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Bmi, Universal Reference Or Dethroned Index? Credibility Of Bmi In Obesity

Alternatives To Body Scanning For The Diagnosis Of Obesity

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SUMMARY

Objective: We studied the relevance and limitations of the Body Mass Index (BMI) the universal corpulence indicator. Its formula, established by Mr. Quetelet, a Belgian mathematician in 1832, is BMI = Weight/Height^2 [kgm^{-2}]. This metric utilizes a uniform scale, independent of gender, age or race. The following are threshold values: below 18 [kgm^{-2}] for underweight, 18 to 25 [kgm^{-2}] for healthy weight, between 25 and 30 [kgm^{-2}] for overweight, and obesity if BMI is above 30 [kgm^{-2}]. Given the increasing prevalence of obesity and its complexity, how much credibility can we still give to this two-century-old index?

Method: This bibliographical review recalls some definitions and obesity epidemiological data. We then retrace the history of the BMI its use and limitations. We recount the questions and concerns of some clinicians and experts, who have become reluctant to diagnose a chronic disease as complex as obesity, on the basis of a simple formula that was established more than 200 years ago, and still used today without any changes!

Conclusion: BMI widely used in clinical practice, scientific research and population studies runs the risk of under-diagnosing the adverse health effects of obesity. Experts recommend clinical monitoring of "toxic" waist circumference. The outcome of this literature review argues in favor of body exploration using more accurate, simple and inexpensive techniques, such as bioimpedancemetry-BIA, and the adoption of a new body mass index focusing on trunk fat mass and cardiometabolic risk.

Mots clés : BMI- Obesity - abdominal fat mass - cardiometabolic risk - bioimpedancemetry - new corpulence indicator.

INTRODUCTION

As defined by the WHO, obesity is the abnormal or excessive accumulation of body fat that can seriously harm health [1]. It is now well established that excess weight is the result of a syndemic relationship between various obesogenic factors: dietary, neuroendocrine, metabolic, environmental, behavioral, genetic and epigenetic... etc.

But, whatever the obesogenic factors, in fine, the increase in body mass remains the result of the excess balance between kilocalories ingested versus those burned by the body [2] [3]. In fact, the positive energy balance or kcal ingested in excess are metabolized and stored as triglycerides in adipocytes. Adipose accumulation leads to inflation of adipose tissue. Over time, this leads to overweight and obesity [4].

The consequences of depositing excess fat mass vary according to its nature and location. The central adipose tissue characteristic of android obesity has a high metabolic acitivity and a proinflammatory secretome whose role is determinant in the cardiometabolic syndrome and other Non-Communicable Diseases (NCDs) [5].

OBESITY: EPIDEMIOLOGICAL DATA

In four decades, the number of obese people worldwide has tripled [6]. The WHO estimates that 1.9 billion adults worldwide are overweight, including 650 million obese. That's 39% overweight and 13% obese. The phenomenon is also preoccupying among children under 18. 340 million children aged between 5 and 19 were overweight or obese in 2016 [4]. A third of adults in the United States are obese [7]. In France the Obépi investigation which involved a cohort of adults aged, revealed that the prevalence of obesity has doubled over the last two decades [8].

According to the WHO, obesity and overweight are the fifth cause of mortality, causing 2.8 million deaths per year worldwide [9]. Whether in high-income or developing countries, risk factors linked to nutrition, obesity and a sedentary lifestyle contribute **to one in five deaths** [10].

The role of obesity in noncommunicable diseases is widely documented. Obesity is incriminated in 44% of cases of type 2 diabetes, we even speak of diabesity [11]. Obesity is found in the etiology of 23% of cardiovascular diseases and 7 to 41% of cancers, depending on their locations [3].

Projections for 2030 in the developed countries of the OECD predict an increase in the frequency of morbid forms of obesity in the thirty member countries [12]. At the same time, many low- and middle-income countries find themselves faced with the “double burden” of morbidity. While continuing the fight against infectious pathologies and malnutrition; they are faced with the growing burden of overweight and obesity as well as the non-communicable pathologies that result from them [13]. This is the case of Morocco, where among the adult population aged over 20 and suffering from NCDs, we find an obesity rate higher than the national average, i.e. 53% and 20% respectively [8].

Concerned about the morbidity-mortality burden of obesity, the WHO states verbatim: "National health organizations can no longer afford to cut back on public awareness and education campaigns; efforts must be intensified to contain the progression of overweight and limit the health problems associated with it". It is well established that even modest weight loss (5% of initial weight) improves health, with appreciable benefits for the metabolic, cardiovascular, respiratory and musculoskeletal systems [14]–[16]. The WHO has established a road map recommending intervention on modifiable behavioral risk factors, mainly including food hygiene and a sedentary lifestyle [17] [18].

OBESITY: CIVILIZATION DISEASE?

How did obesity become a public health issue? A symbol of abundance and over-consumption in rich countries, how did this disease spread to the entire planet? So much so, in fact, that obesity is now progressing at an alarming rate in emerging countries [9].

The globalization of lifestyles and eating habits, characterized by excessive calorie consumption and sedentary lifestyles, has contributed to the emergence and dissemination of overweight on a worldwide scale [19]. Some experts speculate that obesity is a disease of adaptation to major changes in lifestyle [20].

