01 Are age-related bioimpedance analysis effects also present in patients with spinal cord injury? Relevance to clinical prediction of skeletal muscle mass

Christopher Nuñez[1], Dympna Gallagher[1], Ann Spungen[2], William Bauman[2] and Steven B. Heymsfield[1]

[1]Department of Medicine, Obesity Research Center, St Luke's-Roosevelt Hospital, Columbia University, College of Physicians and Surgeons, New York, NY; [2]The Spinal Cord Damage Research Center, Veterans Administration Medical Center, Bronx, NY, Mount Sinai School of Medicine, New York, NY, USA.

Bioimpedance analysis (BIA) is a practical means of potentially evaluating skeletal muscle mass in clinical populations. However, measured extremity resistance at 50 kHz appears not solely determined by muscle size and length. Rather, an 'age' predictor term appears in most BIA regression models and the basis of this senescence-related effect remains uncertain. The aim of this study was to establish if 'premature' skeletal muscle atrophy, as induced by spinal cord injury (SCI), alters measured leg resistance at 50 kHz in a pattern similar to that observed with aging. As skeletal muscle atrophy beyond that for age is present in many clinically-relevant populations in whom BIA can be applied, the finding of an age-related BIA pattern in SCI patients would have important implications for underlying BIA theory and prediction formula development. Conventional foot-to-foot 50 kHz BIA was applied to healthy adults and subjects with SCI with an estimate of leg skeletal muscle provided by dual-energy X-ray absorptiometry-measured leg lean soft tissue (LST). Leg resistance (R) and height^2/R were set as dependent variables and LST, gender, age, and group (control or SCI) set as potential independent predictor variables in multiple regression models. The hypothesis tested, based upon earlier research, was that after controlling for LST, stature, and age, subjects with SCI would have a lower leg resistance than control subjects. A total of 91 control subjects and 11 subjects with SCI completed the study protocol. Leg R and H^2/R were both well correlated with LST (r=0.40 and 0.77, P<0.001). After controlling for LST, age entered as a significant predictor variable in both the leg R and H^2/R prediction models. Additionally, group (ie control or SCI) was a significant predictor variable after controlling for other predictor variables in both models with composite r values of 0.63 and 0.80, respectively (both P<0.001). Resistance, according to these models, is lower in subjects with SCI than in controls after adjusting for the other predictor variables. It is concluded that aging and SCI produce similar effects on BIA resistance at 50 kHz, after controlling for lean soft tissue and other covariates. Establishing the mechanisms of these electrical changes is important because BIA is often applied in patients with SCI and other conditions associated with skeletal muscle atrophy. Until these mechanisms are understood and corrected, population-specific BIA formulas will be required in skeletal muscle mass prediction by BIA.

International Journal of Body Composition Research 2003, Vol. 1 No. 1: 17–22

02 Comparison of whole and regional body composition measured by Hologic QDR-2000 and Lunar DPX-L dual-energy X-ray absorptiometry

Lynn M. Bairos, Bess Dawson-Hughes and Ronenn Roubenoff

US Department of Agriculture Human Nutrition Research Center on Aging at Tufts University, Boston, MA 02111, USA.

Dual-energy X-ray absorptiometry (DXA) scanners have become the standard instruments for measuring whole and regional body composition. In multicenter clinical trials Lunar and Hologic instruments are often intermixed. However, little is known about the differences between these instruments and the potential errors that such a practice may cause. Therefore, we assessed the degree of agreement between Hologic QDR-2000 (fan-beam) and Lunar DPX-L (pencil-beam) absorptiometers. Seventy-nine healthy volunteers, 41 women and 38 men, underwent two DXA scans on the same day to compare lean, fat, and bone mineral density in the whole body, appendages, and trunk. There were significant differences between the scanners for women and men in whole-body lean, fat, bone, and percentage body fat; leg lean, fat, and bone, and arm lean and fat (all P≤0.0001). Women also showed significant differences in estimates of trunk fat (P=0.006) and arm bone (P≤0.0001). These differences increased with increasing body mass, but not with age. We concluded that Lunar and Hologic densitometers give different estimates of regional and whole-body soft-tissue composition, which are biased by increasing mass. Multicenter trials that combine Hologic and Lunar data should address systematic differences between these instruments.

