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LEAN BODY MASS ASSESSMENT BY DUAL-ENERGY X-RAY ABSORPTIOMETRY AND THE METHOD OF HUME

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Summary: Dual-energy X-ray absorptiometry (DXA) as a gold standard of body composition assessment enables development and calibration of the anthropometric equations in estimation of the body composition, as well as the lean body mass (LBM). Lean body mass can be calculated from height and weight using the method of Hume. The aim of this study was to discover the accuracy of the Hume's equation in determining LBM.

DXA was performed in 88 women with mean BMI (28.22±5.12 kg/m^2), divided in 4 groups according to their BMI: 1st gr.<25 kg/m^2; 2nd gr. 25-29,9 kg/m^2; 3rd gr. 30-34,9 kg/m^2; and 4th gr. 35-40 kg/m^2. Hume's equation calculated LBM (kg), LBM = [0.29569 x (body weight in kg)] + [(0.41813 x (height in cm)] - 43.2933, and it was compared to the LBM values determined by DXA.

Mean lean body mass determined by the method of Hume was 49.42±3.68 kg, and it was significantly higher compared to the mean lean body mass (40.59±4.5 kg) determined by DXA ($p<0.0001$). The lean body mass values determined by the method of Hume in the 1st group (41.81±4.1 kg), in the 2nd group (43.53±3.69 kg), in the 3rd group (46.74±3.69 kg) and in the 4th group (46.74±4.26 kg) were significantly higher compared to the correspondent LBM values determined by DXA (37.96±4.06 kg) in the 1st group ($p<0.001$), (39.25±2.95 kg) in the 2nd group ($p<0.0001$), (43.1±3.93 kg) in the 3rd group ($p<0.005$) and (46.11±3.07 kg) in the 4th group ($p<0.042$). BMI increase was associated with significant LBM increase in the 3rd and 4th group compared to the 1st gr.

Hume's equation overestimated lean body mass compared to DXA, and it couldn't be used for lean body mass assessment in clinical practice.

Key words: lean body mass, DXA, Hume's equation

Introduction

Obesity is a multi-factorial chronic disease characterized with an accumulation of excess fat sufficient to harm health. Lean body mass is the mass of the body minus the fat. Body composition is simply the ratio of lean body mass to fat body mass. BMI does not quantitate body composition (Dencker, 2007), and does not show the difference between excess fat and muscle. Two people can have the same BMI but different body fat percentages. BMI overestimates body fat in persons who are very muscular, and it can underestimate body fat in persons who have lost body mass (e.g. many elderly). Weight scales can be misleading since body weight is muscle, fat and bone all added together (Gallagher, 2000). Standard scales can tell a total weight, but can't determine the lean-to-fat ratio of that weight. Body composition refers to the amount of body that is composed of fat, versus the amount that is composed of "lean mass" (Heyward, 1998). Naturally, the objective for optimum health is to minimize body fat and maximize lean mass. The study of body composition attempts to partition and quantify body weight or mass into its basic components (Heyward, 1998).

There are a number of methods for determining the lean body mass. LBM is predicted by using a complex and imperfect equations. One of them is Hume's equation (Hume, 1966). It is a rapid way of generally accessing lean body mass in individuals from epidemiologic studies. Imaging technologies, magnetic resonance imaging, computer tomography and DXA, are precise and accurate techniques used to study lean body mass and adipose tissue distribution (Müller, 2002; Shen, 2003). DXA is sensitive technique of body composition assessment, which measures whole and segmental body fat and lean body mass. It is a relatively new method for reliable and direct measurements of body mass in its three basic components: total body bone mineral content, mineral free lean tissue mass, and fat. Today DXA is considered the gold standard to assess bone health and body composition (Ravaglia, 1999; Hunter, 2002; Salamone, 2000). Using DXA to determine the proportion of lean body mass (muscle) versus total body fat is a valuable clinical tool in the management of long-term health and fitness. DXA should be used for the development and calibration of the anthropometric methods, and anthropometric equations that are used for body composition assessment (Lear, 2006).

This study performed LBM assessment in dependence on BMI, and examined the inter-relationship of lean body mass derived from Hume's prediction equation and DXA in women. The purpose of this study was to discover the accuracy of Hume's equation in lean body mass assessment.

Materials and Methods

DXA examination was performed on 88 healthy women with mean age 50.79±13.57yr, BMI 28.22±5.12 kg/m^2 and BW 71.5±12.5kg. The examinees were divided in 4 groups according to their BMI expressed in kg/m^2: 1st gr with mean BMI value 22.45±1.86; 2nd gr. 27.38±1.16; 3rd gr 32.04±1.41 and 4th gr 36.86±1.82. The 1st gr consisted of 27 patients, the 2nd gr 28, the 3rd gr 22 and the 4th gr 11 patients. The patients groups did not differ according to their age.