On a global scale, economic progress has had an impact on the risk of obesity, which in recent decades seems to have shifted more markedly from wealthier to poorer communities, and from better-educated to less-educated populations [21].

Several studies have looked at the urban environment and the profile of residential neighborhoods in terms of food supply, shops, services and green spaces. They show the influence of the profile of the living space on eating habits and a positive correlation between the profile of the neighborhood, the living area and corpulence. They also reveal a higher incidence of obesity in urban areas [22]. The link between education, socio-economic status and obesity is also well established [23].

OBESITY: GENDERED PHENOMENON?

The female gender seems to be more exposed to obesity, even in developing countries. In 2016, the WHO put the obesity rate for women at 15%, compared with 11% for men [4]. According to this organization, this phenomenon is linked not only to hormonal factors specific to women and their life cycle, but also to women's greater vulnerability and social precariousness. But it has also been shown that sedentary lifestyles and/or lack of physical activity affect women more than men. 70% of women are under the physical activity threshold, compared with 42% of men [6] [24].

In the USA, obesity affects 31.6% of men and 33.9% of women [25]. The cohort study « Constances » on the prevalence of obesity in France, revealed in 2016, an abdominal obesity rate of 41.6% for men compared with 48.5% for women [26]. A trend towards abdominal obesity, predominantly among adult Chinese women, was also observed [27].

In Africa, a study of 878,000 women carried out in 56 countries between 1991 and 2009 showed that overweight among African women was positively associated with urban residence, with a greater increase (+50%) among poor women with little or no schooling [21]. In North Africa, 22.7% of Tunisian women are obese, compared with 6.4% of men s [28], [29].The Algerian study on the population of Constantinople showed an increase in the prevalence of obesity to 40.83% for women vs. 22.08% for men, with abdominal obesity more frequent in women (64.3%) than in men (35.9%) [30].

In Morocco, the rate of obese women is 29%. Obesity has risen by +10% in less than twenty years and affects 3 times more women than men [30] [31].

OBESITY IN MOROCCO	***OBESITY = A COMPLEX DISEASE CAUSING A VARIETY OF DISORDERS***	***OBESITY AND RISK OF COMPLICATIONS OF CHRONIC PATHOLOGIES***
• *Affects **20%** of adults.* • *Affects women 3 times more than men.* • *Progresses more rapidly in urban areas.*	• *Biological,* • *Physiopathological,* • *Metabolic,* • *Neurological, Psychological... etc.* ***Obesity remains a major challenge for science and medicine.***	*Type 2 diabetes, respiratory, cardiovascular, kidney, joint and liver diseases, hormonal and dermatological disorders, cancers ...etc.*

OBESITY & BODY MASS INDEX- BMI

We owe the BMI formula to Mr. Lambert Adolphe Quetelet (1796-1874). Famous Belgian mathematician and pioneer of statistics applied to health. His initial research focused on physical and social characteristics such as average weight, average age at marriage and so on.

Initially, the Quetelet index established in 1832 concerned a study commissioned by banking and insurance organizations that had noted the early death of "overweight" customers compared with those of "ideal weight". In 1832, following his standard formula based on two variables, weight (kg) divided by the square of height (m^2). In 1853, Quetelet initiated the concept of epidemiology, giving rise to the first nomenclature of causes of death to include the parameter of corpulence (figure 1).

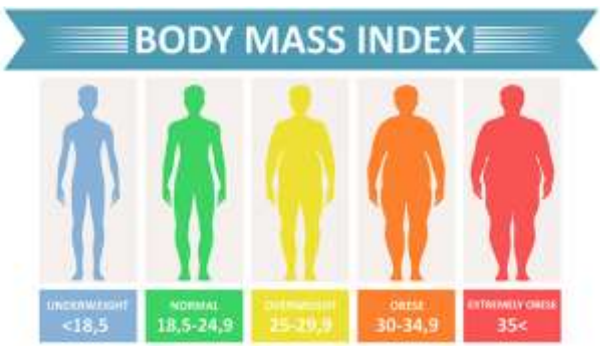


Figure 1: Quetelet index formula and classification of corpulence

At the end of the Second World War, insurance companies exploring actuarial risks adopted the Quetelet formula to calculate life expectancy. This inexpensive and simple work had already confirmed that individuals with a high Quetelet index value, were more prone to diabetes, hypertension and cardiovascular diseases. Thus was born the first risk classification, linking corpulence to cardiometabolic comorbidities.

In 1972, Mr. Ancel Keys (1904-2004) renamed the Quetelet body mass index or BMI. In 1997, the WHO adopted and adapted the BMI or BMI-body mass index, making it a universal reference for the study of corpulence and setting its scale regardless of sex, age or race, with unique thresholds: 18 to 25 [kg m-2], 25 to 30 [kg m-2] and obesity for BMI above 30 [kgm-2] (figure 2).

