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Research article

Differences in body composition parameters between female handball players and non-athlete girls during puberty

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Abstract: Background and Study Purpose.: The body composition study (Inbody 720/Biospace (Korea)) presents the advantage of a detailed exploration of some complex parameters, which can pro-vide useful information related to the nutritional status and health of those evaluated. The purpose of the research is the comparative analysis of these indicators for pubertal girls, divided in-to two categories: handball practitioners and non-athletes.

Material and Methods. The study participants come from 2 groups: 59 handball players/HB (Age=11.72±.82, Height =157.64±8.62, Weight =53.16±10.36) and 115 non-athletes/NA (Age=11.67±.75, Height = 155.33±7.16, Weight =48.84±10.40). The groups were investigated be-tween March and April 2023. Results. The BMI values obtained were interpreted by calculating the international percentages, for the age range 2-19 years. The group of handball players pre-sents superior values regarding weight, height, BMI percentiles, bone mineral content, body cell mass, basal metabolic rate, arm muscle circumference and fitness score. According to the BMI classification, there are no handball players in the underweight class, and 40% of the HB group and 31% of the NA belong to the Overweight and Obese classes. Better values for lean mass of the HB group are reported for all body areas and body segments, with significant differences compared to the NA group. Fat control recommendations indicate the need to remove more fat for the NA group and add more muscle (over 80% of the components of this group). Both groups have problems with abdominal obesity; approximately a quarter of the students having WHR values within Abd. Obesity. The Strength levels indicator shows better values for the HB group (majority in the Normal and Developed categories), and over a quarter of the NA group has problems at the lower body level (fall within the Weak level).

Conclusions. According to the values provided by Obesity Degree by Body Fat, one third of the female students of both groups have obesity problems, which represents an alarm signal for the health of the young generation, aspects also confirmed by the analyzed studies. The muscle/fat ratio indicates for the NA group lower percentage values for muscle/SMM and higher for fat/BFM, compared to the HB group, so the physical activity specific to handball players has a de-termining role in explaining these values. The results of our study provide important data relat-ed to body composition values in the puberty stage for handball girls. These data are useful as values to which these parameters can be compared in other stages of preparation (the competi-tive phase or the recovery phase after competitions).

Keywords: body composition, handball, differences, fitness score, Body mass index, obesity

1. Introduction

The pubertal stage is characterized by multiple and intense transformations for most of the body organs and systems, including body composition indicators [1,2]. During puberty, differences in body composition between the sexes are noted. Girls show higher amounts of FM/fat mass and men show better values of FF/fat free mass and SMM/skeletal muscle mass. These values influence health at later stages and can predict body composition for future adults [3]. Considering the body composition, boys have higher percentages of muscle mass compared to girls [4].

The absolute amounts and the proportions of the constituent elements in the body (proteins, lipids, minerals, water) change according to life cycles [5]. The increases in intra-abdominal fat mass lead to increased risks of cardiovascular diseases, the development of insulin resistance and diabetes. Obesity among young people is a problem that manifests itself more and more at the global level. Obesity in the case of children is one of the factors that negatively influence the functionality of the joint system, limiting the amplitude and quality of movements [6,7]. Body composition assessment can be done in several ways, Quantitative Magnetic Resonance Imaging (qMRI) being among the most advanced [8].

A study on 3,500 children and adolescents/5-18 years - evaluated at the level of body composition by the bioimpedance method - identified lower fat percentages for boys, who also have a better/higher muscle-to-fat ratio [9]. Reliability at the level of the various versions of the InBody Body Composition Analyzers is studied by [10]. Research shows that indicators related to FM, FFM and BF percentages are faithfully measured, generate small errors and that these devices can be used when DXA/Dual-Energy X-Ray Absorptiometry investigations are not available. Even if the evaluation of BF% (Body fat percentage) - by the method of equations based on bio-impedance and by the use of skin folds/Skinfolds - allows a good classification; there are also sources that indicate inaccuracies in the measurement of body composition in Chilean children [11]. Other studies highlight the need to avoid the use of BMI and the percentage of FM/fat mass for the assessment of obesity, indicating the evaluation and programmed interventions according to the particularities of individual body composition phenotypes. Early onset of puberty in children generates greater increases in FFM and not necessarily FM in the early years compared to those for whom puberty is delayed [12]. The sedentary lifestyle and isolation generated by the Covid 19 pandemic have affected the life quality, the physical condition and increased the incidence of obesity among young people [13–15]. Another study identifies the negative effect of technology on children's health, embodied in the high number of medical exemptions [16].

A synthesis of scientific studies that address obesity in children indicates that the signs of puberty appear more quickly for obese girls, an aspect generated by a complex of factors: nutritional factors, activation of the hypothalamic-pituitary-gonadal axis, disruption of the endocrine system through various chemical substances [17]. Research on separate groups of girls (obese, normal and underweight) from China/Shenyang identified higher estradiol concentration and earlier onset of puberty for the obese girls [18]. Studies on groups of girls from Brazil (8-16 years) have highlighted associations between the existence of excess weight and age, respectively early menarche. Approximately 28.3% of the evaluated girls fall into the excess weight category and 44.3% into the body fat category for those with early menarche [19]. A study targeting earlier menarcheal age in Spanish girls (interval 6-8/13-16 years) confirmed higher values of body weight and fat mass, for cases of early pubertal development (Gavela-Pérez et al., 2015). The presence of premature adrenarche (PA) in young Turkish girls is characterized by higher values of height and body weight, and for this group high percentage values of FM/fat mass, a reduction of the percentage FFM/fat free mass and the percentage of water in the body [20]. Research on Portuguese preadolescent girls (10 years old) demonstrated that for cases with early puberty, (Tanner stage ≥2) a greater amount of adipose tissue is reported; they also present higher values of insulin, glucose and homeostatic model assessment - insulin resistance (HOMA-IR) [21]. Studies on groups of girls have shown that, in the case of obese

groups, there are more cases where early puberty is manifested and cases with menarche, according to [22].

