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Research Article

Relationship Between Body Composition and Body Mass Index in Obese Women

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Abstract

Objective: The aim of our work is to study the links between anthropometric parameters and body composition obtained by bioelectric impedancemetry in case of obese women of peri- menopausal age.

Method and Materials: 154 obese women were classified according to their degree of obesity according to WHO criteria. The analysis of body composition was performed by impedancemetry. Pearson's (r) and Spearman's (r^2) correlations were calculated to check the relationships between age, weight, BMI, as well as total and segmental body fat composition.

Results: 154 women of mean age 40.20 ± 13.13 years, obese, mean BMI 38.66 ± 6.56 Kg/m^2 participated in our study. Impedance reduced an average total fat mass% (TFM%) of 45.39 ± 5.67%. BMI is strongly correlated with TFM% ($r = 0.73$; $r^2 = 0.82$; $p \geq 0.05$). For obesity stages 1-2, weight is correlated with BMI ($r\text{-}r^2 > 0.40$; $p \leq 0.001$). Likewise, a strong correlation exists between weight and TFM in Kg ($r^2 = 0.82$; $p \geq 0.05$). For a BMI ≥ 35 Kg/m^2, weight is inversely correlated with age [$r^2 \geq (-0.36)$; $p \leq 0.003$]. The FM of the trunk (Kg) is correlated with the weight for obesity grade 3 ($r = 0.49$; $p = 0.0002$) and whatever the stage of obesity at the BMI ($r \geq 0.32$; $p \leq 0.02$).

Conclusion: The use of bioelectrical impedancemetry in the diagnostic management of obese people is quite useful. This tool gives us better information on the location and distribution of fatty tissue.

Keywords: Obesity; Impedancemetry; Total Fat Mass; Body Composition; BMI

Introduction

The prevalence of overweight and obesity is increasing at an alarming rate in developed and developing countries and around the world [1,2]. Numerous epidemiological studies indicate that overweight and obesity are important risk factors in the occurrence of co-morbidities such as diabetes, cardiovascular disease, cancer and early mortality [2]. This increase in prevalence, combined with these cardiometabolic risks, has become a major public health challenge [3]. The prevalence of overweight and obesity has been observed in various regions of the world. This is a major public health problem, the details of which in anthropometric, clinical and biological aspects are crucial for the development of public health strategies focused on its primary prevention and on treatment [3]. According to the World Health Organization (WHO), obesity is defined as excess of fatty tissue which can be harmful to health [4]. The incidence of obesity is growing, it is considered a global epidemic affecting both developed and developing countries

[5]. The universally accepted index for the diagnosis and classification of obesity is the BMI (body mass index), which is expressed by the subject's weight in kg divided by the height squared in meters (weight/height^2). [6]. In 1997, WHO adopted this index as a benchmark for overweight gradation. Overweight being defined as a BMI range of 25.0-29.9 kg/m^2 and obesity as a BMI ≥ 30.0 kg/m^2 [7]. These values were obtained on the basis of associations between BMI and mortality in European populations. These combinations therefore formed a J curve between the values of 18.5 and 25.0 kg/m^2 [8]. Therefore, these cut- offs were used as a standard for different populations and different ethnic groups on the assumption that these different ethnic groups have an identical risk of morbidity and mortality. In addition, and in recent years, new obesity phenotypes have been described, two of which seem interesting. The metabolically healthy obese person from the English "Metabolically Healthy Obesity" or MHO [9,10] and the subject with normal weight metabolically ill from the English "Normal Weight Obesity" or NWO [11]. For these two phenotypes, the BMI would no longer be adequate with the definition of obesity according to WHO criteria. It is the degree of body fat accumulation, usually expressed as a percentage that would be more appropriate for assessing the risk of developing chronic diseases in NWO subjects [12]. Although investigations are recent, it has been estimated that approximately 30 million Americans have this form (NWO) of the disorder [13,14]. However, the prevalence of these two phenotypes (MHO and NWO) is not well established and there are large variations between studies conducted to date. Variations which are attributed to aspects such as ethnic differences, the various methods used to assess body composition and the different thresholds established for a diagnosis [9].