WHO CLASSIFICATION OF WEIGHT STATUS	
WEIGHT STATUS	BODY MASS INDEX (BMI), kg/m^2
Underweight	<18.5
Normal range	18.5 – 24.9
Overweight	25.0 – 29.9
Obese	≥ 30
Obese class I	30.0 – 34.9
Obese class II	35.0 – 39.9
Obese class III	≥ 40

Figure 2: BMI threshold values set by the WHO.

However, the WHO points out that this approximate indicator does not reflect the degree of adiposity, which can differ from one individual to another for the same BMI value [6]. On the other hand, the formula is not applicable to children under 18, for whom it is advisable to adjust it to age and use growth curves [33].

Despite the WHO's reservations, BMI is still widely used not only in clinical practice but also in epidemiological studies and health surveys [34].

But in recent decades, skepticism about the universality of BMI has been growing in the scientific and medical community. This is the case of Dr Margaret Ashwell and Dr Pamela Peeke, experts in central obesity, whose work focuses on the underestimation of cardiometabolic risk when BMI alone is considered. At the 19th European Congress on Obesity, held in Lyon, France, in May 2012, Dr. Peeke argued in favor of a new corpulence index more focused on the risk of trunk fat mass deletere, and made an unfamiliar appeal to congress attendees: "Goodbye BMI, to your meters!".

Other experts, warning that the crude interpretation of BMI may be questionable, given the great interpopulation variability in terms of pathophysiology, ethnicity, morphology and biology, no longer accept BMI as the sole criterion for the clinical diagnosis of overweight and obesity (Figure 3).

Figure 3: BMI and body shape.

Today, it's indisputable that excess body fat, mainly abdominal or visceral fat, which is highly metabolically active, induces pathological changes in adipose tissue, with major health repercussions and increased cardiometabolic risks. But a paradox remains concerning the association between BMI and mortality [35] [36] [37].

The debate might persist as to the precise point at which the association between continuous BMI with excess mortality becomes statistically significant [38].

Is there any point in reconsidering BMI? An indicator that no longer seems to be the most powerful marker of nutritional status, nor the best predictor of the risks of morbidity and mortality associated with body status?

In fact, the assessment of corpulence, through the application of a single norm based on a standard formula developed some two centuries ago, raises a number of questions, and is even being called into question.

In fact, since the 2000s, the literature has been reporting on scientists' and clinicians' questions and observations about BMI.

- The IOTF-International Obesity Task Force, a global organization dedicated exclusively to the problem of obesity, recognizes that BMI thresholds are somewhat arbitrary. The value of 24.9 as a threshold of normality is very generous and is quite far from the optimum, which lies between 21 and 23 kg m^{-2} » [39].

- John Bosomworth, in the Canadian Family Physician, June 2019 edition, writes "BMI does not distinguish subcutaneous fat from visceral fat whose effect on morbi-mortality is more important". In his publications "Central obesity despite normal

BMI", J. Bosomworth relates the cardiometabolic risks underestimated by BMI [40].

- The work of Wildman RP and the observations of N.Beck, question the phenotypes of metabolically obese subjects with a normal weight and BMI [41].

- Studies of correlations between BMI and clustering of cardiometabolic risk factors have demonstrated a high prevalence of cardiometabolic abnormalities in individuals of normal weight and BMI, and a significant proportion of obese subjects with high weight and BMI without clustering of cardiometabolic risk factors [46].

- Jean-Yves Nau, describes the BMI as an indicator based on a crude and simplistic formula [45].

- Wei Zheng, epidemiologist at Vanderbilt University Medical Center-Nashville, notes that the vast majority of studies associating BMI with mortality risk have been conducted on populations of European origin, whereas the Asian population makes up 60% of the world's population. This finding prompted him to conduct a titanic study in Asia, including 1.1 million Asians aged ≥18 years, divided into 19 cohorts followed for 10 years [42].

- Wei Zheng concluded that high BMI was moderately correlated with excess mortality in East Asian populations (China-Japan-Korea), but was not correlated with excess mortality in either Indian or Bangladeshi populations, i.e. around 20% of the world's population! [43] [44]. Wei Zheng, also found that metabolic diseases related to overweight began to appear significantly for a BMI≥23. Therefore, he suggested modifying the BMI ranges for Asian populations, the suggested cutoff being a BMI ≥23 kgm^{-2} for overweight and ≥ 27.5 kgm^{-2} for obesity [42].

- Song X and Jousilahti concluded in the article published in the "European journal of clinical nutrition" in 2013, that while the aim of BMI is to predict cardiac risk in the obese, other indicators, such as abdominal circumference and hip/abdomen circumference ratio, are better indicators [27].

- In volume 41 of ANTIPODE magazine, published in 2009, Bethan Evans and colleagues, drawing on the work of public health governance expert Michel Foucault, already invited health institutions to question the power of BMI in anti-obesity policy [47].

BODY MASS INDEX-BMI LIMITS

In this bibliographic review we list the main limitations of BMI.

1. BMI does not distinguish between male and female morphotypes [48].

2. Corpulence evolves with age and life cycle, aspects not integrated into the BMI formula [49].

3. BMI defines threshold values without taking into account individual differences in constitution. Yet each individual is unique, with his or her own particularities in terms of weight, body shape and health [50].