Another research on US/New York City girls identifies delays in pubertal development in girls with prenatal exposure to PAHs/Polycyclic aromatic hydrocarbons [23]. For UK children and adolescents (7-15 years), decreases in some lung function parameters were identified for those with high fat mass values, and higher lean body mass values are associated with improved lung function [24]. An analysis of healthy children and youth (girls aged 9-18) indicates that trabecular morphology at puberty is correlated with body composition, adipose tissue and muscle mass, having a role in maintaining long-term bone health [25]. Other research has found a high prevalence of depressive symptoms in obese children [26]. High levels of BPA/bisphenol A may be associated with higher FM values for US girls (8-19 years), but this is not confirmed for boys [27]. Obesity and unfavorable body image negatively influence self-esteem and increase the risks of aggression from other people [28,29].

The anti-inflammatory nature of high-intensity physical activities and their role in reducing obesity is analyzed by [30]. Reducing dietary energy intake is a solution to reduce the degree of obesity and prevent its associated diseases for youth in Southwest China [31]. Another study points to the relationship between the body composition of young people and their eating habits [32]. The need to control body weight can lead to unhealthy eating habits for handball players [33]. For young people, regular dairy consumption provides superior and significant parameters for bone density/BMD and mineral content/BMC, but the effects on anthropometric dimensions and body composition are insignificant in most research [34]. Reducing the risk for teenage girls to become overweight or obese involves actions in various directions: involvement in sports activities, careful selection of food, the support and education in schools and family [35]. Other studies highlight that the anthropometric dimensions and the level of fitness are influenced by social, economic, geographical and cultural factors, and that the BMI values influence the level of body perception in young people [36,37].

The level of physical training, body composition and physical performance in different sports activities are correlated and conditioned by the quality of training and the systems that support the workload [38–43]. Caloric consumption is closely related to the intensity of effort in sports activities [44]. In handball, the effort has high complexity and involves powerful demands for top performance [45,46]. The quality of training and nutritional supplements influence fitness levels and body composition values [47–49]. The combined use of resistance training with aerobic exercise training for obese adolescents (12 weeks x 3 sessions/week) led to a decrease in fat mass by 3.6%, according to [50]. For overweight teenage girls in Serbia, recent studies identify the effectiveness of the combined application of high-intensity interval training (HIIT) and nutritional measures/interventions to improve body composition and physical fitness level [51]. Other research indicates that the use of different sports materials should be adapted to the weight and BMI values of the practitioners [52,53]. Modern technologies and artificial intelligence offer the advantage of detailed explorations related to body composition and physical problems caused by sports activities [54–56].

Aquatic physical activities are beneficial for increasing bone density and improving body composition indicators for practitioners [57–60]. Physical activities are important in reducing the incidence of obesity for children in primary education as well. [61,62]. Sport specificity generates different values of body composition among handball, volleyball, basketball and soccer players in Serbia, Muscle - Content of body (%), Fat content of body (%), Bone content of body (%), Lean body mass (kg), Ideal body mass (kg). Differences are also reported between the national/elite teams of handball and volleyball from Serbia, according to [63,64] . Research on young Spanish handball players identified a progressive decrease in fat mass% and an increase in lean mass% with the transition to higher leagues/age categories [65]. Lower and significant values of fat mass are identified for male university students (Tunisia) compared to girls of the same age. Excess body fat in girls results in lower performance of muscular strength in horizontal and vertical jump

tests [66]. A study on young Serbian handball players indicates that obesity affects the quality and speed of multidirectional and linear movements [67]. High BMI values for pre-pubertal children affect physical performance. Those classified as overweight and obese have poorer results on tests of muscle strength, speed, agility, balance and endurance, but have similar scores compared to normal weight on tests of flexibility and throw/catch [68]. Most of the studies analyzed by us indicate influences of various sports activities on physical performance and body composition parameters.

The purpose of our research is the investigation of the differences related to body composition values between female handball players/HB and non-athletes/NA from the urban environment during puberty.

Working hypothesis: We estimate that we will record statistically significant differences for most of the parameters associated with body composition between the two analyzed groups, as an effect of the physical effort specific to the handball game.

2. Materials and Methods

2.1. Participants

The research involved two different groups (pubertal girls). The first consisted of 115 non-athletes/NA girls (11.67±.75 years old), included in the study by random selection from schools covering 5 different neighborhoods of the city of Galați. The second group included 59 handball players/HB (11.72±.82 years and seniority in the sport=2.64 years), who come from 4 different clubs in Galati, being included in the junior IV category currently in the preparatory phase/stage (not yet involved in the official competitive phase). The inclusion criteria for non-athletes were the medical consent for participation in physical education classes and also the non-involvement in physical sports activities, which would thus influence the results. The inclusion criteria for handball players were experience and continuity in training for at least 6 months. The main results related to the anthropometric parameters and the classification of the groups by BMI values and percentiles are summarized in table 1. Between handball players and non-athletes we noticed a balance only regarding the average values related to age. For all anthropometric dimensions we found higher values for handball players, who are taller and heavier, have a higher BMI score and a higher fit percentage and Z-scores.

Table 1. Average scores for age and anthropometric dimensions for HB and NA

Group	Age	Height	Weight	BMI values	percentiles	Z score BMI
a. HB	11.72±.82	157.64±8.62	53.16±10.36	21.36±3.41	72.13±24.47	.75±.82
b. NA	11.67±.75	155.33±7.16	48.84±10.40	20.15±3.70	65.84±26.97	49±.99

1.2 Research Design.

The investigation of both groups was planned between March 1st and April 15th, 2023, using the bioimpedance device Inbody 720/Biospace (made in Korea), within the University Center for Physiotherapy and Medical Rehabilitation belonging to the Dunarea de Jos University from Galati. The Inbody 720 device provides a multitude of parameters related to body composition, as do its newer versions (Inbody 770, Inbody970) or with the Tanita device used in such research. From the multitude of results provided by the software, the most relevant were selected, statistically processed and presented in tables: Fitness score (points), TBW/Total body water(L and %), Protein%, Mineral percent%, Body fat mass(kg), Soft lean mass(kg), Fat free mass (kg), Skeletal muscle Mass (kg), Waist Hip ratio, Lean Trunk, Lean Right/Left arm, Lean Right/Left leg, Body cell mass (kg), Basal metabolic rate (kcal), Bone mineral content (kg), Arm circumference, Weight control (kg), Fat and Muscle control (kg) etc. Edma-related data were not included in this study and are the subject of a future scientific article. Both groups were informed about the purpose of the investigation, and the consent of the legal guardians was obtained in relation to the

participation of young people in this study. In this way, all the requirements associated with research involving studies on human subjects were respected and the confidentiality of the data obtained was ensured [69,70]. For the publication of this study the approval of the University Ethics Committee was obtained (CEU no. 466/20.09.2023).

