>0.05$). For the overweight category and especially for the obese, we identified lower BMR values compared to the recommended individual normal range. For Weight control at the level of the Under 12 group, it is indicated that 32.73% should lose weight and 67.27% should add kg. At the level of Over 12, 46.67% receive a recommendation to lose weight and 53.33% to increase body mass. For Fat control 50.91% need to remove adipose tissue and 49.09% should add different amounts of fat for Under 12. For Over 12 the value of those who need to remove fat increases to 56.67%. For muscle control, only 14.55% of the Under 12 group and 20% of the Over 12 group have the optimal amount of muscle

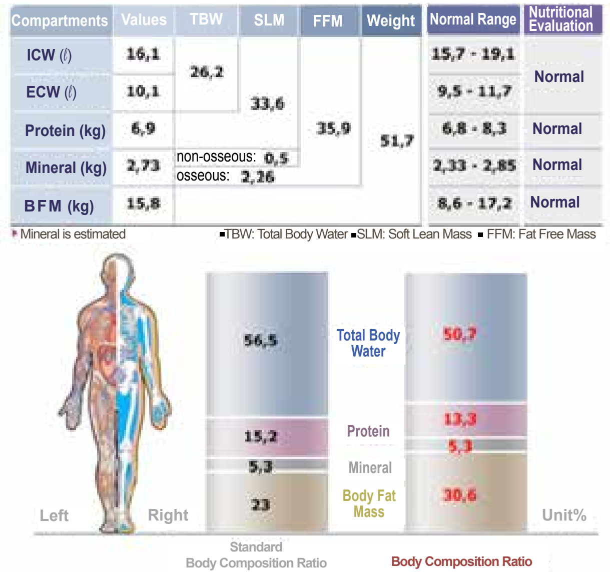

Figure 5. Female 12 years – Normal body composition percentages

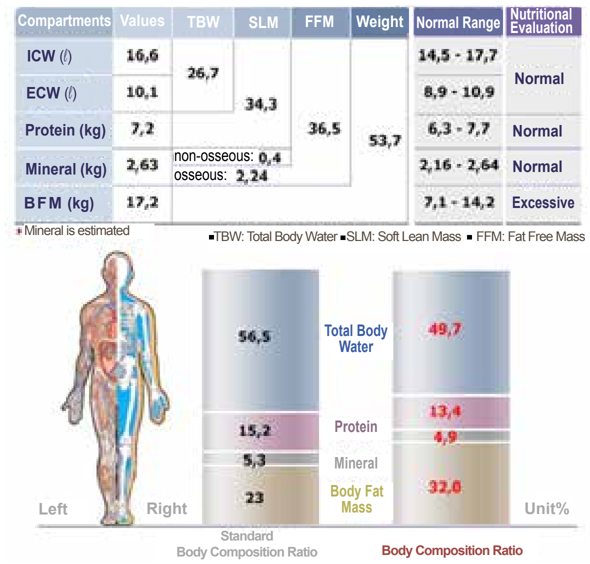

Figure 6. Female 12 years – Excessive percentage of adipose tissue

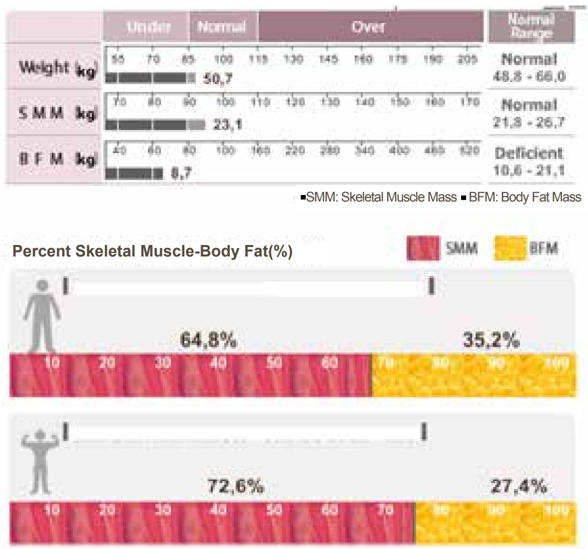

Figure 7. Female 12 years / Fat mass deficient

Figure 8. Female 12 years / Fat mass excessive

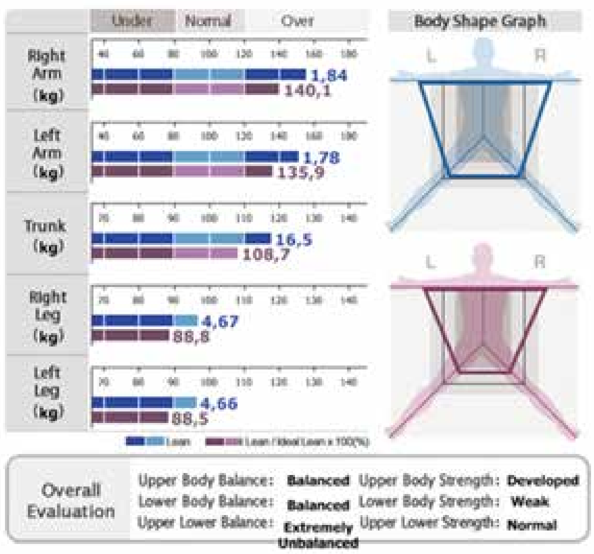

Figure 9. Female 12 years / Imbalance in muscle development by area

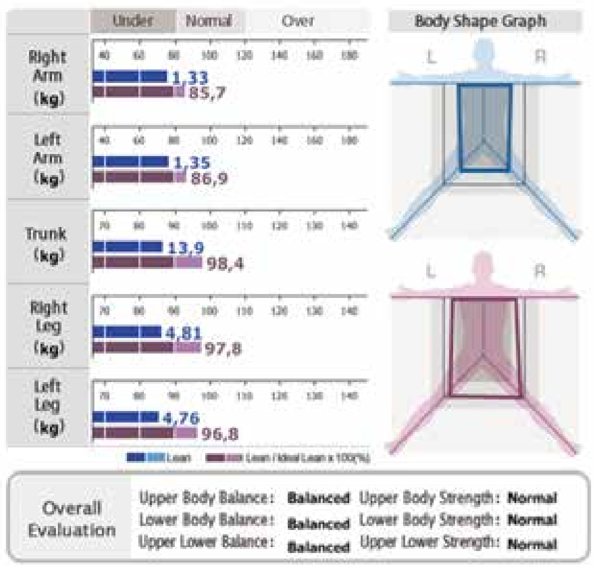

Figure 10. Female 11 years / Balance in muscle development by area