BMI was defined as the weight (in kilograms) divided by the square of the height in meters (kg/m^2). Height was measured by a wall stadiometer in subjects without shoes and weight was measured by a digital scale.

Lean body mass in adults can be estimated from a patient's gender, height and weight with Hume's equation. For men over the age of 16, lean body mass in kilograms = (0.32810 x (body weight in kilograms)) + (0.33929 x (height in centimeters)) - 29.5336. For women over the age of 30, lean body mass in kilograms = (0.29569 x (body weight in kilograms)) + (0.41813 x (height in centimeters)) - 43.2933.

DXA assessment was performed with Lunar DPX-NT system which uses encore 10.x Windows-XP Professional OS computers. For body composition measurements, a

DXA scan of the entire body was performed. DXA assessment of the total body and regional values (arm, leg, trunk, android, gynoid) of the tissue mass (TM) and TM%, as well as FM, FM%, bone (mineral) free LBM, bone mineral content (BMC) and bone mineral density (BMD) was performed, as well as LBM as a sum of bone free LBM and BMC. LBM values were expressed in kilograms (kg). DXA lean body mass values were compared to the Hume's equation values.

Statistical analyses were performed using statistical software program SPSS for Windows, version 14.0. $P<0.05$ was considered significant. Each parameter was presented as the mean±SD. Differences among groups were evaluated by performing an analysis of variance (ANOVA) for normally distributed parameters or by the Kruskal-Wallis test for non-parametric data. Correlation coefficients were determined by Pearson's product moment.

Results

LBM determined with Hume's equation in the 1st group was 41.81±4.1kg, in the 2nd group (43.53±3.69kg), in the 3rd group (46.74±3.69kg), in the 4th group (46.74±4.26kg) and total (49.42±3.68kg). LBM determined with DXA in the 1st group was 37.96±4.06kg, in the 2nd group (39.25±2.95kg), in the 3rd group (43.1±3.93kg), in the 4th group (46.11±3.07) and total (40.59±4.5kg).

The significance of the difference between the two methods in the 1st gr. was $p<0.001$, in the 2nd gr. $p<0.0001$; in the 3rd gr. $p<0.005$, in the 4th gr. $p<0.042$ and total difference $p<0.0001$.

There was no significant LBM increase in the 2nd gr. compared to the 1st gr. There was significant LBM increase in the 3rd and 4th group compared to the 1st group that was discovered by the two methods.

LBM values determined with Hume's equation correlated significantly ($p<0.0001$) with LBM values determined with DXA. They also correlated significantly with BMI ($p<0.0001$), confirming LBM increase related to BMI increase.

Discusion

BMI and total body weight do not assess lean vs. fat mass and do not quantitate body composition. At the same BMI, more body fat tends to have women compared to men, and older people compared to younger adults. A bodybuilder with a large muscle mass and low percentage of body fat may have the same BMI as a person who has more body fat. BMI does not provide information on fat distribution, and do not distinguish between excess fat and muscle. A person can have a lot of muscle, but be considered "over-weight" by many height/weight charts. The opposite can also be true – a person can have a lot of fat and little muscle and be "over-fat" but not overweight. Because measuring a person's body fat is difficult, health care providers often rely on other means to diagnose obesity (Goh, 2004).

Body composition is simply the ratio of lean body mass (structural and functional elements in cells, body water, muscle, bone, heart, liver, kidneys, etc.) to fat body (essential and storage) mass. Body composition, including fat mass, fat distribution and muscle mass, gradually changes with aging, even if the body weight remains unchanged. Lean body mass decreases significantly, while fat mass increases and is preferentially stored in abdominal tissues (Srrensen, 2001; Zamboni, 1997).

Measurements of body composition have been used to study how lean body mass and body fat change during health and disease. Naturally, the objective for optimum health is to minimize body fat and maximize lean mass. By measuring body composition, a person's health status can be more accurately assessed and the effects of both dietary and physical activity programs better directed. Also, measurements of body compositions have provided a research tool to study the metabolic effects of aging, obesity, and various wasting conditions. Because a scale measures "body weight," which includes fat, muscles, bones and organs, it can't specifically tell how much fat have been lost. The only way to measure actual fat loss is to measure "body composition," not body weight in weight loss programs, and by getting body composition measured, we will have full knowledge of how body is developing - whether for the good or bad.

There are a number of methods for determining the lean body mass. Some of these methods require specialized equipment such as underwater weighing (hydrostatic weighing), BOD POD (a computerized chamber), and DXA. Other methods for determining the lean body mass are simple such as skin calipers and bioelectric impedance analysis (BIA).