Statistical Analysis. S.PSS/Statistical Package for the Social Sciences/IBM Vers.24 Chicago, IL, USA software was used for statistical data entry and processing. The application of the parametric t test for independent samples was preceded by the assessment of the distribution curve of the normality of the results (Kolmogorov–Smirnov test / Shapiro–Wilk test). In addition, we also calculated the size effect values (Cohen's d). The confidence interval was set at 95% ($p<0.05$), according to [71–73].

3. Results

The calculation of the percentages and the classification on the 4 BMI levels indicate the absence of female handball players for the Underweight level, but the NA group also has few representatives in this classification (table 2). We note the higher percentage of the NA group for the Normal Weight category (65%), both groups having the majority of girls in this level. However, female handball players have higher percentages than the NA group for the Overweight (25%) and Extreme Overweight (15%) categories, so over 40% of the handball players have problems with excess body mass, and for the NA group approximately 31% of the girls are in this situation.

Table 2. Numerical and percentage distribution on the 4 BMI categories (according to Obesity Degree by BMI)

Levels	Percentiles interval	Group	Percentile Average/SD	BMI Average/SD	No cases	Percent
Underweight	< 5th	HB	-	-	0	0%
		NA	.70±.34	13.20±.00	4	3.48%
Normal Weight	5th to < 85th	HB	57.87±22.29	19.00±1.68	35	59.33%
		NA	56.59±21.32	18.46±1.63	75	65.21%
Overweight	85th to < 95th	HB	90.86±3.19	23.46±.99	15	25.42%
		NA	89.55±2.93	22.67±1.55	22	19.13%
Extreme Overweight/Obese	≥ 95th	HB	96.41±.59	27.03±1.34	9	15.25%
		NA	96.71±1.19	27.27±2.06	14	12.17%

The classification on the 5 levels (according to Obesity Degree by Body Fat) offers interesting results (table 3). For both groups, a progressive decrease in protein percentage is observed; by moving from the Slim type and Normal type level to the Obesity for high level, where the lowest values are recorded. For the percentile values, the percentage of adipose tissue and abdominal fat/WHR, the situation is reversed, with a progressive increase in these parameters and the recording of maximum values for the Obesity for high level group. The NA group is more represented in the Slim type category, with almost 27% of girls at this level. For the Normal type category, handball female players have better values, with more than 25%, while NA have only slightly more than 17%. We note higher NA values for the Chubby/normal type category (almost 25%), while the group of female handball players has a little over 18%. For the Obese/excessive fat type level, however, we observe a higher percentage of handball players (17%), compared to 14% for NA. The situation changes for the Obesity for high level level, where the NA group has a slightly higher percentage than handball female players. A total of the last 2 levels of classification (where girls with different levels of obesity are classified) indicates problems

under this aspect for about 34% of handball players and 31% of members of the NA group, so for both groups, one in three girls has obesity problems.

Table 3. The classification values for the 2 groups through the analysis of Obesity Degree by Body Fat

Levels	Group	Percentile Average/SD	BF% Average/SD	WHR Average/SD	Protein% Average/SD	No cases	Percent
Slim type	HB	37.32±18.02	16.22±2.83	.74±02	16.35±.61	13	22.30%
	NA	32.23±23.58	18.80±2.93	.74±.03	15.79±.59	31	26.96%
Normal type	HB	70.40±13.43	20.41±1.56	.79±.01	15.56±.27	15	25.40%
	NA	62.57±10.86	20.43±1.75	.78±.01	15.79±.75	20	17.39%
Chubby/normal type	HB	79.39±18.35	25.60±1.39	.82±.03	14.58±37	11	18.40%
	NA	72.39±9.89	25.64±1.43	.80±.02	14.50±.28	28	24.35%
Obese/excessive fat type	HB	88.64±6.17	29.80±1.00	.85±.03	13.79±.15	10	16.95%
	NA	86.46±5.16	31.52±.98	.83±.03	13.31±.28	16	13.91%
Obesity for high level	HB	95.52±1.79	36.25±3.22	.87±.02	12.47±.60	10	16.95%
	NA	95.54±2.33	38.13±4.54	.90±.03	12.05±.91	20	17.39%

The average values of the 2 groups and the significance of the differences between the main parameters associated with body composition are summarized in table 4. Female handball players have higher values for most situations, but significant differences ($p<0.05$) are reported only for: Protein (kg), Mineral (kg), Total body water (L), Soft lean mass (kg), Fat free mass (kg), Skeletal muscle Mass (kg). At the level of these parameters, we also found average values of size effect (0.5<Cohen's d<0.8). Handball female players also have higher values for the parameters: Body fat mass (kg), Total body water (percent), Protein percent, Mineral percent, SMM ratio percent, Waist Hip ratio, but with insignificant differences ($p>0.05$) and values that indicate the lack of (Cohen's d <0.2) effect. The group of NA girls has values superior to handball female players only in BFM ratio percent, which indicates a lower muscle ratio than handball female players, doubled by a higher fat ratio than theirs. Figures 1-4 represent the graphs of the different classifications according to BMI levels and percent body fat patterns.