Table 5. Lean mass distribution values for main body areas and lean/ideal lean% ratio

Parameters	Group	Mean	Std. deviation	Std. error	a-b	Test t	Sig.	Cohen's d (df=113)
Lean Right arm (kg)	a. <12	1.452	0.455	0.061	-0.173*	-2.304	0.023	0.433
	b. >12	1.625	0.347	0.044				
Right arm - Lean /Ideal Lean (percent)	a. <12	95.098	15.825	2.133	.27485	0.087	0.931	0.164
	b. >12	94.823	17.745	2.290				
Lean Left arm (kg)	a. <12	1.442	0.450	0.060	-0.205	-2.643	0.009	0.497
	b. >12	1.648	0.382	0.049				
Left arm – Lean/Ideal Lean (percent)	a. <12	94.632	15.509	2.091	0.426	0.136	0.892	0.025
	b. >12	94.206	17.893	2.310				
Lean Trunk (kg)	a. <12	14.583	2.972	0.400	-1.293*	-2.702	0.008	0.508
	b. >12	15.876	2.121	0.273				
Trunk – Lean/Ideal Lean (percent)	a. <12	98.216	5.186	0.699	-0.513	-0.474	0.636	0.089
	b. >12	98.730	6.311	0.814				
Lean Right leg (kg)	a. <12	4.951	1.219	0.164	-0.521*	-2.639	0.009	0.496
	b. >12	5.473	0.888	0.114				
Right leg – Lean/Ideal Lean (percent)	a. <12	95.940	9.194	1.239	-1.606	-0.907	0.366	0.170
	b. >12	97.546	9.742	1.257				
Lean Left leg (kg)	a. <12	4.940	1.188	0.160	-0.523*	-2.699	0.008	0.507
	b. >12	5.463	0.878	0.113				
Left leg – Lean /Ideal Lean (percent)	a. <12	95.710	8.443	1.138	-1.609	-0.968	0.335	0.182
	b. >12	97.320	9.307	1.201				

* The mean difference is significant at the 0.05 level.

