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SEIDEL'S AND LEAN'S EQUATION RELATIONS TO DUAL-ENERGY X-RAY ABSORPTIOMETRY DETERMINATION OF THE TOTAL FAT MASS PERCENTAGE

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Summary: Dual-energy X-ray absorptiometry (DXA) provides accurate and precise body composition and adiposity assessment, and enables development and calibration of the anthropometric equations. Seidel's and Lean's equation as well as DXA are used to determine total body fat mass percentage (FM %). The aim of this study was to evaluate the accuracy of Seidel's and Lean's equation in comparison to DXA FM% estimate.

DXA was performed in 88 women with mean body mass index (BMI) (28.22±5.12 kg/m^2) and age (50.79±13.57yr.), 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. Seidel's equation (FM% = 4,201/D - 3,813 x 100; D= 1,1369 - 0,0598 x logSUMA; SUMA= triceps skinfold (SF) + biceps SF + subscapular SF + suprailiac SF) and Lean's equation (FM% = 0,439 x waist circumference + 0.221 x age – 9,4) calculated FM%, and it was compared to FM% determined by DXA.

Total FM% determined by Lean's equation (42.67±7.14%) was not significantly different compared to FM% determined by DXA (41.44±7.14%), but FM% determined by Seidel's method was significantly lower (28.06±3.46%). FM% determined by Lean's equation was not significantly different, but FM% determined by Seidel's equation was lower compared to DXA in all groups divided according to their BMI. FM% determined by Lean's equation correlated significantly with FM% determined by DXA ($p<0.0001$).

DXA examination discovered that Seidel's equation underestimated FM% in all groups, and it was confirmed that Lean's equation provide accurate and precise FM% assessment, and it could be used in clinical practice.

Key words: body fat mass percent, DXA, Lean's equation, Seidel's equation

Introduction

Obesity is defined as the pathological condition in which an individual possess an excess of body fat of above 30% for women and 25% for men. Women have more body fat than men. Body fat ranges from under 10 percent in well-trained athletes to slightly over 50 percent in obese patients. Body composition refers to the amount of body that is composed of fat, versus the amount that is composed of "lean mass" (Heyward, 1998). 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).

Obesity and body fat distribution are known risk factors for cardiovascular disease (Dencker, 2007; Van Pelt, 2002). The higher measured body fat percentage above average levels, the higher health risk for weight related illness. The measurement of body fat is more accurate than body weight for assessing health. Total body fat content measurement is useful for athletes, models and health-conscious people. By knowing body fat percentage, and the range it falls in, measures can be taken to improve the health and reduce the risk for various diseases. A scale measures "body weight," which includes fat, muscles, bones and organs, it can't specifically tell how much fat have been lost during weight loss programs. The only way to measure actual fat loss is to measure "body composition," not body weight.

BMI does not quantitate body composition, and does not show the difference between excess fat and muscle. The relationship between BMI and body fat content varies according to body build and body proportion. However, a BMI of 30 or higher usually indicates excess body fat (Dencker, 2007).

There are simpler anthropometric methods to estimate body fat. Seidel's and Lean's equation are also used to determine FM%. Lean's equation is the most robust prediction with the least bias from waist circumference adjusted for age (Lean, 1996). No anthropometric assessment can directly measure visceral fat, and data from imaging techniques are necessary for the development and calibration of simpler, less expensive approaches to the estimation of adipose tissue. 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 a gold standard of body composition assessment and precise determination of body fat content. It is used to estimate total body fat and percent of body fat (Hunter, 2002; Salamone, 2000). DXA should therefore be used for the development and calibration of the anthropometric methods, and anthropometric equations that are used for FM% assessment.

The purpose of this study was to assess the accuracy of Seidel's and Lean's anthropometric equations for women in comparison to FM% estimate with DXA, and to determine their relation to BMI.

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: 1stgr with mean BMI value 22.45±1.86; 2ndgr. 27.38±1.16; 3rdgr 32.04±1.41 and 4thgr 36.86±1.82. The 1stgr consisted of 27 patients, the 2ndgr 28, the 3rdgr 22 and the 4thgr 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's equation was calculated: percent BF for women = 0.439 waist (cm) + 0.221 age (y) - 9.4; and for men = 0.567 waist (cm) + 0.101 age (y) - 31.8. Seidel's equation was also calculated as follows: FM% = 4,201/D - 3,813 x 100; D = 1,1369 - 0,0598 x logSUMA; SUMA = triceps skinfold (SF) + biceps SF + subscapular SF + suprailiac SF.