In this regard, studies [15-17] have shown that the use of BMI is subject to imprecise interpretations in classifying obesity in different populations. In addition, the relationship between increased BMI and body fat percentage differs between different ethnic groups. Severe obesity is characterized by significant changes in body compartments compared to overweight people or those with normal weight [18,19]. Besides the excessive deposition of fat, there is an increase in the extracellular water (ECW) and intracellular water (ICW) ratio but also the ratio between (ECW) and total body water (TBW) [18,20]. These changes place several limitations on the methods commonly used to assess the body composition [19]. X-ray absorbimetry (DXA), pletysmography and *in vivo* neutron activation (IVNA) systems are no longer effective in severely obese subjects. These patients are unable to perform the maneuvers necessary to determine body fat.

However, the evaluation of body composition is important in choosing strategies to reduce body fat, but do you still need to quantify this fat mass using realistic and inexpensive means? [21,22]. In contrast, bioelectric impedance analysis (BIA) is a simple and reliable method for estimating fat accumulation [23]. This means makes it possible, thanks to a passage of electric current in the body, to determine the sectors which resist (hydrophobic sector) to this passage (resistance or impedances) of the sectors which conduct this current (hydrophilic sector). Bioelectrical impedance thus makes it possible to distinguish the hydrophobic sector as being essentially the fat mass of the body, whether total or segmental [24]. The applications of this technique are reported by several authors. Nyboer [25] applied four surface electrodes for bioimpedancemetric measurements to estimate the fat-free mass of the human body. Hoffer [26] presented the association between total body impedance and total body water content in reference to tritium dilution techniques. Mialich., *et al*. [27] examined the applications of bioimpedance analysis in assessing body composition and monitoring chronic disease through the use of a comprehensive list of equations. With regard to these readings, and in particular those relating to the limits of the use of BMI for the estimation and localization of body fat in the diagnosis and follow-up of obesity, it seems interesting to us to '' study the contributions of the analysis of body composition by bioelectrical impedancemetry in case of obese subjects. Objective. Our aim is to study the links between anthropometric parameters and body composition obtained by bioelectrical impedancemetry in obese women of perimenopausal age.

Method and Materials

Subjects

One hundred and fifty-four (154) women, aged between 18 and 65, obese (BMI ≥ 30Kg/m^2) participated in our study. They are followed at our level for the management of their obesity. They were weighed scantily clad. Those in genital activity (non-menopausal) were weighed outside the menstrual cycle. The exclusion criteria were: People whose age was under 18 or over 65. Women who were unable to walk, amputees, and those who had water retention or carried metal objects in their bodies that could interfere with bioelectric impedance results.

Data collection

All subjects included in the sample (n = 154) were measured for weight and height in order to classify their degree of obesity according to BMI according to WHO criteria [4]. The height was measured with a 2-meter fixed height rod with an accuracy of 0.1 cm (a maximum variation of 0.5 cm was allowed between two measurements and the average value was calculated). Weight and body composition analysis was performed on 8-electrode impedancemetry (Tanita BC 418 MA Tokyo, Japan) Class III medical. This is a single-frequency device (50 Hz) whose analysis of the measured parameters are expressed in percentage and in kilograms. The parameters of this body composition analysis are total body fat (TBF) and segmental (right and left legs-arms and trunk), body water, total lean mass (TLM) and segmental (straight legs-arms and left and trunk). Muscle mass is estimated by the device and is expressed in kilograms. The device has a maximum capacity of 200 kg and an accuracy of 0.1%. The reliability and validity of this tool in the measurement of FM as a percentage have already been verified in several ethnic groups [28,29].

For the examination of body composition, subjects were asked to wear light clothing without socks or thin stockings. Care was taken to verify that the heel was correctly aligned with the electrodes of the measurement platform. Then the subjects held retractable handles with electrodes from which electrical signals were emitted. Subjects were instructed to come after a fast of at least 8 hours, to avoid strenuous physical activity during the last 12 hours, to refrain from caffeinated drinks 24 hours before the exam, and to urinate 30 minutes before the start of the exams. All metal objects were removed from them and the measurements were taken after a 10-minute rest while lying down in an air-conditioned room with a constant temperature of 20°C.

Statistical analysis

Continuous variables are expressed as mean values and standard deviations for normally distributed data. Categorical variables are expressed in frequencies. Pearson (r) and Spearman (r^2) correlations were calculated to verify the associations between age, weight, BMI, and total and segmental body composition as a function of stages of obesity. All analysis were carried out on the open access statistical analysis site BiostaTGV https://biostatgv.sentiweb.fr/. The level of significance was set at $p < 0.05$.

