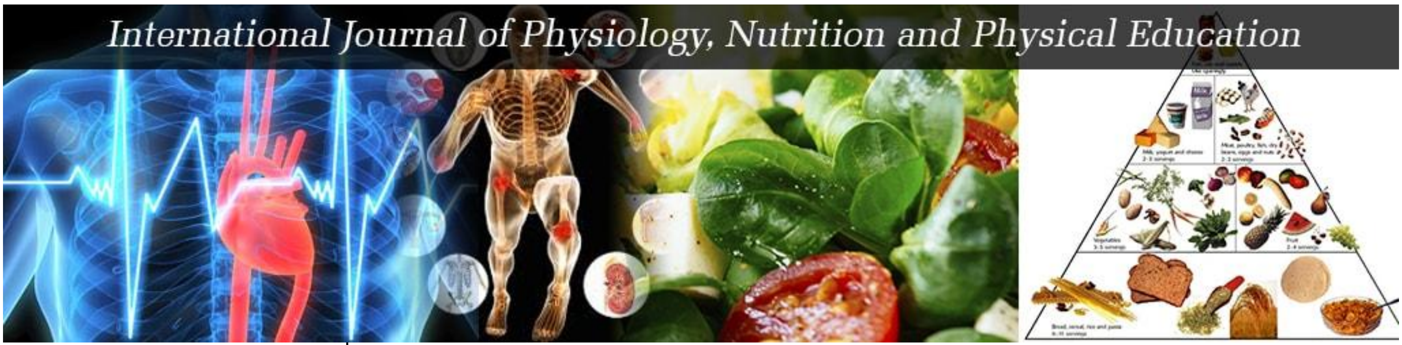

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Body composition assessment methods

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Abstract
Purpose of current research paper reviews the newest and precise, applicable methods for measurement of human body composition. Current data findings human body composition measurement methods are constantly existence fulfilled. Current efforts include multi-divisional and multi repetitiveness bioelectrical impedance analysis, measurable magnetic resonance for total body water, fat, and lean tissue analysis, imaging to advance explain ectopic fat depots. applicable methods admit for the assessment of total body fat, fat-free mass, whole body water, bone mineral content, cellular water, total adipose fat tissue and visceral, subcutaneous, skeletal muscle, elite organs, and ectopic body fat depots. Summary There is a continuous requirement for a technique that field data on metabolic and biological functions. Based on the wide range of measurable characteristic, analytical technique and known total body composition models, clinicians, and scientists can measure a number of body element and with longitudinal determination, can record development in health and disease with implications for understanding efficacy of nutritional and clinical interference, diagnosis, determent, and treatment in clinical settings. With the greater need to understand precursors of health risk beginning prior to conception, a gap exists in appropriate measurement methods with application beginning during gestation, that is, fetal development.

Keywords: Body composition, methods

Introduction

Obesity is a universal health problem for children, adults, and the elderly (WHO. Physical Status, 1995 [1], Popkin BM [2], Doak CM, 1998) [2]. That can lead to the increase of type 2 diabetes, raise risk factors for the cardiovascular and similar disorder, and is associated with raised cancer risk and renal deficiency (Deitel M, 2003) [15]. Modification in body composition that accompanies the onset and progression of obesity have an exciting impact on metabolism and insulin subtlety. Adipose tissue is premised to be a key point in hypothesizing total body lipid flux, thus balance lipid and glucose homeostasis (Guo S, Chumlea WC, Roche AF, *et al*., 1994) [3].

The world increase in the predominance of obesity has led to a development need for measurement tools and device for research, management and treatment of the obesity or obese person (James PT., 2004) [16]. The physical size restriction place on obesity, deviation in body composition from that of normal weight, and a complex psychopathology all pose tremendous challenges to the evaluation of an obesity and obese person (Mellits, E.D., Cheek, D.B., 1970) [20].

We present here the simplest methods for evaluating body composition, including Simple measurements, Predictive techniques, Two-component techniques and models. The field of obesity research would benefit from having more uniform methods of assessment which would enable researchers for clinical and community-based studies, evaluation teams to assess intervention programs and health professionals for counselling individuals (Roche AF, Heyms SB, Lohman TG., 1996) [21]. Standardized evaluation methods help better comparison of health between various studies and across different populations. This is particularly important since the reported results are attributed value that drives policy, organization, and treatment (Chumlea WC, Guo SS, Wholihan K, *et al*., 1998) [29]. The assessment of body structure occurs in different areas of medicine and biology when the conclusion is a better accepting of nutrition and growth status evaluation in syndromes states and their medication in populations. The aim of this paper is to review the presently available methods for assessment of body composition.