International Journal of Body Composition Research 2003, Vol. 1 No. 1: 23–29

03 Validity of predicted percentage body fat from skinfolds in Singapore Chinese, Malays and Indians

Paul Deurenberg[1] and Mabel Deurenberg-Yap[2]

[1]Nutrition Consultant in Singapore; [2]Director, Research and Health Information Management Division, Health Promotion Board, Singapore, adjunct Associate Professor, National University of Singapore.

Body composition was measured using a chemical four-compartment model in 291 Singaporean Chinese,

Malays and Indians of both sexes, and body fat percentage (%BF) obtained via this model was used as a reference. In addition biceps, triceps, subscapular and suprailiac skinfolds were measured following the Durnin and Womesley protocol and %BF was predicted using age and sex specific prediction formulas from the sum of biceps and triceps and from the sum of all four skinfolds. In Singapore females, especially Malays and Indians, predicted mean %BF from two skinfolds was an underestimation. Mean %BF predicted from four skinfolds was also underestimated in Malays and Indian females, but not in Chinese females. The differences in validity from predictions based on two or four skinfolds could be explained by differences in subcutaneous fat pattern, with the Singaporean females having a more truncal fat pattern than the Scottish population in which the formulas had been developed. In males, predicted mean %BF from two skinfolds was underestimated only in Indians. Mean %BF from four skinfolds did not differ from the reference value in Chinese, Malay and Indian males. The bias of predicted %BF was positively correlated with level of body fatness and negatively with age in both gender groups, resulting in considerable underestimations of %BF in fatter and younger subjects. Differences in validity of predicted %BF across the ethnic groups could be explained by differences in body fatness and age across the groups. It is concluded that the Durnin and Womersley equations are not valid in Singaporeans because of a different body fat distribution (in females) and because of a different age-related increase in body fatness (in males and females), compared to the population in which the formulas were developed.

International Journal of Body Composition Research 2003, Vol. 1 No. 1: 31–35

---

04 Comparison of estimated percentage body fat from foot-to-hand, foot-to-foot and hand-to-hand bioimpedance analysis with densitometry in young females

Paul Deurenberg[1] and Frans JM Schouten[2]

[1]Nutrition Consultant, Singapore; [2]Department of Nutrition and Epidemiology, Wageningen University, The Netherlands

Body composition was measured in 59 normal weight, healthy females, aged 20 to 24 years. Their BMI ranged from 17.4 to 29.4 kg/m^2 and their %BF as measured by densitometry (underwater weighing) from 16.6 to 35.6 per cent. Body fat was also estimated from bioelectrical impedance using the traditional foot-to-hand approach (total body impedance), foot-to-foot approach (Tanita) and hand-to-hand approach (Omron). From total body impedance %BF was predicted using a published prediction equation including weight and age as additional predictors. For the foot-to-foot and hand-to-hand impedance the formulas incorporated in the instruments were also used. These formulas use weight and age as additional predictors. The correlation coefficients of estimated %BF with measured %BF ranged from 0.70 (foot-to-hand) to 0.75 (hand-to-hand), all values $P<0.01$. The correlation of estimated %BF from foot-to-foot with BMI was higher (r=0.93, $P<0.01$) than with actual %BF (r=0.71, $P<0.01$), which suggests that the formula used overemphasizes weight in the prediction formula. The mean bias (measured minus predicted) of %BF was –0.3 ± 3.4, –0.9 ± 3.6 and 1.0 ± 3.2 percentage points body fat for foot-to-hand, foot-to-foot and hand-to-hand respectively. All biases were positively correlated with the level of %BF, resulting in underestimations of %BF in the fatter subjects. The number of subjects with a bias greater than 5 percentage points body fat was 8, 12 and 8 for foot-to-hand, foot-to-foot and hand-to-hand impedance respectively. The current data do not show a clearly better validity of predicted %BF for the total body impedance approach compared to the foot-to-foot or hand-to-hand approach.