The methods are divided into four general categories: anthropometric indices and skinfold, body volume measurements, body water measurements including bioelectrical methods, and imaging techniques. Among the newest technologies are air-displacement plethysmography, three-dimensional photonic scanning, multifrequency bioelectrical impedance spectroscopy and whole-body tomography using electrical impedance and magnetic induction. These newer approaches are compared with the established reference methods. The advantages and limitations of each technique as a field method are presented relative to the corresponding concepts of an ideal method (Ellis, 2001).

In vivo methods use equations to predict percentage of body fat, fat-free mass, muscle, hydration, etc. Using a form of statistics known as multiple regressional analysis, this allows an unmeasurable component, such as body fat, to be predicted from one or more measured variable, where studies have proved there is a correlation. Equations can be population-specific (developed for specific types of people, including such categories as gender, age, ethnicity, fitness level, disease, etc.) or generalized to cover a wide range of people types. A given equation is validated according to how well the results match the results of the reference method. It is important to note that results of reference methods themselves do not agree 100 percent. Therefore, when comparing different methods or products, we should consider which reference method was used and the appropriateness of both the method and particular product for the body type being analyzed.

DXA determines total and regional body composition. It is considered a gold standard because of its reliability, precision, and the fact that it is based on a three-compartment model. DXA method determines total body fat mass and FM%, bone mass and lean mass, and separately their regional values for the arms, legs, head and trunk (which included ribs, pelvis, thoracic spine, and lumbar spine) (Lear, 2006).

Although imaging techniques such as computed tomography, magnetic resonance imaging and DXA provide more accurate and precise assessment of visceral adiposity, they require technical skill to operate, they are expensive, impractical for routine clinical use and, in the case of CT, deliver unacceptable levels of radiation exposure (Heymsfield, 1998; Brennan DD, 2005; Müller, 2002). These methods, especially DXA should therefore be used for the development and calibration of anthropometric methods and equations.

Hume's method significantly overestimated lean body mass as determined by DXA, and overall, this prediction equation was not interchangeable (Eisenmann, 2004). DXA enabled Hume's equation accuracy assessment. This study discovered that Hume's equation overestimated lean body mass compared to DXA, and it couldn't be used for LBM assessment in clinical practice.

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PROCENA LEAN BODY MASS SA DUAL-ENERGY X-RAY APSORPCIOMETRIJOM I METODOM HUMEA

Izvod

Dual-energy X-ray absorptiometry (DXA) kao zlatni standard za procenu telesnog sastava omogućava razvoj i kalibraciju antropometrijskih jednačina u proceni telesnog sastava, a isto tako i lean body mass (LBM). Lean body mass može biti izračunat iz visine i težine pomoću Humeovog metoda. Cilj ovog rada je bio da se dokaže tačnost Humeove jednačine u određivanju LBM.

DXA je bio određivan kod 88 žena sa prosečnim BMI (28.22±5.12 kg/m^2), podeljenih u 4 grupe prema njihovim BMI: gr.1 <25 kg/m^2; gr.2 (25-29,9 kg/m^2); gr. 3 (30-34,9 kg/m^2) i grupa 4 (35-40 kg/m^2). Humeova jednačina kalkulira LBM (kg), LBM = [0.29569 x (body weight in kg)] + [(0.41813 x (height in cm)] - 43.2933, a rezultat je upoređen sa LBM vrednostima određenim DXA metodom.

Prosečne vrednosti lean body mass određene metodom Humea su bile 49.42±3.68 kg, značajno veće u poređenju sa lean body mass određenom DXA metodom (p<0.0001). Vrednosti lean body mass određene metodom Humea u gr. 1 (41.81±4.1 kg), u gr. 2 (43.53±3.69 kg), u gr. 3 (46.74±3.69 kg) i u grupi 4 (46.74±4.26 kg) bile su značajno veće u poređenju sa korespondentnim LBM vrednostima određenim metodom DXA (37.96±4.06 kg) u gr. 1 (p<0.001), (39.25±2.95 kg) u gr. 2 (p<0.0001), (43.1±3.93 kg) u gr. 3 (0<0.005) i (46.11±3.07 kg) u gr. 4 (p<0.042). Porast BMI je bio povezan sa značajnim LBM porastom u trećoj i četvrtoj grupi u poređenju sa prvom grupom.

Jednačina Humea je precenila lean body mass u poređenju sa DXA i zato se ne može koristiti za procenu lean body mass u kliničkoj praksi.

Ključne reči: lean body mass, DXA, jednačina Humea