Methods for Assessing Body Composition

Numerous techniques have been used to estimate body composition. None of the methods currently used actually measure %BF; the only way to truly measure the volume of fat in the body would be to dissect and chemically analyze tissues in the body (Chumlea WC, Guo SS, Steinbaugh ML, 1994) [29]. The techniques routinely used to estimate %BF are based on the relationship between %BF and other factors that can be accurately measured, such as skinfold thicknesses or underwater weight. Because of the predictable relationship between the measured value and body composition, %BF can be estimated through these indirect methods (Kuczmarski RJ, Chumlea WC., 1997) [27].

Each of the techniques described in the following sections has advantages and disadvantages. Knowing these characteristics will help you decide wisely when choosing the method for body composition assessment. A comparison of important considerations can be found for fitness professionals, ease of measurement, relative accuracy, and cost are the primary considerations when choosing a technique. In other situations (for research or clinical applications), the accuracy of the measurement may outweigh other considerations.

Anthropometry

Anthropometric measurements describe body mass, size, shape, and level of fatness. Body size changes with weight gain, which alters the associative power among anthropometric measures and indices. Standardized anthropometric techniques are necessary for comparisons between clinical and research studies, and video and text media describing these techniques are available (Onis M, Onyango AW, Van den Broeck J, *et al*., 2004. Kuczmarski RJ, Chumlea WC, 1997) [26, 27]. Those interested in using anthropometric equipment and methods should first consult these several resources.

Weight and Stature

Weight is the obvious measure of obesity. Various scales are available for measuring weight, but these must be calibrated regularly. Persons with high body weights tend to have high amounts of body fat although this is not always true among the elderly with sarcopenia obesity, in whom stable or even low body weights occur with increased percent body fatness (Lohman T, Martorell R, Roche AF., 1988) [25]. Changes in weight reflect corresponding changes in body water, fat, and lean tissue. However, weight is not always the best indicator of obesity because the weight is related to stature, i.e., tall people are, on average, heavier than short people (Moore, F.D., 1963) [24]. Weight also increases with age in children (because of growth) and in adults (because of fatness). To overcome this lack of specificity, weight is divided by stature squared to create the body mass index or BMI as a descriptive index of body habitus encompassing both the lean and the obese (WHO. Physical Status, 1995) [1]. Stature is also easily measured with a variety of wall-mounted equipment that also needs to be calibrated regularly. In addition, methods are available for predicting stature when it cannot be measured for the handicapped or mobility impaired (Chumlea WC, Guo SS, Steinbaugh ML., 1994. Chumlea WC, Guo SS, Wholihan K, *et al*., 1998) [3, 28].

Body Mass Index

The advantage of BMI as an index of obesity is the availability of extensive national reference data worldwide, its established relationships with levels of body fatness, morbidity, and mortality (WHO. Physical Status, 1995) [1] and it is highly predictive of future risk. High BMI percentile levels based on percentiles on the CDC BMI growth charts and changes in parameters of BMI curves for children are linked to significant levels of risk for adult obesity at corresponding high percentile levels (Sun SS., Wu W., Chumlea WC, *et al*., 2002. Heymsfield SB, Lohman T, Wang Z, *et al*., 2005) [4, 31]. A boy with a BMI at the 85th percentile at age 12 has a risk of 20% of having a BMI at that same level at 35 years of age. For a girl with a BMI at the 95th percentile, the corresponding adult risk is greater than 60%. The relationship of obesity as indexed by BMI with mortality has been revised for the US adult population (Flegal KM, Graubard BI, Williamson DF, *et al*., 2005) [19]. In the elderly, sarcopenia causes a person of normal weight and BMI to become obese owing to an increasingly high percentage of body fat. BMI is also useful in monitoring the treatment of obesity, but a weight change of about 3.5 kg is needed to produce a unit change in BMI (Moore F.D., 1963) [24].