4. BMI is not applicable:
   - for children and teenagers, this index tends to vary with age, so reference curves should be used [51].
   - In pregnant women, the pre-conception BMI is taken into account, but in the event of pregnancy, it is the monitoring of weight gain that takes precedence [52].
   - for very short (≤0.914 m) or very tall (≥2.108 m) adults, as well as single-leg or single-arm amputees [53] [54].

5. In epidemiological surveys, BMI interpretations can be biased by self-reported height and weight. The tendency to underestimate weight and overestimate height is well established [34].

6. BMI does not reflect body composition or the proportion and distribution of different tissues (lean mass, fat mass, muscle mass, bone mass, water volume) [55].

7. BMI can be falsely reassuring for subjects of normal weight, but with central fat mass, characterized by a high abdominal perimeter known as "toxic waist"[41] [55].

8. Muscle is heavier than fat, and individuals with a high muscle mass, or great athletes, can have a high BMI and be erroneously classified as obese [56].

9. The BMI international standard ignores intra- and inter-ethnic corpulence diversity. Anthropometric parameters can vary from one ethnic group to another, and even from one ethnic group to another, as in the case of Asians, who generally have a slim build [57].

10. The BMI attributes to them an irrelevant state of thinness. On the other hand, black Africans may have a high BMI without necessarily being overweight or obese [58] [59].

11. BMI does not take into account variations in individual and community body ideals [60].

12. What relevance should BMI have in cases of obesity comorbidities with other pathologies such as renal failure, edema, COPD, CVD, diabetes, hypertension, PAR.... etc? [61].

13. The BMI, a standardized numerical indicator, maintains a standardized relationship with the body. However, the uniformity of corpulence-aesthetic reference points can be unsuitable from a personal point of view, impacting on body identity with a potentially anxiety-provoking effect and a lack of self-confidence and self-esteem, or even the appearance of eating disorders [62] [63].

14. BMI is not the indicator to be considered in the case of binge eating disorder, which is more a matter of psychology as recognized in the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders [64].

15. One-size-fits-all weight standards may not correspond to people's body ideals, depending on the cultures and beauty ideals of different countries [65].

16. BMI can encourage a focus on weight instead of priority health standards [60].

17. The emergence of the slimming business and the misuse of BMI as an indicator accessible to the general public. BMI is the "butter" of commercial promotional messages and often questionable and ruinous dietary solutions. Faced with the advertising impact and popularity of "slimming" diets, the French food and health safety agency -ANSES, has vigorously denounced certain risky practices of low-

calorie weight-loss diets and restrictive solutions that often aggravate weight problems [66].

WHAT ALTERNATIVES TO BMI?

Anthropometric measurements predictive of body fat.

Measuring weight and height is inexpensive, easy and practical, whether at the individual level or in population epidemiological studies. The measurement of waist circumferences-WC, hip circumferences-HC - are useful and used to calculate the WC/HC or WC/H ratios [67].

A- MEASUREMENT OF CIRCUMFERENCES

1. **Hip circumference-HC and Waist circumference-WC**

With the tape measure placed on the buttocks, the hip circumference is measured at the level of the pubic symphysis, the widest area of the hips, feet together, palms inward and during normal expiration (figure 4).

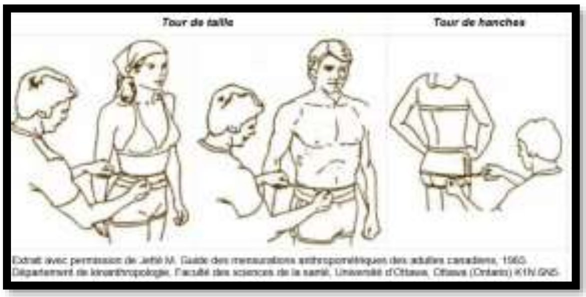


Figure 4: Circumference measurements

The measurement of waist circumference constitutes a second very appreciable anthropometric indicator both in the clinic and for epidemiological studies, because intra-abdominal peri-visceral fat is involved in determining the metabolic and cardiovascular complications of obesity [68].

2. Waist/ Hip ratio or WHR

The ratio of waist circumference to hip circumference (WC/HC ratio) or WHR should be less than 0.85 in women and less than 1.00 in men; it allows the evaluation of fat stored around the waist, hips and buttocks. An increase in WHR is a risk factor particularly for the occurrence of coronary events [69].

3. Waist/ Height Ratio

A Waist circumference/ Height ratio > 0.5; despite a normal BMI indicates a high risk of mortality from cardiometabolic damage[70]. In the case of abdominal obesity, several studies have shown that waist circumference and the waist/height ratio are better predictors of cardiometabolic risk than BMI [71] [72].

4. Measurement of subcutaneous folds

Much of the adipose tissue is subcutaneous [73]. We can estimate a subject's fat panniculus by measuring the thickness of subcutaneous adipose tissue. Predictive equations allow fat mass to be determined from subcutaneous fold measurements. The reference is the Durnin and Womersley equation, which calculates body density and then determines fat mass according to the revised equation known as the **SIRI** formula.