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. FM and FM% total body and regional values (arm, leg, trunk, android, gynoid) were determined with DXA.

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

FM% determined by Seidel's method in the 1stgr. was 24.34±3.14%, in the 2ndgr. 28.55±1.81%, 3rdgr. 30.29±1.62%, 4thgr 31.76±1.14% and total FM% (28.06±3.46%). FM% determined by Lean's method in the 1stgr. was 35.69±4.81%, in the 2ndgr. 42.03±4.51%, in the 3rd gr. 48.78±3.96%, in the 4thgr. 49.94±5.29% and total (42.67±7.14%). DXA FM% measurements were for the 1st gr. 33.99±6.64%, for the 2ndgr. 42.33±3.42%, 3rdgr. 46.06±3.99%, 4thgr. 48±3.35% and total (41.44±7.14%).

DXA FM% values in 4 groups divided according to their BMI were not significantly different compared to the correspondent FM% values determined by Lean's equation, but were significantly higher compared to the correspondent values determined by Seidel's equation. Seidel's equation underestimated FM% compared to DXA.

FM% determined by Seidel's and Lean's equation correlated significantly ($p<0.0001$) with FM% determined by DXA, confirming FM% increase related to the BMI increase.

Discussion

Obesity is a multi-factorial chronic disease characterized with an accumulation of excess fat sufficient to harm health. Obesity is a multihormonal disease. Everyone needs a certain amount of body fat for stored energy, heat insulation, shock absorption, and other functions. Just as too little body fat can cause physiological complications, too much body fat is also harmful. For men over 25 percent and women over 32 percent fat there is a dramatic correlation with illness and disease (Gallagher, 2000; Van Pelt, 2002). Normal body fat percentages are 15-20 per cent in men and 20 to 25 per cent in women (Gallagher, 2000). Women naturally have a higher body fat to lean tissue ratio than men, and body fat naturally increases with age (Zamboni, 1997).

Because differences in weight among individuals are only partly due to variations in body fat, body weight is a limited, though easily obtained, index of obesity. In view of these limitations, some authorities advocate a definition of obesity based on percentage body fat. For men, percentage body fat greater than 25% defines obesity, and 21-25% is borderline and for women, over 33% defines obesity, and 31-33% is borderline. Most health care providers agree that men with more than 25 percent body fat and women with more than 30 percent body fat are obese.

Overweight is defined as an excess (10 - 20%) of body weight in relation to height and it indicates mild or moderate health risks. Obesity represents a state of excess storage of body fat, and it is defined in terms of body composition, percent body fat. Obesity carries a more significant health risk. The measurement of body fat is more accurate than body weight for assessing health (Chung 2005; Gallagher, 2000; Srrensen, 2001). 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.

The higher measured body fat percentage above average levels, the higher health risk for weight related illness, like heart disease, high blood pressure, gallstones, type 2 diabetes, osteoarthritis, and certain cancers (Van Pelt, 2002; Zamboni, 1997). Also, the higher percentage of fat (and the smaller percentage of muscle) fewer calories are needed to maintain the weight and therefore it is much easier to gain weight. The reason for need fewer calories is simply because muscle requires more calories because of its density vs. less dense fat tissue.

However, a BMI of 30 or higher usually indicates excess body fat. BMI increase is associated with progressive and significant FM increase. FM increase in our study was progressive from the 1st to the 4th group, and was significantly different between the groups. BMI increase was associated with significant FM% increase that was discovered by the two methods, DXA and anthropometric equations. Estimates of abdominal visceral adipose tissue and saturated adipose tissue areas increase with greater BMI. Percentage body fat and total body fat are all closely associated with BMI, but a significantly lower correlation exist for BMI vs. body fat distribution (Dencker, 2007; Goh, 2004).

Because measuring a person's body fat is difficult, health care providers often rely on other means to diagnose obesity (Goh, 2004). Weight-for-height tables, which have been used for decades, usually have a range of acceptable weights for a person of a given height. One problem with these tables is that there are many versions, all with different weight ranges. Another problem is that they do not distinguish between excess fat and muscle. A very muscular person may appear obese, according to the tables, when he or she is not.

The fact is that there are many ways to measure improvements in health and fitness, and fat loss happens to be one of them. Getting on the scale every day, however, is at best an inaccurate way to measure fat loss and at worst a potentially insignificant measurement given the many other positive changes that are likely occurring. If we focus on body fat loss, some accurate and reliable methods are needed to get.