Abdominal Circumference

Obesity is frequently associated with increased amounts of intraabdominal fat. A central fat pattern is associated with the deposition of intraabdominal adipose tissue, but subcutaneous abdominal adipose tissue is involved also. The ratio of abdominal circumference (sometimes incorrectly referred to as “waist” circumference) to the hip circumference is an early index describing adipose tissue distribution or fat patterning Roche (AF, Heymsfield SB, Lohman TG., 1996, Heymsfield SB, Lohman T, Wang Z, *et al*., 2005) [21, 22]. Ratios greater than 0.85 represent a masculine or central distribution of fat. Most men with a ratio greater than 1.0 and women with a ratio greater than 0.85 are at increased risk for cardiovascular disease, diabetes, and cancers (Deitel M., 2003, James PT., 2004) [15, 16]. However, this ratio is an imperfect indicator of intraabdominal adipose tissue and the use of the abdominal circumference alone provides much the same information (Salom IL., 1997. Arterburn DE, Crane PK, Sullivan SD., 2004) [6, 7].

Persons in the upper percentiles for abdominal circumference are considered obese and at increased risk for morbidity, specifically, type 2 diabetes and the metabolic syndrome, and mortality (Heber D, Ingles S, Ashley JM, *et al*., 1996. Valsamakis G, Chetty R, Anwar A, *et al*., 2004) [8, 12]. Circumferences of other body segments such as the arm and leg are possible (Lohman T, Martorell R, Roche AF., 1988) [25]. But there are little available reference data except for arm circumference. The calculation of fat and muscle areas of the arm is not accurate or valid in the obese. Abdominal thickness is associated with levels of abdominal obesity because a large abdomen should be a thick abdomen (Valsamakis G, Chetty R, Anwar A, *et al*., 2004) [12]. However, there is some inconsistency in standardizing this measurement; should it be taken standing or recumbent, from the small of the back, or from the top of a table when recumbent? There are little available reference data.

Skinfolds

Taking skinfold measurements is a common method for determining body fat composition. The accurate measurement technique is important. Here is the standard technique that is used. You should read this information in conjunction with the description of each of the standard measurement sites. Skinfolds measure subcutaneous fat thickness, but they are not very useful for the obese. Most skinfold callipers have an upper measurement limit of 45 to 55 mm, which restricts their use to the "moderately" obese or thinner. A few skinfold callipers take larger measurements, but this is not a significant improvement because of the difficulty of grasping and holding a large skinfold, plus the additional problem of reading the calliper dials, all of which create additional errors. The majority of the available national reference data is for triceps and subscapular skinfolds, but the triceps is a sex-specific site and can reflect changes in the underlying triceps muscle rather than an actual change in body fatness. Skinfolds are useful in monitoring changes in fatness in children because of their small body size, and the majority of the fat is subcutaneous even in obese children (Flegal KM, Carroll MD, Ogden CL, *et al*., 2002. WHO., 1998) [9, 10]. The statistical relationships of skin fold with percent and total body fat are often not as strong as that of BMI in both children and adults (Flegal KM, Graubard BI, Williamson DF, *et al*., 2005) [19]. Also, we do not know the real upper distribution of subcutaneous fat measurements because most obese children and adults have not had their skinfolds measured.

Waist to Hip Ratio (WHR)

The purpose of this test to determine the ratio of waist circumference to the hip circumference, as this has been shown to be related to the risk of coronary heart disease ((Salom IL., 1997. Moore F.D., 1963) [6, 24]. Equipment required tape measure. A simple calculation of the measurements of the waist girth divided by the hip girth. Waist to Hip Ratio (WHR) = Gw / Gh, where Gw = waist girth, Gh = hip girth. It does not matter which units of measurement you use, as long as it is the same for each measure. The table below gives general guidelines for acceptable levels for the hip to waist ratio. You can use any units for the measurements (e.g. cm or inches), as it is only the ratio that is important. Target population this measure is often used to determine the coronary artery disease risk factor associated with obesity. Advantages the WHR is a simple measure that can be taken at home by anyone to monitor their own body composition levels. (Kuczmarski R, Flegal K, Campbell S, *et al*., 1994) [17].