Table 6. Comparison between groups for additional data

Parameters	Group	Mean	Std. deviation	Std. error	a-b	Test t	Sig.	Cohen's d (df=113)
BCM (kg)	a. <12	22.212	4.244	0.572	-1.610*	-2.355	0.020	0.443
	b. >12	23.823	3.034	0.391				
BMC (kg)	a. <12	2.071	0.397	0.053	-0.122	-1.957	0.053	0.368
	b. >12	2.193	0.262	0.033				
BMR (kcal)	a. <12	1113.727	142.902	19.268	-51.439*	-2.254	0.026	0.424
	b. >12	1165.166	99.693	12.870				
AMC (cm)	a. <12	20.180	1.996	0.269	-0.916*	-2.621	0.010	0.493
	b. >12	21.096	1.752	0.226				
AC (cm)	a. <12	24.916	3.187	0.429	-1.386*	-2.384	0.019	0.448
	b. >12	26.303	3.051	0.393				
Target weight (kg)	a. <12	47.810	7.610	1.026	-3.679*	-2.995	0.003	0.563
	b. >12	51.490	5.470	0.706				
Weight control (kg)	a. <12	1.520	7.544	1.017	1.200	0.788	0.432	0.148
	b. >12	0.320	8.672	1.119				
Fat control (kg)	a. <12	-1.752	5.938	0.800	1.234	1.053	0.294	0.198
	b. >12	-2.987	6.573	0.848				
Muscle control (kg)	a. <12	3.272	2.385	0.321	-0.033	-0.066	0.947	0.012
	b. >12	3.306	3.032	0.391				
Fitness score (points)	a. <12	72.890	4.067	0.548	1.290	1.541	0.126	0.290
	b. >12	71.600	4.840	0.624				

* The mean difference is significant at the 0.05 level

tissue, the remaining 85.45% and 80% respectively, have the recommendation to add muscle tissue. Fitness score (the lower threshold of 70 points) is met by 83.63% of those in the Under 12 group and only by 73.33% of the Over 12 group members.

Discussion

Other similar researches were analyzed, to which our results were reported, most of them signaling the problem of the manifestation of obesity in the investigated age groups.

The body fat tends to increase in girls with age, with variable values in different regions of India depending on pubertal stage, involvement in physical activity and quality of nutrition. For girls from rural areas (Assam region) values of BF=23.5% at 10 years and 26.1% at 12 years are obtained [35]. Similar aspects are highlighted for girls in Korea, where fat mass increases at puberty are found [36]. A 2-year longitudinal study of Danish children highlighted the variations that occur in changing body composition. The differences between the analyzed parameters (at 9.5 and 11.5 years) are obvious between the 2 moments for girls: Weight=32.3 vs. 40.9kg, Height=138.2 vs. 150.7cm, BMI=16.82 vs. 17.86, Lean mass = 22.8 vs. 28.5 kg, Fat mass = 7.8 vs. 10.4kg, BF%=23% vs. 25%, BMC= 0.846 vs. 1,184 kg [37]. Our research also identified increases in fat mass with age, the measured BF% values being similar.

An increase in childhood obesity has been found in Mexico. Research on a group of 1061 girls and 1121 boys (3-17 years) identified the differences between obesity estimated by BMI alone and that measured by bioimpedance/body composition analysis. Diagnosis by BMI values indicates only 20.1% cases of obesity, while the use of body composition analysis shows much higher values of obesity/BF, of 40.7%. BMI assessment of obesity alone underestimates the diagnosis of obesity in girls by about 30% [38]. Other studies on German youth indicate a high prevalence of adipose tissue for the analyzed samples [39]. These aspects are also highlighted by our study, by reporting as fat mass, the percentage of overweight and obese increases.