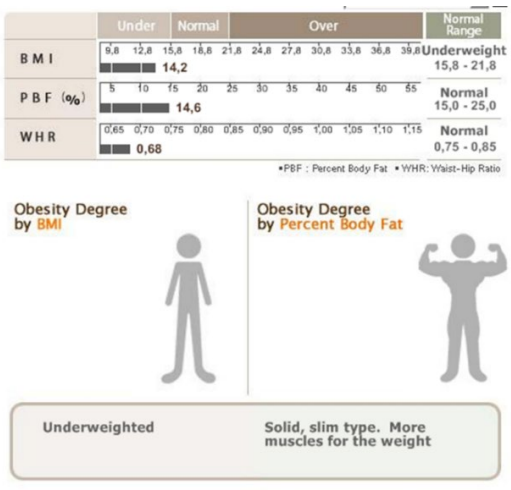

Figure 1. Female NA – Underweight (BMI) and Solid/Slim type (percent body fat)

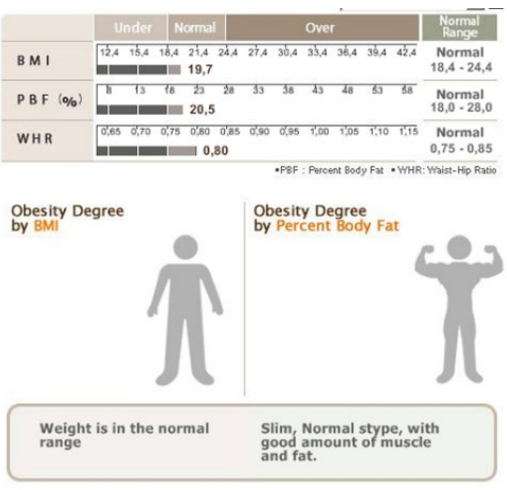

Figure 2. Female HB - Normal Weight (BMI), and Normal type (percent body fat)

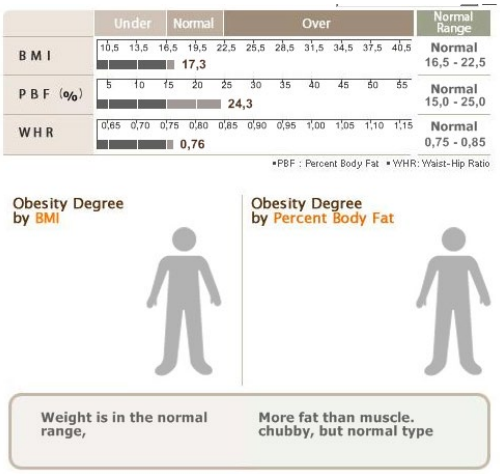

Figure 3. Female HB – Normal Weight (BMI) and Chubby/Normal type (percent body fat)

Figure 4. Female NA – Overweight (BMI) and Obesity for high level (percent body fat)

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=172)
Protein(kg)	HB	7.752	1.269	.165	.849	4.364	.000*	.665
	NA	6.903	1.186	.110				
Mineral(kg)	HB	2.835	.472	.061	.275	3.951	.000*	.602
	NA	2.560	.414	.038				
BFM/Body fat mass(kg)	HB	13.576	5.779	.752	.411	.417	.678	.006
	NA	13.164	6.366	.593				
TBW/Total body water(L)	HB	29.006	4.690	.610	2.841	4.042	.000*	.617
	NA	26.165	4.229	.394				
SLM/Soft lean mass(kg)	HB	37.232	6.040	.786	3.693	4.088	.000*	.623
	NA	33.539	5.426	.506				
FFM/Fat free mass (kg)	HB	39.591	6.431	.837	3.927	4.093	.000*	.624
	NA	35.664	5.755	.536				
TBW/Total body water (percent)	HB	55.162	5.388	.701	.825	.936	.350	.142
	NA	54.337	5.562	.518				
Protein percent	HB	14.730	1.411	.183	.247	1.036	.301	.158
	NA	14.482	1.533	.143				
Mineral percent	HB	5.386	.514	.067	.066	.825	.410	.125
	NA	5.320	.496	.046				
BFM/Body fat mass (percent)	HB	24.733	7.270	.946	-1.150	-.967	.335	.147
	NA	25.884	7.513	.700				
	HB	21.367	3.827	.498	2.375	4.173	.000*	.637

SMM/Skeletal muscle Mass (kg)	NA	18.992	3.408	.317				
SMM ratio percent	HB	62.554	9.020	1.174	1.753	1.215	.226	.185
	NA	60.801	9.012	.840				
BFM ratio percent	HB	37.444	9.020	1.174	-1.754	-1.215	.226	.185
	NA	39.198	9.012	.840				
WHR/Waist Hip ratio	HB	.810	.052	.006	.005	.603	.547	.091
	NA	.804	.060	.005				
* The mean difference is significant at the 0.05 level.								

Figures 5-8 graphically represent body composition distribution variants for the HB group.