Bioelectric Impedance Analysis

Bioelectrical impedance analyzers (BIAs) do not measure any biological quantity or describe any biophysical model related to obesity. The impedance index, stature squared divided by resistance *(S2/R)* at a frequency, most often 50 kHz, is an independent variable in regression equations to predict body composition (Velazquez-Alva J, Irigoyen M, Zepeda M, *et al*., 2004. Ismail MN, 1995) [13, 14]. Bioelectrical impedance analyzers use such equations to describe statistical associations based on biological relationships for a specific population, and as such the equations are used only for subjects that closely match the reference population in body size and shape. BIA has been applied to overweight or obese samples (James PT., 2004. Chumlea WC, Guo SS, Wholihan K, *et al*., 1998) [16]. In a few studies; thus the available BIA prediction equations are not applicable to overweight or obese children or adults. The ability of BIA to predict fatness in the obese is difficult because they have a greater proportion of body mass and body water accounted for by the trunk, the hydration of fat-free mass (FFM) is lower in the obese, and the ratio of extracellular water (ECW) to intracellular water (ICW) is increased in the obese. BIA validity and its estimates of body composition are significant issues for normal weight individuals. BIA is useful in describing mean body composition for groups of individuals, but large errors for an individual limit its clinical application, especially among the obese. The large predictive errors with BIA render it insensitive to small improvements in response to treatment. Commercial BIA analyzers contain all of the problems associated with this methodology. Recent BIA prediction equations have been published (Sun SS, Chumlea WC, Heymsfield SB, *et al*., 2003) [30]. Along with body composition mean estimates for non-Hispanic whites, non-Hispanic blacks, and Mexican-American males and females from 12 to 90 years of age (Chumlea WC, Guo SS, Kuczmarski RJ, *et al*., 2002) [31]. These equations are not recommended for obese individuals or groups.

Body Density

Hydro densitometry estimates body composition using measures of body weight, body volume, and residual lung volume. Historically, body density was converted to the percentage of body weight as fat using the two-compartment models of Siri (Siri W., 1963) [32]. Or Brozek and co-workers (Brozek J, Grande F, Anderson J, *et al*., 1963) [33]. but more recently, a multicompetent model is used to calculate body fatness (Guo SS, Chumlea WC, Roche AF, *et al*., 1997) [32]. Body density is plagued with the problem of subject performance because it is difficult if not impossible for an obese adult or child to submerge. Weight belts reduce bouncily, but not all aspects of performance. Air displacement devices (Lohman T, Martorell R, Roche AF., 1988. Flegal KM, Graubard BI, Williamson DF, *et al*., 2005) [25, 19] are limited to adults who are "moderately" obese at best. Regardless, most overweight and obese persons are reluctant to put on a bathing suit and participate in body density measurements.

Total Body Water

Total body water (TBW) is easy to measure because it does not require undressing or any real physical participation, but this method is limited in the obese. The major assumption is that FFM is estimated from TBW based on an assumed average proportion of TBW in FFM of 73%, but this proportion ranges from 67% to 80% (Siri W., 1963. Guo SS, Chumlea WC, Roche AF, *et al*., 1997) [32, 34]. In addition, about 15% to 30% of TBW is present in adipose tissue as extracellular fluid, and this proportion increases with the degree of adiposity. These proportions tend to be higher in women than in men, higher in the obese, and produce underestimates of FFM and overestimates of fatness. Variation in the distribution of TBW as a result of disease associated with obesity, such as diabetes and renal failure, affects estimates of FFM and TBF further. TBW is a potentially useful method applicable to the obese but there are details that need to be considered. The several analytical chemical methods used to quantify the concentration of TBW (and extracellular fluid) have errors of almost a litre. Equilibration times for isotope dilution in relation to levels of body fatness are unknown, because, theoretically, it might (and should) take longer for the dilution does to equilibrate in an obese person as compared with a normal weight individual. Also, a measure of extracellular space is necessary to correct the amount of FFM in an obese person. Such data could also be very useful in the treatment of end-stage renal disease.

Dual-energy X-ray Absorptiometry

Dual-energy x-ray absorptiometry (DXA) is the most popular method for quantifying fat, lean, and bone tissues. DXA is fast and user-friendly for the subject and the operator, but the machines require regular maintenance and calibration. DXA has inherent assumptions regarding levels of hydration, potassium content, or tissue density in the estimation of fat and lean tissue, and these assumptions vary by the manufacturer (Sun SS, Chumlea WC, Heymsfield SB, *et al*., 2003 Chumlea WC, Guo SS, Kuczmarski RJ, *et al*., 2002) [30, 31]. DXA estimates of body composition are also affected by differences among manufacturers in the technology, models and software employed, methodological problems, and inter-machine differences (Deitel M., 2003. Troiano RP, Flegal KM, Kuczmarski RJ, *et al*., 1995) [15, 18]. There are physical limitations of body weight, length, thickness and width, and the type of DXA machine, i.e., pencil or fan beam. Most obese adults and many children are often too wide, too thick, and too heavy to receive a whole-body DXA scan although some innovative adaptations have been reported (James PT., 2004) [16]. The pediatric software is available for DXA and should be used according to the manufacturer's recommendations. DXA is a convenient method for measuring body composition in much of the population, and it is currently included in the ongoing National Health and Nutrition Examination Survey (NHANES). The other imaging systems, such as computed tomography (CT) and magnetic resonance imaging (MRI) are not practical for obese individuals. CT is able to accommodate large body sizes but has high radiation exposures and as such is inappropriate for whole-body assessments, but it has been used to measure intraabdominal fat. MRI is not able to accommodate large body sizes in many instances but can be used for whole body assessments. Both these methods require additional time and software to provide whole-body quantities of fat and lean tissue (Seim HC, Holtmeier KB., 1993. Flegal KM, Carroll MD, Ogden CL, *et al*., 2002) [5, 9].