International Journal of Body Composition Research 2003, Vol. 1 No. 1: 37–43

---

05 Validation of dual-energy X-ray absorptiometry in the assessment of change in fat compartments, compared to measurement by magnetic resonance imaging, in HIV-infected adults

SJ Lan[1], ES Engelson[2], D Agin[2] , P. Homel[3], J Wang[4], SB Heymsfield[4] and DP Kotler[2]

[1]Department of Nutrition and Health Sciences, Taipei Medical University, Taiwan; [2]Gastrointestinal Division, St Luke's-Roosevelt Hospital Center, New York, NY, USA; [3]Office of Research Support, Beth Israel Medical Center, New York, NY, USA; [4]Weight Control Unit, Body Composition Unit, Department of Medicine, St Luke's-Roosevelt Hospital Center, Columbia University, College of Physicians and Surgeons, New York, NY, USA.

Fat redistribution has been described in HIV-infected people. Magnetic resonance imaging (MRI) provides a criterion measure of total and regional adipose tissue. Dual-energy X-ray absorptiometry (DXA) also can quantify total and regional fat contents. We evaluated the ability of DXA to estimate changes in regional body fat, as determined by MRI scanning, by analyzing data from two longitudinal trials: 25 HIV-infected subjects given growth hormone for fat redistribution with excess visceral adipose tissue (VAT), and 30 malnourished, HIV-infected women treated with exercise training and/or protein supplements. Changes in subcutaneous adipose tissue (SAT) and VAT measured by MRI and regional fat measured by DXA were compared. The limits of agreement between values from the criterion and surrogate (predicted) measures were analyzed by the methods of Bland and Altman. The results showed that the change in limb fat measured by DXA reflected change in SAT by MRI (R^2=0.70, $P<0.001$) while change in trunk fat measured by DXA reflected change in VAT by MRI (R^2=0.72, $P<0.001$). The estimates of the slope and intercept values of the prediction equations were confirmed by boot-

strap resampling. Bland-Altman analyses showed no systematic errors over the range of changes in SAT or VAT. The limits of agreements for the prediction of change were +3.2 l for SAT and +1.5 l for VAT, respectively. The precision of the limits of agreements were (–0.4; +0.4) and (–0.3; +0.1) l for SAT and VAT, respectively. The standard errors of the estimate were 1.8±1.9 l for SAT and 1.0±1.2 l for VAT. We conclude that DXA measurements of regional body fat reflect changes in fat compartments as measured by MRI. The prediction models are appropriate for epidemiological studies, but should be applied with caution in clinical situations.

International Journal of Body Composition Research 2003, Vol. 1 No. 1: 45–50

---

06 The adjustment of measures of energy expenditure for body weight and body composition

PSW Davies[1] and TJ Cole[2]

[1]Children's Nutrition Research Centre, Department of Paediatrics and Child Health, University of Queensland, Royal Children's Hospital, Brisbane, QLD, Australia; [2]Centre for Paediatric Epidemiology and Biostatistics, 30 Guilford Street, London, UK.

The appropriate adjustment of data relating to energy expenditure for body weight and body composition is critical for the correct interpretation of those data. This paper discusses the historical development of methods that have been used to try and adjust energy metabolism data for body weight and body composition. We have also shown that simply expressing energy expenditure relative to body weight, or fat-free mass as per kilogram, is not the best adjustment in many cases and that a power function of body weight or body composition should be used. Details of how such a power function can be calculated and interpreted are given. Finally, we have described how potential differences in energy expenditure between groups can be appropriately examined, and attempted to explain why simple expression of energy expenditure relative to body composition does not adjust appropriately.

International Journal of Body Composition Research 2003 Vol. 1 No. 2: 53–58

---

07 Validity of body fat percentage using skinfold measurements in 12–14-year-old Chinese boys and girls

Y. Li, G. Ma, Q. Zhang, W. Du and H. Pan

Institute for Nutrition and Food Safety, Chinese Center for Disease Control and Prevention, Beijing, China.