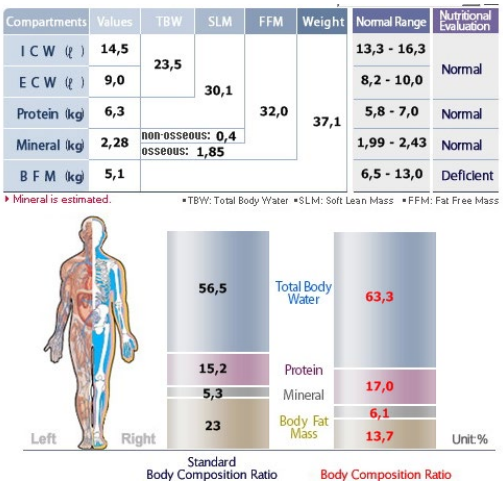

Figure 5. Female HB / Deficient body fat mass

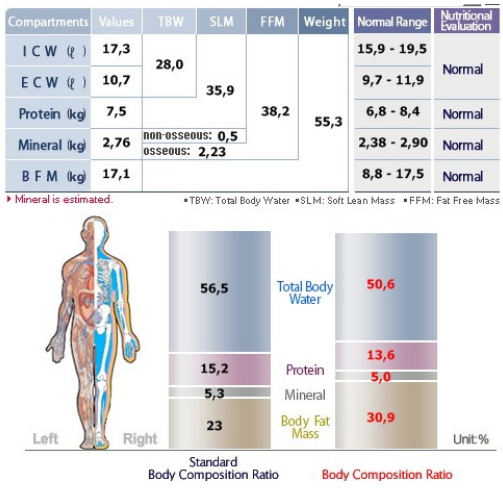

Figure 6. Female HB / Normal body composition percentages

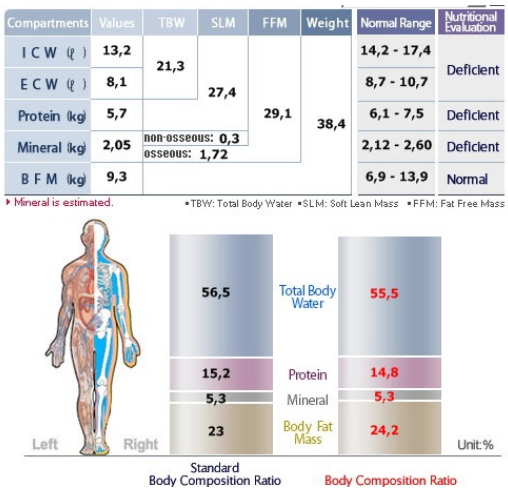

Figure 7. Female HB / Deficient body water, protein and mineral

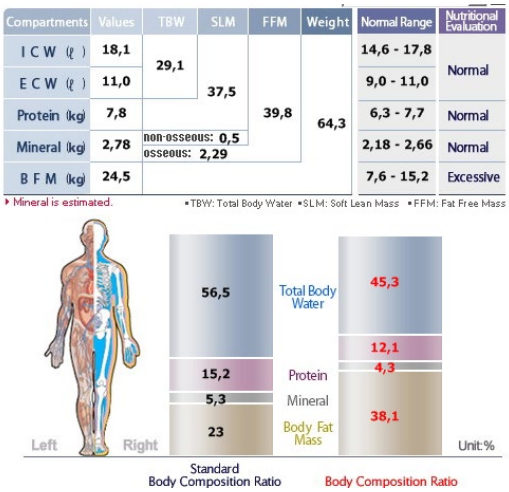

Figure 8. Female HB / Excessive body fat mass

Graphs 9 and 10 show variants of balanced or unbalanced distribution of SMM and BFM (ratio percent) by comparison with the standard values provided by the software.

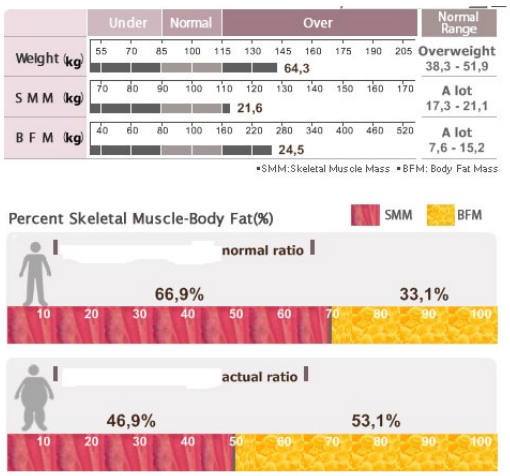

Figure 9. Female HB / imbalanced ratio SMM/BFM (actual ratio)

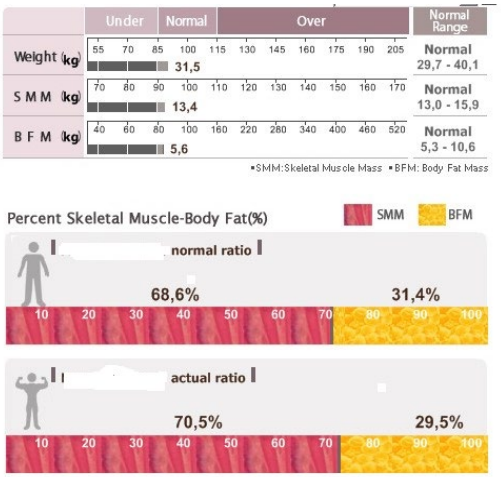

Figure 10. Female NA / relatively balanced ratio SMM/BFM (actual ratio)

The distribution of lean mass for the main body segments and areas is summarized in table 5. For all pairs of data, superior values of female handball players and significant differences ($p<0.05$) are obtained, and the size effect has medium values in most situations ($0.5<$Cohen's d <0.8), but there are also some situations with weak values ($0.2<$Cohen's d <0.5). An interesting fact is that the ratio between Lean / Ideal Lean (percentage) is over 100% for female handball players, for all analyzed segments (so they have on average more lean mass than the standard), aspect that is not confirmed at the level of the NA group, where this ratio indicates a deficit of lean mass (average values are < 100%).

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)	HB	1.787	.414	.053	.244*	3.711	.000	.566
	NA	1.542	.410	.038				
Right arm - Lean /Ideal Lean (percent)	HB	102.871	12.788	1.664	7.916*	3.179	.002	.485
	NA	94.954	16.782	1.564				
Lean Left arm (kg)	HB	1.751	.416	.054	.201*	2.971	.003	.453
	NA	1.550	.427	.039				
Left arm – Lean/Ideal Lean (percent)	HB	100.772	13.108	1.706	6.362*	2.547	.012	.388
	NA	94.410	16.724	1.559				
Lean Trunk (kg)	HB	16.683	2.743	.357	1.424*	3.331	.001	.508
	NA	15.258	2.633	.245				
Trunk – Lean/Ideal Lean (percent)	HB	100.418	4.673	.608	1.934*	2.223	.028	.339
	NA	98.484	5.781	.539				
Lean Right leg (kg)	HB	5.984	1.232	.160	.760*	4.175	.000	.637
	NA	5.224	1.086	.101				
	HB	103.123	8.448	1.099	6.345*	4.334	.000	.661

Right leg – Lean/Ideal Lean (percent)	NA	96.778	9.477	.883				
Lean Left leg (kg)	HB	5.989	1.218	.158	.776*	4.329	.000	.660
	NA	5.213	1.066	.099				
Left leg – Lean /Ideal Lean (percent)	HB	103.069	8.137	1.059	6.519*	4.705	.000	.717
	NA	96.550	8.902	.830				
* The mean difference is significant at the 0.05 level.								

Graphs 11 and 12 indicate lean mass distribution variants for the upper body and lower body, with balanced or unbalanced variants.