Results

The study was conducted on 154 women with a mean age of 40.20 ± 13.13 years, obese with an average BMI of 38.66 ± 6.56 Kg/m^2. The average height was 159.7 ± 10.88 cm and the average weight was 98.30 ± 19.05 Kg. Analysis of body composition by bioelectrical impedancemetry yielded an average percentage of total body fat (TBM %) of 45.39 ± 5.67%, the equivalent of an average total fat mass in kilogram (TBM Kg) of 45.83 ± 13.47 Kg. Total lean mass (TLM) was 56,86 Kg while the trunk fat mass (trunk fat) was 21.62 ± 6.08 Kg. Weight and BMI are highly correlated with TBM in Kg, in order, r = 0.85 IC at 95% [0.86; 0.92], r^2 = 0.92 and r = 0.90 IC at 95% [0.87; 0.92], r^2 = 0.90 (Table 1).

		Weight (Kg) (98,30 ± 19,05)		**BMI (Kg/m^2) (38,66 ± 6,56)**	
	Average ± standard deviation	***r***	***r*²**	***r***	***r*²**
Age (years)	40,20 ± 13,13	(-0,0939) CI à95% [-0,2483; 0,0653]	(-0,0273)	0,0218 CI à 95% [-0,1369; 0,1793]	0,1293
Height (cm)	159,17 ± 10,88	0,3193 CI à 95% [0,1697; 0,4545]	0,4291	0,0629 CI à 95% [-0,0963; 0,2188]	0,0217
Total fat mass (%)	45,39 ± 5,67	0,6486 CI à 95% [0,5465; 0,7317]	0,7403	0,72 CI à 95% [0,634; 0,7884]	0,8286
Total fat mass (Kg)	45,83 ± 13,47	0,8971 CI à 95% [0,8611; 0,9241]	0,9169	0,9044 CI à 95% [0,8708; 0,9296]	0,9073
Total lean mass (Kg)	56,86 ± 52,91	0,3151 CI à 95% [0.1652; 0,4508]	0,855	0,2229 CI à 95% [0,0671; 0,3681]	0,6619
Truncal fat mass (Kg)	21,62 ± 6,08	0,7947 CI à 95% [0,7281; 0,8465]	0,8379	0,7015 CI à 95% [0,6111; 0,7738]	0,7399

Table 1: Correlations between body composition and weight and BMI parameters.

r: Pearson Correlation; r^2: Spearman Correlation; CI: Confidence Index 95%.

The classification of our study population according to the level of obesity (WHO criteria) [4] resulted in a three-thirds distribution (Table 2).

BMI Kg/m^2	Population (%)	weight (Kg)	TBM (%)	TBM (Kg)	TLM (Kg)	Trunk FM (Kg)
30 ≤ BMI ≤ 34,9	51 (33)	82,71 ± 8,38	40,25 ± 5,02	33,76 ± 5,86	48,23 ± 5,16	16,66 ± 3,34
35 ≤ BMI ≤ 39,9	53 (34)	95,91 ± 9,22	45,80 ± 3,26	43,72 ± 5,30	52,02 ± 5,72	21,58 ± 3,56
BMI ≥ 40	51 (33)	116,73 ± 19,14	50,21 ± 3,44	60,37 ± 11,38	70,80 ± 19,53	26,72 ± 6,10

Table 2: The distribution of population and body composition according to the grade of obesity.

51 (33%) women have grade 1 and 3 obesity with respectively a (TFM%) of 40.25 ± 5.02% and 50.21 ± 3.44%. We found that, depending on stages 1 and 2 of obesity, a strong correlation between weight and, TLM in Kg ($r = 0.81$, $r^2 = 0.82$), TLM in Kg ($r = 0.72$, $r^2 = 0.87$) as well as the FM of the trunk in Kg ($r = 0.86$, $r^2 = 0.87$) (Table 3).