Computed Tomography and Magnetic Resonance Imaging

The other imaging modalities, such as CT and MRI, are gaining in popularity and represent important new techniques for body composition assessment. Unfortunately, these methods are often not practical for obese individuals (WHO, 1998 [10]. Ismail MN, 1995) [14]. CT is able to accommodate large body sizes but has high radiation exposures and, as such, is inappropriate for whole body assessments, but it has been used to measure intra-abdominal fat. In many instances, MRI is not able to accommodate large body sizes but can be used for whole body assessments in normal weight or moderately overweight individuals (Popkin BM, Doak CM., 1998. Flegal KM, Graubard BI, Williamson DF, *et al*., 2005) [2, 19]. Both these methods require additional time and software to provide whole body quantities of fat and lean tissue. In addition to its imaging capabilities, CT can also distinguish body tissues based on signal attenuation. This technique is especially useful for assessing non adipose fat or the fatty infiltration of skeletal muscle or liver tissue. These lipid stores may play a substantial role in the development of insulin resistance in type 2 diabetes patients (Arterburn DE, Crane PK, Sullivan SD., 2004. Chumlea WC, Guo SS, Wholihan K, *et al*., 1998) [7, 29].

Whole-Body Air-Displacement Plethysmography

Using air displacement technology for measuring and tracking body fat and lean mass. Equipment required Bod Pod by Life Measurements Instruments, Concord, CA. The Bod Pod system measures body composition by determining body volume and body weight (Siri W., 1963. Guo SS, Chumlea WC, Roche AF, *et al*., 1997) [32, 34]. The subject should not have exercises for the previous two hours, as they must be fully rested and hydration status and increases in muscle temperature can adversely affect the results. Body weight is measured using scales. Body volume is measured by first measuring the volume of the chamber while empty. Then the volume of the subject chamber is measured with the subject inside. By subtraction, the volume of the subject is determined. Once those body volume and weight are determined, body density can be computed and inserted into an equation to provide percent fat measurements. Body volume is determined by monitoring changes in pressure within a closed chamber. These pressure changes are achieved by oscillating a speaker mounted between the front testing chamber and a rear reference chamber, which causes complementary pressure changes in each chamber. The pressure changes are very small and are not noticed by the individual being tested. High level of accuracy, ease-of-use, and fast test time. Compared to underwater weighing, the Bod Pod does not require getting wet and is well suited for special populations such as children, obese, elderly, and disabled persons. The Bod Pod unit is very expensive ($30,000 - $40,000) and only a few facilities have it. Some research or academic institutions may offer tests for a fee. The accuracy of the manufacturers indicates that the general error range of the BOD POD is 1-2% (the same as hydrostatic weighing) (Flegal KM, Graubard BI, Williamson DF, *et al*., 2005. Mellits, E.D., Cheek, D.B., 1970) [19, 20].

Conclusion

It does not appear that the present epidemic of overweight and obesity will attenuate in the near future. Our ability to diagnosis, monitor, and treat obesity is limited, in part, by our limited ability to assess body fatness easily. There is no universally accepted method of measuring body fatness or for quantifying obesity clearly, and current methods are hampered with problems of non-universal assumptions and limited by application of the methodology for obese individuals. The WHO (WHO, 1998) [10]. Has made several recommendations concerning obesity. One of these addresses the need for the development and validation of new and existing techniques. In this chapter, we have briefly reviewed many of the existing techniques and their limitations when applied to obese persons. In support of this WHO recommendation, it is clear that existing techniques are not applicable to many obese who are in great need of this technology. This limitation also affects our ability to determine the real prevalence of obesity because the current methods are not applicable to large epidemiological and clinical studies. Obviously, much work is yet to be done.

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