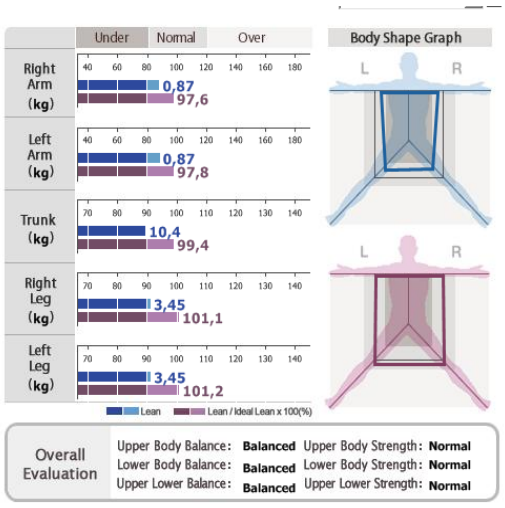

Figure 11. Female HB / balance for lean mass distribution)

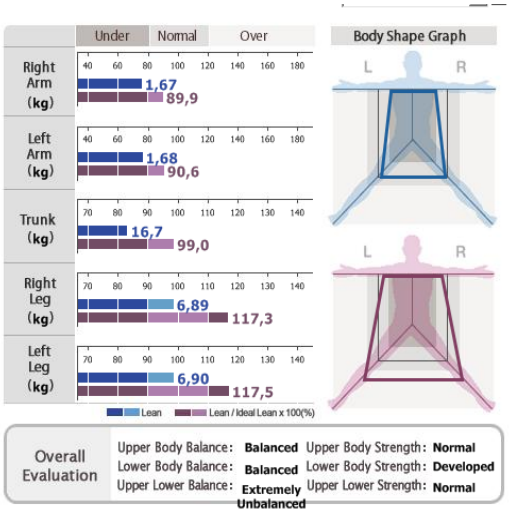

Figure 12. Female NA / imbalance for the distribution of lean mass between upper body and lower body

For the additional data (table 6), we note significant differences between the two groups for most of the analyzed parameters ($p<0.05$), except Weight control and fat control ($p>0.05$). The group of handball female players has superior values for body cell mass, bone mineral content, basal metabolic rate, arm muscle circumference and arm circumference, target weight and fitness score. It is interesting that for the Weight control parameter, handball female players have an average weight loss/weight loss recommendation of 0.3kg (so negative value), while the NA group has a recommended weight gain target of approximately 0.9kg (positive value). However, the fat control parameter indicates the need to eliminate a large amount of body fat for the NA group than for the handball players, but the values are close. The muscle mass deficit of the NA group is supported by the average recommended target value of 3.3kg, while the female handball players receive an average recommendation to add only 1.8kg for muscle tissue. The higher percentage of muscle tissue of the handball players also explains their superiority in the average fitness score. Almost 90% of the handball players have a fitness score above the threshold of 70 points, while only 78% of the NA girls meet this threshold.

For female handball players, we noted that 49.15% have the recommendation to lose weight, 5.8% have an ideal weight and 45.76% need to gain weight. For the NA group 40% must lose weight and 60% must gain body mass, without any case of ideal weight. For fat control, 55.93% of female handball players have a recommendation to reduce fat mass, 3.39% of them have ideal values (2 cases), and 40.68% of them need to add adipose tissue. For NA 53.91% receive the recommendation to eliminate fat; not even one student has

ideal values (0%) and 46.09% must increase these values. In muscle control, we note that 49.15% of handball players have an optimal amount of muscle tissue and 50.85% need to add more muscle mass. By comparison, in the NA group only 17.39% have an optimal percentage of muscle mass, and 82.61% need to increase this parameter.

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/body cell mass (kg)	HB	25.671	4.199	.546	2.618*	4.194	.000	.640
	NA	23.053	3.735	.348				
BMC/bone mineral content (kg)	HB	2.353	.399	.052	.218*	3.784	.000	.577
	NA	2.135	.338	.031				
BMR/basal metabolic rate (kcal)	HB	1222.067	141.348	18.402	81.502*	3.904	.000	.595
	NA	1140.565	124.430	11.603				
AMC/arm muscle circumference (cm)	HB	21.447	1.835	.239	.789*	2.604	.010	.397
	NA	20.658	1.921	.179				
AC/arm circumference (cm)	HB	26.691	2.986	.388	1.051*	2.107	.037	.321
	NA	25.640	3.180	.296				
Target weight (kg)	HB	52.866	8.590	1.118	3.135*	2.626	.009	.400
	NA	49.730	6.806	.634				
Weight control (kg)	HB	-.301	7.150	.930	-1.195*	-.955	.341	.145
	NA	.893	8.139	.759				
Fat control (kg)	HB	-2.079	5.606	.729	.317*	.327	.744	.049
	NA	-2.396	6.280	.585				
Muscle control (kg)	HB	1.778	2.310	.300	-1.512*	-3.637	.000	.554
	NA	3.290	2.730	.254				
Fitness score (points)	HB	74.915	4.561	.593	2.697*	3.719	.000	.567
	NA	72.217	4.514	.420				
* The mean difference is significant at the 0.05 level.								

Graphs 13 and 14 identify the main parameters provided for the additional data, for one representative of each group analyzed.

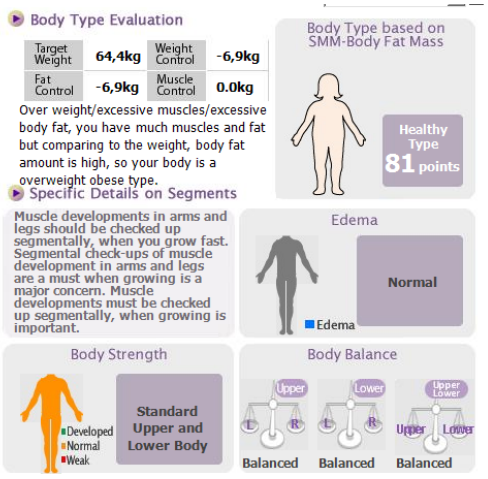

Figure 13. Female HB / Additional data, diagnosis, recommendations and fitness score

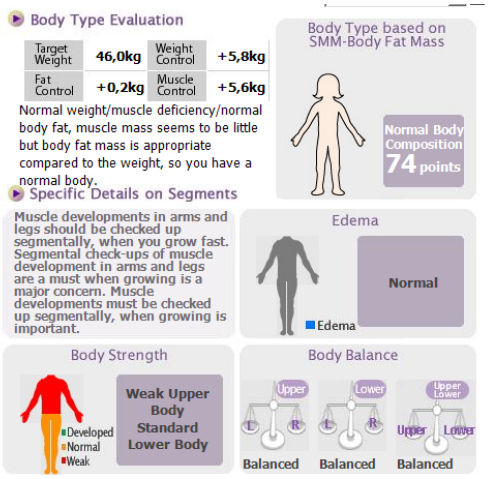

Figure 14. Female NA / Additional data, diagnosis, recommendations and fitness score

Both groups have close percentage values for cases of Abd. Obesity, and in Slight abdominally obese handball female players have a higher percentage (table 7). The NA group has better values for cases of normal WHR, but for both groups around half of the participants have mild or obvious problems with the manifestation of abdominal obesity.