Obesity stage 1				
	r	p-value*	r^2	p-value*
Age years	(-0,14)	NS	0,08	NS
Height cm	0,72	0,02	0,82	NS
BMI Kg/m^2	0,45	0,0006	0,4	0,003
TFM %	0,46	0,0006	0,57	NS
TFM Kg	0,81	NS	0,82	NS
TLM Kg	0,72	NS	0,87	NS
FM Trunk Kg	0,86	NS	0,87	NS
Obesity stage 2				
	r	p-value*	r^2	p-value*
Age years	(-0,38)	0,003	(-0,39)	0,003
Height cm	0,91	NS	0,88	NS
BMI Kg/m^2	0,42	0,001	0,47	0,0003
TFM %	0,04	NS	0,24	NS
TFM Kg	0,79	NS	0,80	NS
TLM Kg	0,82	NS	0,83	NS
FM Trunk Kg	0,78	NS	0,79	NS
Obesity stage 3				
	r	p-value*	r^2	p-value*
Age years	(-0,24)	NS	(-0,36)	0,009
Height cm	0,36	0,008	0,57	NS
BMI Kg/m^2	0,63	NS	0,65	NS
TFM %	0,37	0,007	0,4	0,003
TFM Kg	0,74	NS	0,85	NS
TLM Kg	0,28	0,04	0,86	NS
FM Trunk Kg	0,49	0,0002	0,52	NS

Table 3: The different correlations between weight and body composition depending on the stages of obesity.

r: Pearson Correlation; r^2: Spearman Correlation; NS: Not significant;

* P-value significant for a value < 0, 05.

This correlation is not statistically significant ($p > 0.05$). For obesity stages 2 and 3, weight becomes inversely correlated with age in a highly significant manner. Respectively [r = (-0.38), r^2 = (-0.39), p = 0.003; r = (-0.24), r^2 = (-0.36), p = 0.0009]. The fat of the trunk in kg becomes significantly correlated with the total weight for obesity grade 3 ($r = 0.49$; $p = 0.0002$). Body fat (Kg) is significantly correlated with weight for grade 3 obesity ($r = 0.49$; $p = 0.0002$) and regardless of the stage of obesity at BMI ($r \geq 0, 32$; $p \leq 0.02$). However, TBM in kg tends to lose its statistically significant correlation with the BMI ($r = 0.51$; $p = 0.0001$) of grade 1 obesity for a stronger but non-significant correlation ($r = 0.76$; $p > 0.05$) for obesity grades 2 and 3 (Table 4).

Obesity stage 1				
	r	p-value*	r^2	p-value*
Age years	0,27	0,04	0,39	0,004
Weight Kg	0,45	0,0006	0,4	0,003
Height cm	(-0,002)	NS	(-0,002)	NS
TFM %	0,16	NS	0,38	0.004

TFM Kg	0,50	0,0001	0,52	NS
TLM Kg	0,23	NS	0,22	NS
FM Trunk Kg	0,32	0,02	0,36	0.008
Obesity stage 2				
	r	p-value*	r^2	p-value*
Age years	(-0,009)	NS	(-0,01)	NS
Height cm	0,05	NS	0,07	NS
Weight Kg	0,42	0,001	0,47	0,0003
TFM %	0,27	0,04	0,28	0,04
TFM Kg	0,52	NS	0,52	NS
TLM Kg	0,18	NS	0,25	NS
FM Trunk Kg	0,33	0,01	0,35	0,009
Obesity stage 3				
	r	p-value*	r^2	p-value*
Age years	(-0,34)	0,01	(-0,35)	0,01
Height cm	(-0,06)	NS	(-0,02)	NS
Weight Kg	0,63	NS	0,65	NS
TFM %	0,53	NS	0,5	0,0002
TFM Kg	0,76	NS	0,71	NS
TLM Kg	0,14	NS	0,62	NS
FM Trunk Kg	0,34	0,01	0,23	NS

Table 4: The different correlations between BMI and body composition depending on the stages of obesity.

r: Pearson Correlation; r^2: Spearman Correlation; NS: Not significant;

* p-value significant for a value < 0,05.

We have also seen that the TBM in (%) follows a linear path for a BMI between 30 and 40 Kg/m^2. This linear distribution becomes more heterogeneous beyond a BMI of 45 Kg/m^2 (Figure 1).