SIRI FORMULA

% FAT MASS = (4,95/density- 4,50) x 100

<u>Technique and sites for measuring subcutaneous folds (figure 5):</u>

We use a caliper or the Harpenden skinfold caliper or adiposometer to measure the thickness of the bicipital fold (arm), tricipital fold (forearm), supra-iliac fold (hips) and subscapular fold (scapula).

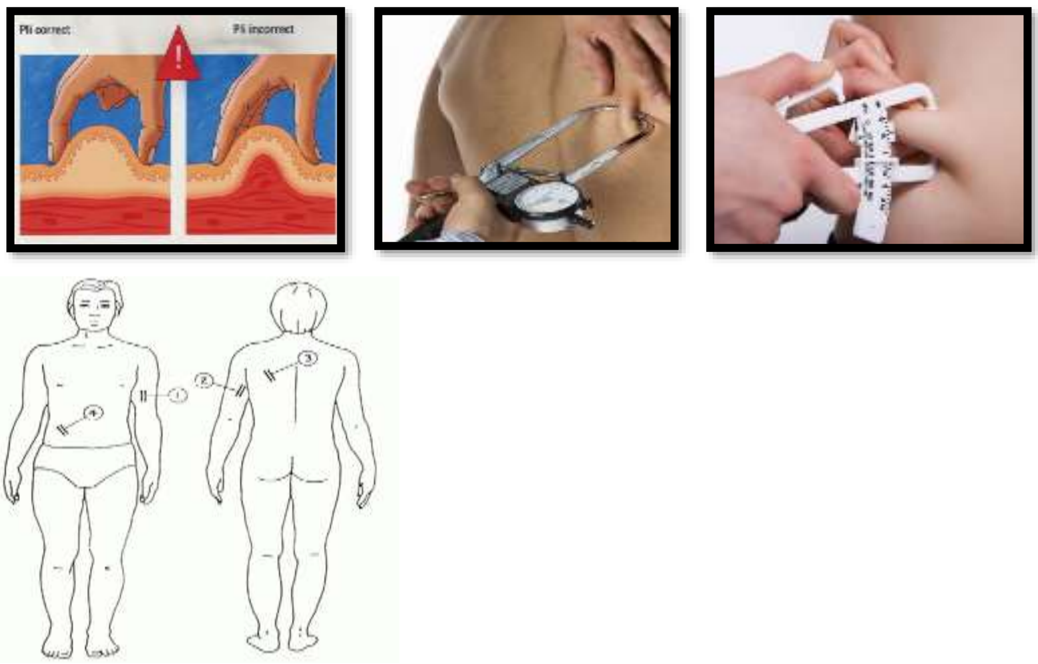


Figure 5 : Measure of subcutaneous folds technique at the four sites.

The subcutaneous fold method is inexpensive and easy to implement, but it has some limitations and the following disadvantages [74]:

a) Operator dependent technique which requires experience because there is a risk of crushing the subcutaneous tissue (personal coefficient of variation must be < 5%) [75].
b) Inaccuracies linked to the experimenter. Method sensitive to differences in observation and interpretation from one user to another [76].
c) The choice of measurement points: the adipose tissue of the lower part of the body is not taken into account, gynoid obesity is therefore not evaluated by this technique [77].
d) Difficulty measuring skin folds in cases of extreme obesity. But also in cases of extreme thinness [78].
e) The method poorly estimates deep adipose tissue and tends to underestimate visceral obesity, which also presents ethnic differences [79].

B- ADIPOSITY AND FAT MASS INDEX-FMI

The FMI integrates three factors: BMI, age and sex (S=1 for men, S=0 for women). It obeys the equation FMI = (1.2 x BMI) + (0.23 x age)-(10.8 x S)-5.4. The normal FMI is between 15 to 20% for men and 25 to 30% for women (Figure 7).

Figure 6 : Fat mass index scale

OTHER BODY ASSESSMENT TECHNIQUES

1. Deuterium ^{2}H dilution technique

Dilution with deuterium ^{2}H or D technique, based on isotopes table non-radioactive products have been used for human nutrition studies since the 70s (Figure 8). Dilution with the hydrogen isotope denoted 2H or D uses the two-compartment organism model. It is based on the postulate that lean mass is made up of 73.2% water. On urine or saliva samples, total body water (ECT), lean mass-LM are determined. Fat mass is calculated as the difference between body weight and lean mass. ^{2}H dilution assesses nutritional status with great precision, but requires great expertise and sophisticated equipment. It remains reserved for scientific research [71].

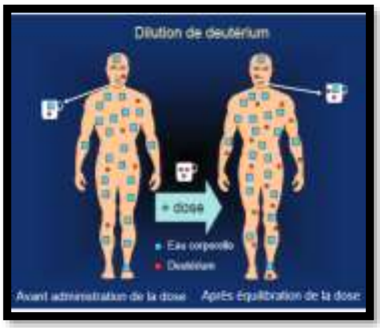


Figure 7 :
Deuterium-^{2}H dilution technique

2. Technique for measuring body volume

A. Hydrodensitometry

Very reliable technique which consists of calculating the fat mass of an individual from its density, obtained by immersing it in water. It is based on Archimedes' principle which gives the volume of a body by immersing it in water. Hydrodensitometry requires special equipment reserved for the research community. It is difficult to implement in cases of severe obesity and is not applicable to children, the elderly, people with reduced mobility or poor cooperation (Figure 9).