Table.**7** Distribution of WHR cases by category for the 2 studied groups

WHR levels	Normal WHR		Slight abdominal obese		Abd. obesity	
	number	percent	number	percent	number	percent
a. HB	28	47.46%	17	28.81%	14	23.73%
b. NA	59	51..30%	28	24.35%	28	24.35%

Handball female players have much lower percentage values than the NA group, related to the manifestation of muscle strength at the upper body level, for distribution in the Weak group (only one case). They also have a higher percentage for the cases in the Normal Strength group, and for the Developed Strength category the percentages are similar. We notice big problems in connection with the NA group, which has more than 15% of participants in the Weak category, according to table 8.

Table. 8 Classification on the 3 levels of manifestation of Strength at the upper body level for the analyzed groups.

Strength levels upper body	Weak		Normal		Developed	
	number	percent	number	percent	number	percent
a. HB	1	1.69%	53	89.83%	5	8.47%
b. NA	18	15.65%	87	75.65%	10	8.69%

The differences are even more obvious for the manifestation of strength in the lower body, where the NA group has more than a quarter of the participants with muscle strength deficiency (table 9). Also for the other classes of manifestation of muscular

strength, handball female players have better percentage values, an aspect explained by the beneficial influence of specific physical effort.

Table.9 The classification of the 3 levels of manifestation of Strength at the lower body level for the analyzed groups.

Strength levels lower body	Weak		Normal		Developed	
	number	percent	number	percent	number	percent
a. HB	4	6.78%	45	76.27%	10	16.95%
b. NA	32	27.83%	76	66.08%	7	6.09%

4. Discussion

The results of our study were reported to similar research in the field, for most of the situations confirming the favorable effect of sports activities on the main indicators related to body composition.

A study looking at body composition and bone density values in Korean youth found a strong increase in fat mass/FM for girls during puberty, but for boys these values decrease by mid-puberty. BMC and lean mass increase progressively, reaching a plateau phase between 20-23 years for men and 17-20 years for women [74]. The groups studied by us have similar values of fat mass (kg), but for fat mass percentage the female handball players show better values than NA.

The specific effect of training for Estonian rhythmic gymnasts (10 years) ensures a higher bone density, even if the percentage of FM is lower. The comparison of their results with a control group of non-athletes highlights the following values related to body composition: Weight=32 vs 34.5kg, Height=141 vs 141cm, BMI=16.1 vs. 17.3, FFM=24.3 vs 23.4kg, FM=5.9 vs 9.1kg, BF%=19.5 vs. 26.5%, BMC=1.3 vs. 1.2 kg [75]. The comparison of anthropometric values and body composition of Estonian rhythmic gymnasts (10.9 years old) and non-sporting girls (11.2 years old) shows the following values: Height=147 vs. 149cm, Weight=37.1 vs. 42.7kg, BMI=17 vs. 19.1kg/m2, BFM=7.4 vs. 12.8kg, BF%=21.2% vs. 30.1%, FFM=27.3 vs. 27.7kg. The study also revealed a higher bone density in the gymnasts as an effect of the specific effort. [76]. The results are useful for highlighting the differences that occur between sports specializations; in this situation we note better (lower) BMI and BF% scores for gymnasts compared to our groups.

The analysis of the body composition for girls at puberty (11.55 years old) indicates that 17.4% are obese, respectively overweight for 20.3% of them. The following values are obtained: Height=156.31cm, Weight=49.07kg, BMI=20.1kg/m2, TBW=26.6l, Proteins=7.9kg, Minerals=2.57kg, BFM=2.57kg, SLM=34.14kg, FFM=36.3 kg, SMM=19.40kg, BMC=2.15kg, PBF%=24.68% [77]. We obtained similar percentage values for the overweight class, but lower for the obese class for both groups.

For Brazilian adolescents (15-17 years), the comparison of groups involved in additional physical activities and those that only participate in physical education lessons indicates improved values of the first category in the main parameters associated with body composition. Even if physically active girls and the control group have similar BMI values, those constantly involved in physical activity have lower BFM/body fat mass values (17.6 vs. 19.8 kg), lower %BF (30.9% vs. 34.3%), respectively better values of lean mass/LM (38.7kg vs. 36.5kg), according to [78]. These results indicate the beneficial effect of physical activities on body composition parameters, also confirmed by our research.

Studies on pubertal children from rural areas involved in extracurricular physical activities have shown for both sexes an increase in body composition values and parameters associated with the level of fitness. Physical performance was positively associated

with muscle mass and chronological age. For girls with an average age of 14, the following results are obtained: Weight=55.41kg, Height=159.02cm, BMI=21.087kg/m2, FM=16.51kg, BF%=28.94%, Muscle mass%=67.42%, according to [79]. Our group of female handball players obtains lower values for BF% and SMM ratio percent, but the comparison should be viewed with caution due to the age difference between the groups. Body composition analysis for young Spanish female handball players (13.26 years old) indicates values of BMI=21.13 kg/m2 and FM/fat mass=17.27%, according to [80]. These values are better than those of our group of handball players, given that the group's placement in a different age category must be considered.

Research on girls from Slovakia (average age 12 years) highlighted the beneficial effect of sports activities (volleyball, basketball and swimming) on body composition values. Lower values of FM and higher values of FFM are identified, compared to groups of children that do not practice sports activities. All groups obtain normal BMI values: non-athletes=19.61, basketball players=19.21, volleyball players=19.47, swimmers=18.24. Non-athletes have the highest FM values=12.84kg, followed by volleyball players=11.01kg, basketball players=10.31kg and swimmers=6.7kg. The order for BF% is non-athletes=25.77%, basketball players=20.68%, volleyball players=20.42% and swimmers=15.15%. For lean mass, volleyball players are in first place=42.8kg, followed by basketball players=38.24kg, swimmers=35.87kg and non-athletes=34kg. For SMM, the best values are for the volleyball players = 23.28kg, then swimmers = 21.13kg, basketball players = 20.66kg and non-athletes = 18.06kg, according to [81]. Our study also confirms the better values of the investigated parameters for female handball players.