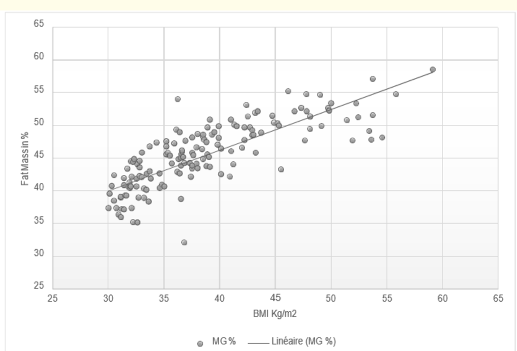

Figure 1: Change in TFM % depending on the stage of obesity. The percentage of TFM follows a linear pattern for BMI between 30 and 40 Kg/m2.

This TBM% is strongly correlated with BMI (r = 0.72; r^2 = 0.82; p ≥ 0.05). Depending on the stage of obesity, TBM% is significantly correlated with obesity stage 1 and 3 (r^2 = 0.83, p = 0.004; r^2 = 0.50, p = 0.0002).

Discussion

Obesity has long been described as an epidemic. This is a significant health threat. The use of BMI plays a central role in defining this excess weight. This clue seems to have a double aim. It is used both to measure a body attribute (weight for height) and to comment on this attribute (normal, overweight and obesity). It is also important to relate the degree of obesity to the risks associated with it. We thus speak of morbid obesity above 40 kg/m^2. This index, which is calculated using the weight/height formula 2, was proposed as a "new" index of overweight in 1972 [6]. In the mid-1990s, it became the standard method for measuring and staging obesity. At the end of the 1990s, the BMI was sufficiently documented and included in a report on anthropometry (WHO, 1995) at a consensus of this organization [7]. However, the accuracy of BMI in measuring body fat continues to be debated to this day. Although widely used as a method of measuring excessive fat tissue built-up, BMI is more of a measure of overweight- for-height than a measure of excess body weight. The BMI does not, in any case, distinguish between body fat (Fat-Mass) and non-fat (Fat-Free Mass, FFM) or lean mass. It does not take into account the distribution of fat throughout the body. So, other adiposity measurements such as waist circumference and waist-to-hip ratio and information on skinfold thickness and body fat, should also be adopted in addition to BMI to decide. On the distribution of body fat. In this regard, the analysis of body composition by impedancemetry seems to find a prominent place in the diagnosis of obesity. Physiologically, there are several models of fluid compartments that are used in the analysis of body composition. A two-compartments model (C2: fat mass and non-fat mass), a three-compartments model (C3: fat mass, total body water and dry fat mass) and the four-compartments model (C4: fat mass, total body water, minerals and residues). The traditional two-compartments model divides the body into a fatty compartment which represents fat mass (Fat Mass: FM) and non-fatty compartment (Fat Free Mass: FFM) which represents lean mass [18,19]. Some methods can be used to assess body fat, such asanthropometric, bio-impedance and plethysmography [18,19]. The analysis of the composition by impedance analysis of the English "Body Impedance Analysis" (BIA) estimates the body compartments (fat mass and lean mass). This estimate exploits tissue impedance based on a constant conductivity cylindrical body model [30]. It is a simple, inexpensive and non-invasive method [30,31]. The compartments of the body have different resistances to the passage of electric current. Bones and fats have low conductivity, while muscles and other tissues (rich in water and electrolytes) easily allow the passage of electric current. We used bioelectrical impedancemetry for the analysis of body composition in 154 obese women. This analysis seems to be interesting because it allowed us to have substantial information on the body composition of obese subjects. The use of BIA as a safe, valid and feasible tool has been accepted [32,33] and the equipment we have used has been validated in previous studies for different ethnic groups [28,29]. The use of different methods to estimate body fat in% for their validity, reliability has been discussed in various studies [34-36]. The classification of FM in% was established by Gallagher [37]. Our work finds its originality in the fact that we have studied possible links between weight and body composition obtained by bioelectrical impedancemetry. Weight is an important semiological parameter. This is the first physical element collected in consultation and scrupulously followed by both nutritionists and their patients, especially those suffering from obesity. The interpretation of this anthropometric parameter is at the heart of the management of obesity, especially the search for possible links with the analysis of body composition and in particular with the TFM in %, the TFM in Kg, the truncal FM. in Kg and the TLM in Kg. This is where our work finds its originality.