Four hundred and two healthy Chinese adolescents (154 boys, 248 girls; 12–14 yr; body mass index 14.1–36.6 kg/m^2) living in Beijing participated in a body composition study. Body fat percentage (%BF), measured by dual energy X-ray absorptiometry (DXA) served as criterion method. Anthropometric measurements (weight, height, triceps and subscapular thickness) were taken in the fasting state in morning. Predicted %BF was obtained from various anthropometric equations: Changling (combined with Brozek's equation), Yuan and Slaughter et al. %BF (mean ± SD) measured by DXA (%BF$_{DXA}$) was 20.1 ± 8.3% and 30.0 ± 5.8% in boys and girls respectively, and was significantly correlated with %BF estimated by various anthropometric equations with correlation coefficients ranging from 0.65 to 0.87. A significant underestimation was found for all three anthropometry equations as compared to %BF$_{DXA}$. The biases between %BF$_{DXA}$ and various anthropometry equations were: –2.8 ± 4.3% for boys and –7.6 ± 4.4% for girls for the Chang Ling equation, –2.4 ± 4.4% for boys and –7.8 ± 4.5% for girls for the Yuan equation and –3.4 ± 4.8% for boys and –6.5 ± 4.1% for girls for the Slaughter equations. No significant difference was found between biases of different anthropometric equations in boys, but in girls the bias of the Slaughter equation was significantly lower than the bias of the Chang Ling and the Yuan equations. Biases from Chang Ling and Yuan were negatively correlated with %BF$_{DXA}$ in boys, whereas in girls the biases from Yuan and Slaughter were negatively correlated with %BF$_{DXA}$. It is concluded that existing prediction equations based on skinfolds generally underestimate body fat percent, and that the bias is, especially in girls, unacceptable high.

International Journal of Body Composition Research 2003 Vol. 1 No. 2: 59–62

---

08 The prediction of total body water using foot-to-foot bioelectrical impedance in children

R.A. Abbott[1,2], K.A. Edmiston[3], A. Grayson[1] and P.S.W. Davies[3]

[1]School of Human Movement Studies, Queensland University of Technology; [2]School of Human Movement Studies, University of Queensland; [3]Children's Nutrition Research Centre, Department of Paediatrics and Child Health, Royal Children's Hospital, Brisbane, Queensland, Australia.

Prediction of body composition via bioelectrical impedance is a simple, rapid and non-invasive method and as such can be useful in children. Most commercially-available equipment has built-in algorithms for prediction of total body water (TBW), in the first instance, from measured impedance and anthropometric variables. It is important that these algorithms be validated before the method is accepted for routine use. The aim of this study was therefore twofold, firstly to compare predicted TBW from foot-to-foot bioelectrical impedance with TBW measured using deuterium oxide dilution technique and secondly to develop a regression equation that

would allow the predication of TBW from measurements of bioelectrical impedance and height. A total of 73 apparently-healthy children aged 5 to 16 years took part in the study. There was a mean bias of 2.0 litres of water between measured and predicted TBW with the foot-to-foot bioelectrical impedance method over estimating TBW. TBW could be predicted from measurements of bioelectrical impedance (I) and height (H) using the equation TBW = –0.63 +0.61 H^2/I. This prediction equation might allow more accurate estimates of body composition to be made in children using foot-to-foot bioelectrical impedance.

International Journal of Body Composition Research 2003, Vol. 1 No. 2: 63–67

---

09 Validation of leg-to-leg impedance for body composition assessment in male Brazilians aged 16–19 years

J.C.K. Wells[1], D. Gigante[2], A. Wright[3], P.C. Hallal[2] and C.G. Victora[2]

[1]MRC Childhood Nutrition Research Centre, Institute of Child Health, London; [2]Post-Graduate Program in Epidemiology, Federal University of Pelotas, Brazil; [3]MRC Human Nutrition Research, Cambridge, UK.