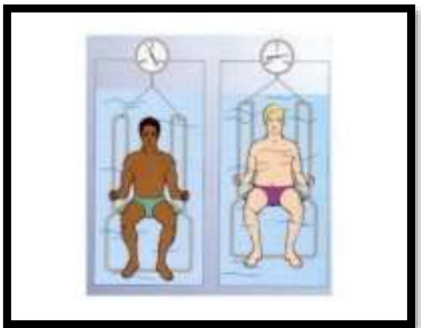


Figure 9 : Hydrodensitométrie

B. Plethysmography

Better known as Bod-Pod, plethysmography (figure 10) works on a principle similar to hydrodensitometry, but is based on the calculation of the air displaced instead of water. This variant of measuring body volume is based on the thermodynamics of ideal gases or the Boyle-Mariotte law of the formula P x V= k (constant).

Figure 9: Plethysmography cabin

3. Measurement of corpulence using imaging techniques

Medical imaging techniques used in nuclear medicine provide very precise data on body composition.

A. Neutron activation medical imaging technology

The technique of bombarding body mass with a fast neutron beam for precise estimation of carbon in fat, bone and protein. This technique enables in vivo analysis of all four compartments (protein, bone, fat and water) with high accuracy (error < 3%). However, it has two major drawbacks: high cost and high irradiation [80].

B. Dual X-Ray absorptiometry DEXA or X-ray biphotonic absorptiometry - X2

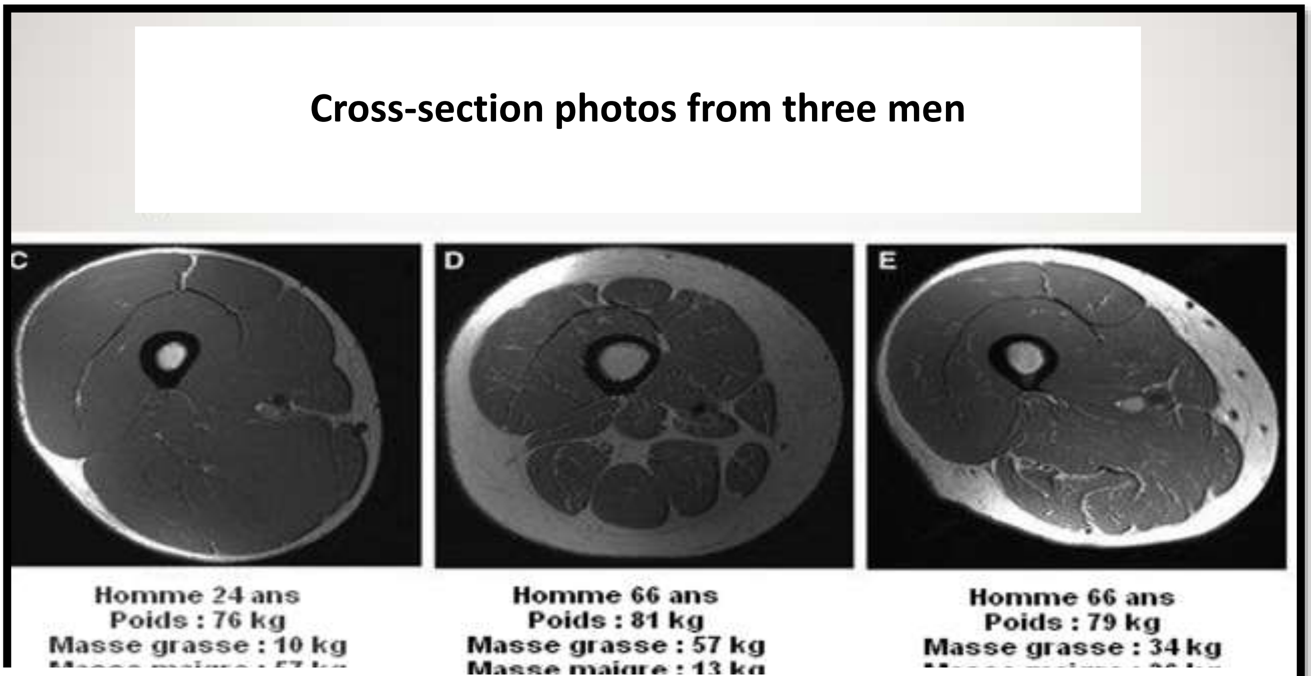
DEXA is the imaging test used in bone densitometry. It also measures fat mass, lean mass and bone mineral content throughout the body. DEXA is a direct measurement based on the principle of dividing the body into three compartments. It involves scanning the body with X-rays of two energy levels. The ratio of the attenuations of these two radiations is a function of the composition of the material in the compartment scanned. DEXA is the "gold standard" method for studying body composition, but its cost limits its routine use (Figure 11).