Body composition analysis for Chongqing adolescents revealed that girls with delayed puberty had lower scores on FM, FFM, and BF-body fat%, compared to early puberty or normal/on-time puberty groups. The average values of the entire group of girls (11.02 years) are 15.43% for BF%, 5.66kg for FM and 32.74kg for FFM [40]. Our investigation reports similar average values for FFM, but much higher BF% values of 24.6% and 27%, respectively.

Differences in body composition according to age at menarche are found for Brazilian girls. The comparison between G1/absence of menarche and G2/presence of menarche indicates for several age categories higher body composition scores at the G2 level, in most cases. For age ≤11 years, weight=52kg vs. 39.1 kg, height=157cm vs. 147 cm, FM =15.9 vs 8.9 kg, muscle mass=19.7 vs 15 kg. For the age of 13, weight=50kg vs. 52.1 kg, height=169cm vs. 155 cm, FM =13.7 vs 9.9 kg, muscle mass=19.3 vs 16.7 kg [41]. Our groups have similar anthropometric values and FM values, compared to the average of the analyzed samples.

Physical activities and high FFM values are important for bone health and reducing the risks of osteoporosis later in life. Recent investigations carried out on young Germans (248 girls with an average age of 13.4 years) revealed the following data related to anthropometric dimensions and body composition values: Weight=51.3kg, Height=158cm, BMI=20.2, FFM=37.6kg, FM=13.5 kg, BF%=24.9%. Of the analyzed group, 6% are in the Underweight category, 73.4% Normal weight, 9.7% Overweight and 8.5% Obese [42]. Our Over13 group shows slightly lower scores for FFM, but higher for FM and FM%. Our results not registered a single case for Underweight, we have lower percentages for Normal weight and much higher for Overweight and Obese.

Body composition is influenced by a complex of factors. For young people in Taiwan (11-16 years old), the impact of environments that favor or limit physical activities (fitness centers, parks, stadiums, grocery stores, internet cafes, reading rooms, etc.) within a distance of 1 km from schools was studied. Healthier body composition was observed for girls with low densities of reading material rental shops and for boys with low densities of drink and food shops, combined with exercise facilities. For girls, the percentage values for BMI classes are 11.4% for underweight, 67.4% for normal weight and 21.2% for overweight/obese [43]. These percentages are similar to our groups only for the normal weight category.

The first part of puberty is characterized by rapid functional and morphological changes, which induce changes in metabolic rate and energy consumption. Increases of approximately 1kg of fat mass, respectively 4.7kg of FFM/fat free mass for both sexes, at the beginning of the period were found in girls from France. For girls with an average age of 12.76 years, height values of 153.7 cm, weight of 43.9 kg, BMI=18.5, FFM=35.5 kg, FM =9.3 kg, FM%=21.2, AC = 21.9 cm were determined [44]. All of these values are higher for our Over 12 group. Bearing in mind that this study was conducted more than 20 years ago, these data confirm the increasing trend of obesity among young people.

Body composition values for obese Chilean girls (11.5 years) show scores higher than our groups for Weight=58.2kg, BFM=41.5kg, BFM%=41.5%, but other parameters have lower scores: Height=147.8cm, TBW=25.6l, FFM=33.5kg [45]. Our investigation also identified for obese and overweight children lower values of TBW compared to standard values according to age and anthropometric data.