Leg-to-leg impedance (Tanita) is potentially useful for assessing body composition in large epidemiological studies. The manufacturer's algorithms that predict body composition values were derived in European or American populations, however, and may not be applicable in other populations. The aim of this study was to evaluate the Tanita TBF-305 body composition analyser in young Brazilian males using total body water (TBW) as the reference method. Measurements of anthropometry, impedance and TBW were undertaken in 48 males aged 16–19 years in Pelotas, Brazil. TBW was predicted using the manufacturers' algorithms, and calculated from deuterium dilution. Agreement between methods was assessed using the Bland and Altman method. The mean bias (SD) between methods was 0.7 (3.4) litres for TBW, 0.8 (4.5) kg for fat-free mass, –0.8 (4.5) kg for fat mass and –1.7 (6.6) % for % fat ($P>0.05$ in all cases). There was a significant correlation (r = 0.56, $P<0.0001$) between the magnitude of TBW and the bias, indicating that Tanita overestimated TBW in those with lower TBW values. New algorithms were derived, predicting TBW from various combinations of data on weight, height and impedance. Weight and height alone predicted TBW with a standard error of the estimate (SEE) of 3.1 litres. The best predictive equation that included impedance had an SEE of 3.2 litres. We conclude that Tanita algorithms developed in European/American populations are not appropriate for young male Brazilians. New equations were derived in the present study, but proved no better at predicting TBW than data on weight and height alone. This study emphasises the need for validating predictive methods for application in epidemiological surveys.

International Journal of Body Composition Research 2003 Vol. 1 No. 2: 69–75

---

10 Body composition is differently associated with puberty onset in girls and boys

Sylvia Kirchengast

Institute for Anthropology, University of Vienna, Austria.

Body composition varies characteristically between the two sexes. During puberty this sexual dimorphism gains in importance. Furthermore body composition is strongly associated with the onset of female puberty. The aim of the present study was to analyze the association pattern between body composition and pubertal onset as well as pubertal status in girls and boys. In total 228 girls and 191 boys ranging in age between 11 and 14 years were enrolled in the present study. Body composition was estimated by BIA method, using a TBF 305 body composition analyzer. Furthermore height, waist and hip girth were measured. Body mass index (BMI) and the waist to hip ratio (WHR) were calculated. Age at menarche and age at voice breaking were determined. Apart from marked sex differences in body composition significant differences within the two sexes according to pubertal status could be documented. In females, puberty was associated with an increased weight status and a higher amount of body fat, while in males puberty was associated with increased height and increased fat-free body mass. A higher weight status was associated with an earlier onset of puberty in girls, but with a later onset of puberty in boys. Body composition shows not only a significant sexual dimorphism during puberty but also a different impact on puberty onset.

International Journal of Body Composition Research 2003, Vol. 1 No. 2: 77–80

---

11 Ratio of soft-tissue mineral to total-body water: a stable body composition ratio

Robert C. Lee[1], Lisa Marie Ramirez[2], Lucian Wielopolski[2], Steven B. Heymsfield[1] and ZiMian Wang[1]

[1]Obesity Research Center, St Luke's-Roosevelt Hospital, Columbia University, College of Physicians and Surgeons, New York; [2]Brookhaven National Laboratory, Environmental Sciences and Medical Departments, Brookhaven National Laboratory, Upton, New York, USA.

Although soft-tissue minerals (Ms) are widely distributed within intracellular and extracellular fluids, accurate methods for estimating Ms are still limited. The aim of this study was to explore the potential existence of a constant relationship between Ms and total-body water (TBW). Based on the known ion

concentrations of intracellular and extracellular fluids, a theoretical model was derived that suggests the presence of a relatively stable ratio of Ms to TBW. Four elements (K, Na, Cl, and Ca) were measured in 356 adult subjects by using whole-body counting in-vivo neutron activation analysis, and TBW was estimated by isotope dilution. Ms was significantly correlated with TBW and the ratio of Ms to TBW was relatively constant at (mean ± SD) 0.0129 ± 0.0008 kg/kg with a CV of 6.1%. This constant relationship between Ms and TBW provides a new body composition rule and may be helpful for improving multi-component total-body fat models.