We found that, depending on the stage of obesity and for obesity stages 1 and 2, a strong correlation between weight and, TBM in Kg ($r = 0.81$, $r^2 = 0.82$), the TLM in Kg ($r = 0.72$, $r^2 = 0.87$) as well as the trunk FM in Kg ($r = 0.86$, $r^2 = 0.87$). This helps in the interpretation of nutritional status both in the diagnostic phase and in the monitoring phase of obese subjects.

More details on body weight are provided by analysing body composition using bioelectrical impedance. To our knowledge, most studies have focused much more on the links between BMI and TBM in % [38]. Few of the studies have given a higher value to weight and even less those that have looked at the contribution of the composition of the trunk segment [39]. It was observed for an average truncal FM of 12.6 ± 5.4 Kg, a significant correlation between the TBM in% and the BMI but also with the truncal MG in Kg ($r = 0.92$; $p < 0, 01$) [39]. In our study, we found a significant correlation ($r = 0.49$; $p = 0.0002$) between the truncal fat mass in kg and the total weight for obesity grade 3. It seems interesting to us to give more importance to this localization of fat mass in this obesity class. This work was carried out with women with an average age of 40 years, therefore in the perimenopausal phase. However, it is well known that this category of women becomes more exposed to the risks of cardiometabolic diseases [40]. Thus, weight has become inversely correlated with age for women whose BMI is ≥ 35 Kg/m^2 [$r = (-0.38)$ $r^2 = (-0.39)$ $p = 0.003$ for stage 2 obesity; $r = (-0.24)$ $r^2 = (-0.36)$ $p = 0.0009$ for stage 3 obesity]. Misra., *et al.* [41] found a significant association between age and the relationship BMI- TBM % ($r = 0.89$; $p < 0.001$) and BMI-TBM Kg ($r = 0.91$; $p < 0.001$). In studies of age and sex, some authors have shown that there is a significant difference ($p < 0.01$) in the middle age subgroup (47.3 ± 4.9) between men ($r = 0.71$) and women ($r = 0.70$) [38]. Likewise, age and sex were found to be significantly predictive variables in the regression models ($p < 0.000$), where gender contributes more to the BMI – TBM % relationship. Women had a significantly higher average BMI than men.

Women had significantly higher total body fat than men ($p < 0.001$). The usual pattern in most populations was that TBM % is higher in women than in men [42], which was observed for all BMI ranges ($p < 0.000$) in the study by Ranasinghe., *et al*. Numerous studies have confirmed the significant effect of age in the BMI-TBM % relationship [42-46]. Yusuf., *et al.* [47] showed that in adulthood body fat accumulation began to increase with age and tended to accumulate in certain areas of the body. BMI decreases with age over 60, while TBM % increases. This may be due to sarcopenia, which is explained by a gradual loss of muscle mass with age and an accumulation of body fat [48]. These changes are attributed to physical inactivity, decreased levels of certain hormones, and decreased protein synthesis that occur with aging [48,49]. In addition, a stabilization of this relationship between BMI and TBM in % is described in subjects of middle age (39 - 45 years). For obese people, as body fat increases, extracellular fluid volume also increases. [50] Several other studies have examined extracellular water volume in relation to BMI. Brochner-Mortensen., *et al.* [51] compared the size and age of obese and non-obese patients, they found a higher extracellular water volume in case of obese, while Visser., *et al.* [52] recorded a correlation positive between BMI and increased extracellular water volume. The relationship between BMI and body composition is better documented, especially when it comes to the link with % TBM [37-39,41]. Our results are close to those of Misra., *et al.* [41] with regard to the link between BMI and

TBM in % ($r = 0.77$; $p < 0.001$) but also BMI and TBM in Kg (r = 0, 79; $p < 0.001$). In our study, TBM % is correlated with BMI but not significantly ($r = 0.72$; $r^2 = 0.82$; $p \geq 0.05$). Depending on the grade of obesity, we found that BMI is only weakly or moderately correlated with TBM % (stage 1 $r = 0.16$; stage 2 $r = 0.27$ and stage 3 r = 0, 53).