There are simpler methods to estimate body fat. One is to measure the thickness of the layer of fat just under the skin in several parts of the body (Goh, 2004). For example, calipers use external skin fold measurements (a method that estimates fat found just under the skin) to calculate total body fat. Another method involves sending a harmless amount of electricity through a person's body. Bioelectrical impedance analysis (BIA) measures the body's impedance (resistance) to an electrical signal to estimate total body fat. Both methods are used at health clubs and commercial weight loss programs. Results from these methods, however, can be inaccurate if done by an inexperienced person or on someone with severe obesity. Anthropometric methods are simpler and cheaper and provide a surrogate index of visceral obesity. They include measurement of the waist circumference, WHR and sagittal diameter, which are useful predictors of the metabolic syndrome in different ethnic groups. Sagittal diameter predicts the adverse metabolic profile of the metabolic syndrome but requires capital equipment; waist circumference, however, has the advantage of simplicity and ease of use and is recommended for routine use.

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. New equations have been developed to predict body fat and its percentage calculated from body density measured by underwater weighing from simple anthropometric measurements (Lean, 1996). Skinfold-thickness measurements continued to give good predictions of mean body density, but with significant bias at extremes of body fat and age. Anthropometric prediction equations that use a combination of circumferences and bony diameters are recommended for older adults (up to 79 years of age), as well as obese men and women (Heyward, 1998).

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, 2005; Müller, 2002). These methods should therefore be used for the development and calibration of anthropometric methods, equations for FM% assessment.

DXA is used to quantify abdominal fat mass (Lear, 2006), total body fat (FM) and also total body fat as percentage of total body mass (FM%)(Brownbill, 2005; Heymsfield, 1998). Our study discovered that FM% determined by Lean's equation was not different compared to FM% determined by DXA, and they correlated highly significantly positively. Lean's equation was confirmed as a very accurate, precise and practical, indirect anthropometric method which is easy to calculate and use in clinical practice. Seidel's equation underestimated FM% and is not useful in clinical practice. BMI increase was associated with significant FM% increase that was discovered by the two methods. DXA and Lean's equation provided accurate and precise FM% and obesity assessment.

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POVEZANOST JEDNAČINA SEIDEL-A I LEAN-A SA DUAL- ENERGY X-RAY APSORPCIOMETRIJSKOM PROCENOM PROCENTA UKUPNE MASNE MASE

Izvod

DXA omogućuje tačnu i preciznu procenu telesnog sastava i gojaznosti, i omogućuje razvoj i kalibraciju antropometriJskih jednačina. Jednačine Seidela i Leana kao i DXA koriste se za određivanje procenta ukupne masne mase (FM%). Cilj ovog rada je bio evaluacija tačnosti jednačina Seidela i Leana u poređenju sa DXA procenom FM%.

DXA je bila urađena kod 88 žena sa prosečnim body mass indexom (BMI) (28.22±5.12 kg/m^2) i starosti (50.79±13.57yr.), 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; and gr.4 35-40 kg/m^2. Jednačinom Seidela (FM% = 4,201/D - 3,813 x 100; D= 1,1369 - 0,0598 x logSUMA; SUMA= triceps skinfold (SF) + biceps SF + subscapular SF + suprailiac SF) i jednačinom Leana (FM% = 0,439 x waist circumference + 0.221 x age – 9,4) izračunat je FM%, koji je upoređen sa FM% određenim sa DXA.

Ukupni FM% određen Leanovom jednačinom (42.67±7.14%) nije se statistički razlikovao od FM% određenim sa DXA (41.44±7.14%), ali FM% određen sa Seidelovom metodom bio je značajno niži (28.06±3.46%). FM% određen Leanovom jednačinom nije se razlikovao, dok je FM% određen sa Seidelovom jednačinom bio niži u poređenju sa DXA u svim grupama podeljenim prema njihovim BMI. FM% određenim sa Leanovom jednačinom korelirao je značajno sa FM% određenim sa DXA (p<0.0001).

DXA ispitivanje dokazalo je da jednačina Seidela potcenjuje FM% u svim grupama, i potvrdilo je da jednačina Leana daje tačnu i preciznu procenu FM%, pa se može koristiti u kliničkoj praksi.

Ključne reči: procenat telesnih masti, DXA, jednačina Leana, jednačina Seidela