International Journal of Body Composition Research 2003, Vol. 1 No. 2: 81–90

12 A simple questionnaire to assess alterations in body appearance in HIV-infected patients

Judith C. Shlay MD, MSPH,[1] Wafaa M. El-Sadr MD, MPH,[2] Glenn Bartsch ScD,[3] Jack Wang, MS,[4] Cynthia Gibert MD,[5] Andrew Carr MD,[6] and Sai Subhasree Raghavan, PhD[2], for the Terry Beirn Community Programs for Clinical Research on AIDS (CPCRA)

From the [1]Denver Community Programs for Clinical Research on AIDS, University of Colorado Health Sciences Center, Denver, CO, USA; [2]Harlem Hospital, Columbia University College of Physicians and Surgeons, New York, NY, USA; [3]CPCRA Statistical Center, University of Minnesota, Minneapolis, MN, USA; [4]Body Composition Unit of St. Luke's-Roosevelt Hospital, Columbia University College of Physicians and Surgeons, New York, NY, USA; [5]Washington Regional AIDS Program, Washington DC, USA; [6]St Vincent's Hospital, Sydney, Australia.

This questionnaire was developed in order to assess perception of any changes in body appearance and to determine its potential use in a large diverse cohort of antiretroviral naïve HIV-infected patients. For this study, HIV-infected patients (n=227) enrolling into a metabolic study completed a ten-item questionnaire on alterations in body appearance and had body mass index (BMI) and anthropometric measurements performed. The questionnaire assessed subjective changes in body appearance over the past four months (thinning, no change, increase in size). Concordance of survey results with mean body circumference (arm, waist, hip, thigh), mean skinfold thickness (triceps, suprascapular, subscapular, abdomen, thigh) and the BMI were evaluated. At baseline, over a third of participants reported no changes for all six sites (ie, face, arms, breast, waist, buttocks, thighs); however, of those reporting any changes for all six sites, thinning was more common (7.9%) than was an increase in size (0.4%). For the body circumference, perceived changes of face, breast, waist, buttocks, and thighs were positively correlated with the mean values for all measured body circumferences ($P \leq 0.05$); perceived changes of arms were positively correlated with all measurements except waist ($P = 0.18$). For the skinfolds, changes in face, buttocks, waist and thighs were positively correlated with all five skinfold thickness measurements ($P < 0.05$); arms and breast were positively correlated with all measurements except suprascapular (arms: $P = 0.06$), abdomen (arms: $P = 0.13$, breast: $P = 0.12$) and triceps (breast: $P = 0.21$). For face, arms, waist, buttocks and thighs, self-reported body perception was correlated with mean BMI ($P < 0.05$). In conclusion, responses from the survey correlated well with body circumference and skinfold measurements, supporting the potential use of this simple questionnaire in antiretroviral naive adults.

International Journal of Body Composition Research 2003, Vol. 1 No. 3: 93–102

13 Total-body and regional skeletal muscle mass measurement methods: an overview

Robert C. Lee, Steven B. Heymsfield, Wei Shen and ZiMian Wang

Obesity Research Center, St Luke's-Roosevelt Hospital Center, Columbia University, College of Physicians and Surgeons, New York, NY, USA.

Skeletal muscle (SM) is the largest component at the tissue-organ level of body composition. Several methods, including recently developed methods, are now available to quantify total-body and regional SM mass in vivo. Two imaging methods, computerized tomography (CT) and magnetic resonance imaging (MRI), serve as the criterion for both total-body and regional SM mass measurement. Other methods for estimating SM can be organized into two categories, property-based and component-based. Property-based SM measurement methods, derived from measurable properties, include ultrasonography, anthropometry, bioelectric impedance (BIA), and urinary metabolites. Component-based methods, derived from measured components, include total-body nitrogen and potassium estimated by in vivo neutron activation analysis, total-body potassium measured by total-body ^{40}K counting, and appendicular lean soft tissue measured by dual-energy X-ray absorptiometry (DXA). Each method is reviewed in the context of the underlying measurement principle, practicality, cost, availability, and desired accuracy.