For Estonian girls (10.86 years), positive associations are found between time devoted to sedentary activities and BF%, but also negative associations with FFM. Involvement in moderate and vigorous physical activity/MVPA is positively associated with FFM and negatively with BF%. The average scores obtained by the tested group are: Height=149.9cm, Weight=43.5kg, BMI=19.14kg/m^2, FFM=33.5kg, BF%=22.17, according to Riso et al. [46]. At the level of some groups of young women from Chongqing/China (for the group with average age=13,902 years), the following indicators are obtained when evaluating the body composition: Height=152,894cm, Weight=46,799kg, BMI=19,846kg/m^2, FM=14,632 kg, SLM=31,028kg, BMC=1,497kg. For both sexes and groups by age stages, the positive association between SLM and FM values with MBC and bone density was found [47]. The body composition and optimal growth processes of Indian children are favorably influenced by the reduction of sedentary activities and an adequate intake of antioxidants and protein compounds. For girls with an average age of 12.1 years, the following values are recorded: height=149.5cm, weight=43.1kg, BF%=25.5%, FFM=32.9kg, SMM%=70.2%, bone mass%=4.3% [48]. The values are closer or even weaker than those obtained by our Under 12 group, but it must be taken into account that there are anthropometric and physical development differences depending on the geographical area and race. By comparison with our results, the higher value of FFM percent values for Indian children is highlighted.

A study of Polish girls at puberty (11.55 years) identifies their higher values for adipose tissue and lower scores for muscle tissue compared to boys. The average values recorded are: Height=150.46cm, Weight=43.63kg, BMI=18.64kg/m^2, FM=11.07kg, FFM=32.56kg, BF%=23.96%, SLM=30.88kg [49]. All these values are similar and even slightly lower than our U12 girls group.

Investigations of Nigerian adolescents (10-20 years) revealed positive associations between BF% and age only for girls. BMI and BF% are negatively correlated with SMM and TBW for both genders [50]. Our investigations also observed lower individual BW% values for overweight and obese girls compared to the other BMI levels.

Another research on girls at puberty (11.3 years) identified average values of fat free mass/FFM of 32.6 kg, FM percent=27.3%, total body water percent=57.2%, BMR =1287kcal. The same study highlights the role of the hereditary component in the development of muscle and adipose tissue in childhood, but in adolescence also the environment has an important role in establishing body composition [51]. Our groups have similar scores, but lower results in BMR/basal metabolic rate and TBW%.

Conclusions

The cross-sectional study confirmed the problems related to the percentage increase in cases of obesity for students in the puberty stage, the percentage increases in fat mass being higher in the last phase of puberty for the girls tested. For the Over 12 group, research identified that 40% of the girls are overweight or obese, and 20% are in the chubby/normal type category, an aspect that is an alarm signal regarding the current and future health of young people. This aspect is also reinforced by abdominal fat values, with WHR results indicating that one in three girls has abdominal obesity at the end of puberty. Overweight and obese girls also get the lowest values in the Fitness score. Almost 33% of Under 12 girls and 47% of Over 12 girls receive the weight loss recommendation. For the Fat control values, 51% of the Under 12 girls and 57% of the Over 12 girls need to eliminate fat mass, and for muscle control major deficiencies are found, 85.45% for Under 12, respectively 80% for Over 12 have the recommendation to add muscle tissue.

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Conflict of interest

No potential conflict of interest that is of any relevance to this study was reported by the authors.

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Information about the authors:

George Danut Mocanu; https://orcid.org/0000-0002-3534-5055; george.mocanu@ugal.ro; Faculty of Physical Education and Sport, “Dunarea de Jos” University of Galati; Galati, Romania.

Madalina Gabriela Postelnicu; https://orcid.org/0009-0001-9266-5338; madalina.postelnicu@ugal.ro; Faculty of Physical Education and Sport, “Dunarea de Jos” University of Galati; Galati, Romania.

Andreea Maria Adam; https://orcid.org/0009-0002-1990-9073; andreea.adam@ugal.ro; Faculty of Physical Education and Sport, “Dunarea de Jos” University of Galati; Galati, Romania.

Gabriel Murariu; (Corresponding Author); https://orcid.org/0000-0002-7107-2007; gabriel.murariu@ugal.ro; Faculty of Sciences and Environment, “Dunarea de Jos” University of Galati; Galati, Romania.

Vladimir Potop; https://orcid.org/0000-0001-8571-2469; vladimir_potop@yahoo.com; Department of Physical Education and Sport, University of Pitesti (Pitesti, Romania); State University of Physical Education and Sport (Chisinau, Republic of Moldova).

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