It is therefore proposed to take the stage of obesity into account when analysing body composition. In his study Ragini found a significant correlation between BMI and TBM in % ($r = 0.92$; $p < 0.01$) [39]. Other studies [39,41,53,54] have found that regardless of the stage of BMI (overweight or obesity) the link between the latter and TBM in % is significant. However, Liang in his study [54] using the gradation of obesity, did not find a significant link ($p = 0.43$) for a BMI between 24 and 28 Kg/m^2 and the TBM in Kg. This reinforces our findings concerning the significant correlation between TBM in Kg and BMI for obesity class 1 ($r = 0.50$; $p = 0.0001$). It seems to us that we must take an even better interest in this parameter of body composition, especially since this correlation increases for obesity class 2 ($r = 0.52$) and class 3 ($r = 0.76$) and especially that this increase remains insignificant for these two classes of obesity ($p > 0.05$). Lachekhab., *et al.* [53] found in a study carried out on 172 overweight or obese women, that the BMI is better correlated ($p < 0.01$) with the TBM in kg whatever the stage of the BMI (overweight $r^2 = 0.33$; stage 1 $r^2 = 0.25$; stage 2 $r^2 = 0.27$ and stage 3 $r^2 = 0.57$) than at TBM in %. This comforts the hypothesis of our study. BMI alone does not seem to provide accurate information about weight and the risks of being overweight. Therefore, quantification of TBM in Kg is substantially useful. It is better correlated with weight ($r = 0.8971$ 95% CI [0.8611; 0.9241]) and BMI ($r = 0.9044$ 95% CI [0.8708; 0.9296]) than the percentage of this ($r = 0.6486$ 95% CI [0.5465; 0.7317]) for weight and for BMI ($r = 0.72$ 95% CI [0.634; 0, 7884]). In this study [53], the correlation between BMI and TBM in % only becomes significant ($p < 0.01$) from a BMI ≥ 35 kg/m^2 (BMI stage 2 $r^2 = 0.07$; BMI stage 3 $r^2 = 0.23$). In the study by Liang., *et al.* [54] no link seems to exist between TBM (23.7 ± 3.25 Kg) and BMI (class 24 and 28 Kg/m^2 according to the standards of the Working Group on Obesity in China. (WGOC) [55]. However, for the BMI class ≥ 28 Kg/m^2, the link is significant ($p < 0.05$). We found that the TBM % follows a linear pattern for BMIs between 30 and 40 Kg/m^2.

This distribution becomes more and more heterogeneous for BMI ≥ 45 Kg/m^2. These results are practically similar to those observed in the studies by Lachekhab [53] and Abulmeaty [56]. Regardless, we found that BMI is weakly, but significantly, correlated ($r^2 = 0.38$; $p = 0.004$) with % TBM for stage 1 obesity. This relationship becomes moderately correlated ($r^2 = 0.5$) but highly significant ($p = 0.0002$) for stage 3 obesity. We can already hypothesize that the hormonal changes during this perimenopausal phase play a role in the distribution of fat mass, which can influence the link of TBM % with BMI described previously [39,41,53,54]. In addition, stabilization of this BMI-TBM % relationship only occurs between the ages of 39 and 45 years [50]. Our study population has an average age below but close to this range. In addition to these hormonal changes, there are the interindividual variabilities that can be proposed to explain the dispersion of the TBM % around an increasingly heterogeneous linear plot of the TBM % for BMI ≥ 45 Kg/m^2.

Overall, our work supports the use of bioelectric impedancemetry analysis of body composition in a clinical setting both for the diagnosis of obesity and for its monitoring. Our work has, like even, some limits. Despite all the readings we have been able to do, the BIA remains a controversial tool when it comes to the precision of its contributions in terms of body analysis. This suggests that comparative studies with other tools like DXA are desirable. Another limitation to the exclusion of males is the sample of our population. It would be useful to expand the size of the study sample to include both sexes. From this perspective, parameters such as ethnicity and larger age groups can be included. In the end, it would be preferable to introduce other clinical elements that can interfere with body composition such as skin folds, waist circumference, hip circumference and certain biological parameters such as fasting blood sugar and lipid balance, but also radiological parameters of hepatic steatosis.

Conclusion

The use of bioelectric impedancemetry in the diagnostic management of obese subjects is quite useful. This tool gives us better information on the location and distribution of fatty tissue (a determining factor in obesity). Whether expressed in (Kg) or in (%), body composition parameters such as fat mass or non-fat mass, can be offered in addition to already known parameters such as weight and BMI.

Conflict of Interest

None.

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