For Danish children (10-12 years old) involved in sports activities with the ball, better lean mass values compared to the NA group (18.4 vs. 16.4kg) are highlighted, respectively lower scores for Body fat percentage (21.9 vs. 23.1 %). Another study on Brazilian teenagers shows higher lean mass and reduced amounts of fat for those involved in vigorous physical activities, for both sexes [82]. Applying HIIT/High-Intensity Interval Training programs to women involved in team sports leads to improvements in body composition values, according to [83]. Our group of handball female players achieves superior performance compared to the NA group in all these indicators.

High BMI values for pre-pubertal children affect physical performance. Those classified as overweight and obese have poorer results in the tests of muscular strength, speed, agility, balance and endurance, but similar scores to normal-weight on tests of flexibility and throwing/catching [68]. A factor that influences bone density and BMC/bone mineral content for young handball female players is the type of playing surface, higher values of these parameters being found for hard surfaces (smooth concrete vs. synthetic), according to [84].

A comparison between a group of Brazilian female handball, basketball and volleyball players (13-17 years) and another group of non-athletes of the same age indicates better values of bone density and body composition for athletes: BMI=22.00 vs. 23.60 kg/m2, body fat %= 32.70 vs. 36.30, Lean mass = 37.10 vs. 34.80 kg [85]. The only score identical to that of our study is for the lean mass 37.10 kg; for the other variables we obtained lower scores, but it must be taken into account that our group has a lower average age.

For teenage female handball players in Turkey, values of BMI= 21.40 kg/m2 and Body fat percentage= 22.90% are reported. Significant negative associations are determined between fat percentage and fitness indicators for the tested group, according to [86]. We obtained similar BMI values, but a higher fat percentage score = 24.733.

The application of specific training for eight weeks for handball female players from Hungary (11.70 years old) provides interesting information on anthropometric values and body composition: (Height=154.57, Body mass=43.62 kg, BF percent=19.35%, BMI=18.21 kg/m2, but without these improvements being significant [87]. Our study indicates higher scores of the group of female handball players for all these parameters.

For the Tunisian handball female players in the U14 and U17 groups, there is an increase in body mass and lean body mass from U14 to U17, but also a reduction in BMI (21.49 vs. 21.22) and Body fat percentage (24.45% vs. 22.27%) , according to [88]. Brazilian

teenage girls practicing handball (for at least one year) have higher values of bone density compared to non-athletes and even compared to soccer players. They have an average BMI score higher than that of female soccer players, but lower than that of non-athletes [89]. However, we identified higher average values of BMI for handball players vs. NA, as a mineral percentage, is slightly better.

Comparative research on sports girls (10.6 years) demonstrated the beneficial effect of physical activities on body composition values. Handball players have the highest values of lean mass=35.56 kg) and body fat percent= 26.99%, and swimmers and soccer players have the lowest values of fat mass. All sportswomen have higher values of lean mass and lower values of fat mass compared to non-athletes. The results are similar in our research, where for soft lean mass handball players have 37,232 kg (slightly higher value), and for Body fat mass (percent) 24,733% (slightly lower value), and these values are also superior to the NA group.

Playing handball and other team sports for young girls (10.6 years) ensures superior values of health and bone mass, according to [90]. Content and bone mineral density (BMD) for young girls (11.32 years) are directly influenced by sports activities and the level of muscle mass development [91]. Comparisons between young handball female players (12-17 years) and a group of Brazilian non-athletes show differences between the body composition values for the 2 groups, as an effect of specific training. The following values are obtained in HB and NA: BMI=22.63 vs. 21.18 kg/m2, Z-score=0.86 vs.0.33, FM (%)=31.61 vs. 32.51, BMC=2250 vs. 2042g, according to [92]. Our study confirms the superiority of the group of female handball players for all these indicators, reinforcing the idea that physical effort optimizes parameters related to body composition.

5. Conclusions

The group of female handball players has superior values regarding weight, height, BMI percentiles, bone mineral content, body cell mass, basal metabolic rate, arm muscle circumference and Fitness score. According to the values provided by Obesity Degree by Body Fat one third of the female students of both groups have obesity issues, which is a warning regarding the health of the young generation, aspect also confirmed by the analyzed studies. According to the BMI classification there are no handball players in the underweight class and 40% of the HB group and 31% of the NA belong to the Overweight and Obese classes. The muscle/fat ratio indicates for the NA group lower percentage values for muscle/SMM and higher for fat/BFM, compared to the HB group, so the specific physical activity has a determining role in explaining these values. Better values for lean mass of the HB group are reported for all body areas and segments, with significant differences compared to the NA group. Fat control recommendations indicate the need to remove more fat for the NA group and add more muscle (over 80% of the components of this group). Both groups have problems with abdominal obesity; approximately one quarter of the students having WHR values within Abd. Obesity. The Strength levels indicator shows better values for the HB group (majority in the Normal and Developed categories), and over a quarter of the NA group has problems at the lower body level (belonging to the Weak level). Periodic measurement of body composition for sportswomen would provide important information for coaches, related to the variations and dynamics of these parameters depending on the training stage, the efficiency of the applied training programs, of the differences that appear between handball players depending on the positions and tasks of the game etc.

Limitations of the study and future directions for investigation: The relatively small groups, the lack of males in the study, the non-reporting of the Tanner stages of sexual maturation and the fact that all the investigated girls come only from the urban environment are the main limitations of our study. Aspects that would be useful to research are: the processing and the presentation of the results related to edema, the relationship of body composition parameters with constitutional type, the relationship between these indicators and physical performance, the effect over different time intervals of specific types

of physical effort on body composition parameters, the influence of the quality of food and lifestyle on these indicators. For handball, longitudinal studies would be interesting to compare (during a macrocycle) these parameters depending on the preparation stages and training intensity.

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