Figure 10 : DEXA or Dual X-Ray absorptiometry

C. Nuclear magnetic resonance-NMR

A technique for analyzing the soft tissues of the human body, validated for measuring body composition (Thomas et al., 1998). NMR measures fat (error < 3%, i.e. 1 kg), distinguishes visceral from subcutaneous fat and allows segmental slicing. There is no risk of radiation exposure. NMR is not applicable to large obese patients whose sagittal diameter is greater than 65 cm (E.K.AGLAGO-2014). NMR is rather reserved for oncology, vascular surgery and other heavy pathologies. its use to determine body composition is not widespread because of the long duration of the examination (1h) and the high cost.

Figure 11 : RMN Scanner



Man 1: 24 years old
Weight: 70 kg
Fat mass: 10 kg
Lean mass: 57 kg

Man 2: 66 years old
Weight: 81kg
Fat mass: 57 kg
Lean mass: 13 kg

Man 3: 66 years old
Weight: 79 kg
Fat mass: 34 kg
Lean mass: 13 kg

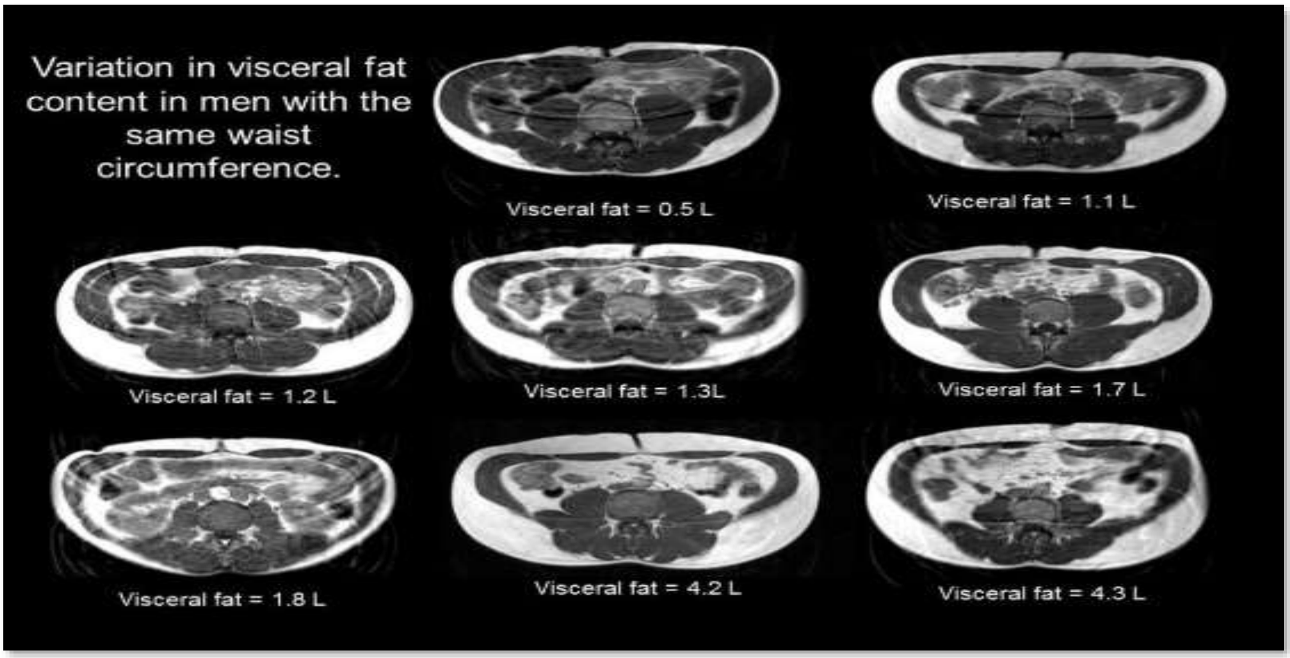


Figure 12: visceral fat content in men with same waist circumference

4. Bioimpedancemetry–BIA: body composition analysis

BIA evaluates the volume of the various hydroelectric compartments in the body. The principle of this technique is based on the ability of hydrated tissue to conduct electrical energy. By measuring resistance to the passage of low-intensity electrical current, fat mass can be determined. Other compartments, which are better conductors of electricity due to their higher water content, are also determined.

The reference BIA is performed in the supine position, and determines the composition of the entire body (lower limbs, upper limbs and trunk). Based on the three-compartment principle, BIA measures lean body mass, fat mass and total body water.

Description of the BIA bioimpedancemetry technique

Age and weight are recorded, along with measurements of the subject's waist, waist circumference and hip circumference. Measurements are taken in the supine position. Two electrodes are placed on the ankle and two on the wrist. Completely painless, the principle of BIA is to apply a low-intensity current of 800 amperes at a frequency of 50 kHz for a few seconds (Figure 14).

Fig

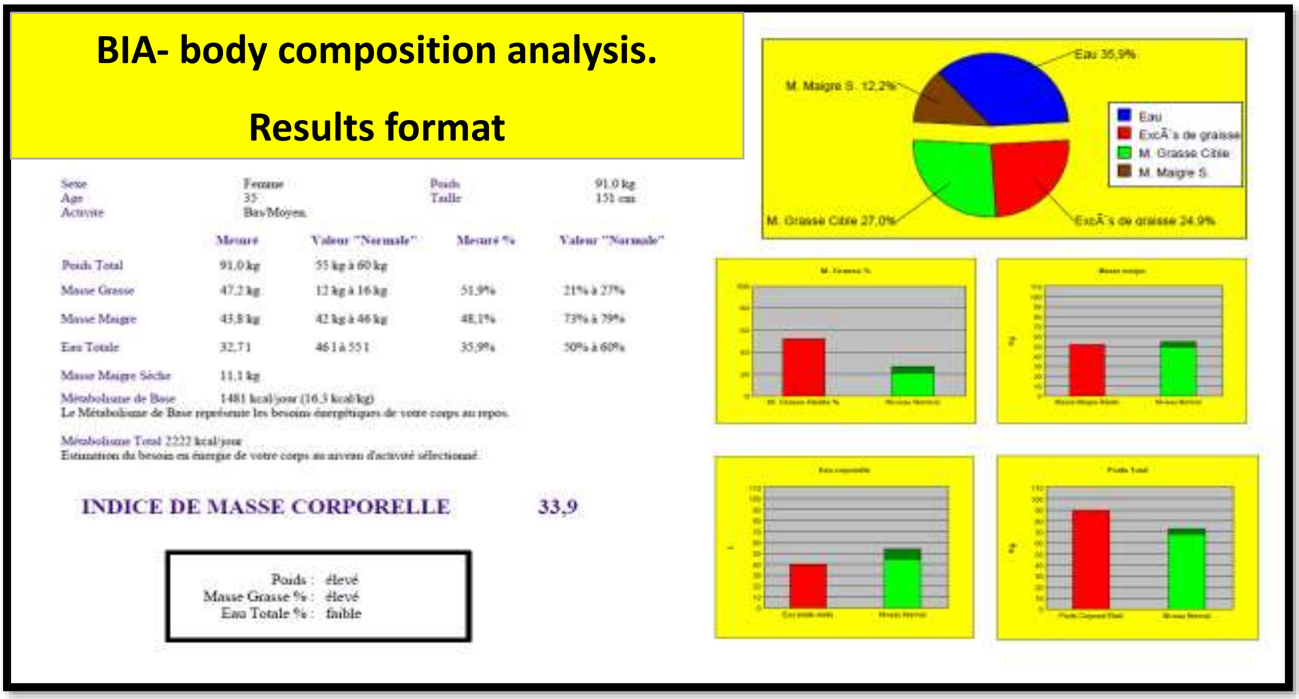


Figure 13 : BIA body composition measurement and results format

DISCUSSION

The BMI, a universal marker for assessing body shape and nutritional status, is an economical, simple and practical indicator. Since its formula was established by Quetelet in 1832, it has remained the standard for epidemiological and population studies. BMI is also well established in the medical world [47].

However, BMI standards and cut-off values are not adapted to all populations [81]. To assess the health risks of androgenic obesity, BMI does not appear to be the most relevant indicator for determining exclusively obesity-related morbidity and mortality [60].

In addition to its many limitations, BMI can also lead to erroneous judgments, or a false self-image in healthy subjects who may wrongly inflict restrictive diets on themselves. Or, conversely, a misinterpreted BMI, despite excess body fat in individuals suffering from excess body fat, who may consider themselves to be in good health [55].

A number of practitioners and specialists are urging caution regarding the use of BMI as the main criterion for assessing obesity [82]. Anthropometric measurements that determine circumferences: waist circumference, hip circumference, calculation of waist/hip circumference or waist/height ratios are useful [83]. For some others experts, the ratio of waist circumference to height would be a more pragmatic clinical measure of central obesity [41].

But others question the reliability and reproducibility of anthropometric measurements performed by untested nursing staff [84]. The performance of anthropometric measurements is judged insufficient in the case of colorectal cancer-CRC characterized by a highly metabolically active abdominal fat mass and in other cancer situations where significant changes in body composition are observed [85].

The technique of measuring the thickness of fat folds is highly appreciated for assessing the level of subcutaneous adiposity, but it is operator-dependent [86] [87].

As for imaging techniques, which are the gold standard for body composition analysis [88], they are still too costly, and their use in corpulence exploration is not routinely applicable. They generate considerable additional costs in the case of population studies, and are reserved for oncology and other serious pathologies.

BIA with a portable or fixed professional-type impedance meter is a non-anthropometric technique that would benefit from greater routine use in conjunction with BMI [89]. This simple, inexpensive technique offers several advantages. It has a proven track record for body composition analysis compared with so-called reference imaging techniques [90]. Measurement is instantaneous, painless and reproducible. BIA provides a precise diagnosis of obesity, and personalized follow-up is tailored to the nutritional status of each individual. Contraindications to BIA are limited to pregnant women and pacemaker wearers, as well as in cases of significant changes in fluid volume, edema and menstruation in women [91].

Body composition analysis helps to clarify the diagnosis of obesity and assess cardiometabolic risk, two prerequisites for grading care levels and optimizing obesity management [92].

CONCLUSION

Using the BMI tool means keeping its limitations in mind, because beyond calculating BMI or analyzing body composition using bioimpedancemetry-BIA, the aim is to make a precise diagnosis of obesity and correctly assess cardiometabolic risk.

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