International Journal of Body Composition Research 2003, Vol. 1 No. 3: 103–109

14 Development and validation of a prediction equation for percentage body fat based on skinfolds for Singaporean adults and adolescents

Mabel Deurenberg-Yap[1,2], Swee Ai Ng[1], Ling Li Foo[1] and Paul Deurenberg[3]

[1]Research and Health Information Management Division, Health Promotion Board, Singapore; [2]National University, Singapore; [3]Nutrition Consultant, Singapore.

Body composition was measured in 291 adult Singaporeans, aged 18 to 67 years, and in 477 adolescent Singaporeans, aged 12 to 17 years. Body fat percentage (%BF) in the adults was measured using a four-compartment model and body fat in the adolescents was measured using deuterium oxide dilution. In addition the biceps, triceps, suprailiac and subscapular skinfold thicknesses were measured. The adult population group was randomly divided into two groups. In one group two prediction equations for %BF, based on the sum of two (biceps and triceps) and the sum of four skinfolds respectively, were developed using stepwise multiple regression analyses. Age did not enter into the regression equation in females though it made a slight but significant contribution to the prediction equation in males. Ethnicity did not enter into the model. The formulas were validated in the second adult group, in the total adult group and in the adolescent group. In adults, the prediction equations showed good cross-validity for the three ethnic groups (Chinese, Malays and Indians) and the bias was not dependent on age. However, in subjects with higher %BF the formulas tend to underestimate %BF. In the adolescents the formula based on two skinfolds significantly overestimated %BF by 1.0 ± 4.3% in females and by 2.0 ± 5.1% in males. This bias was not dependent on age or ethnicity, but was related to level of body fatness. The prediction equation based on the sum of four skinfolds was valid in female adolescents but slightly (0.8 ± 5.2%) underestimated %BF in adolescent males. The bias was not different across the ethnic groups. It is concluded that the 'adult' prediction equations based on four skinfolds can be used to obtain a valid prediction of %BF in adolescents and adults of the three main ethnic groups in Singapore.

International Journal of Body Composition Research 2003, Vol. 1 No. 3: 111–115

15 Bone mineral density in male professional athletes

Maria Teresa Restrepo[1], Luz Amparo Gómez[2], Fabio Sánchez[3], Francisco Ochoa[3], Felipe Marino[4], Oscar Mario Cardona[1], Lina María Parra[1] and Angelo Pietrobelli[5]

[1]Escuela de Nutrición y Dietética Universidad de Antioquia, Medellin, Colombia; [2]Centro de Atención Nutricional, Medellin, Colombia; [3]Unidad de Osteoporosis y Climaterio Clinica del Prado, Medellin, Colombia; [4]Instituto de Deportes de Antioquia Indeportes, Medellin, Colombia; [5]Pediatric Unit, Verona University Medical School, Verona, Italy

Aim of this study was to evaluate bone mineral density in young professional athletes compared to controls and to relate it to calcium consumption. Using dual energy X-ray absorptiometry (DXA) bone mineral density (BMD) was evaluated in 59 professional young high-performance athletes, in three different sports (soccer, roller-skating and swimming), in comparison with 59 normal subjects without high-level physical activity. Bone mineral density was measured at lumbar spine, femur and forearm. Compared with controls, soccer players had significantly higher BMD in all regions studied ($P<0.001$). Roller skaters showed higher BMD at spine and femur levels ($P<0.001$), but not in forearm. Swimmers had higher BMD at spine level only ($P<0.05$). There was no difference in calcium consumption between controls and athletes ($P=0.064$) and in BMD in subjects with the higher average of calcium consumption. These results suggest that in sports with high and medium impact, such as soccer and roller-skating, where the skeleton supports the whole body mass and the distribution of the loads is homogeneous, BMD is higher than controls'. On the other hand, swimmers showed no increase of BMD compared to controls. It is speculated that swimming produces less stress in the bone than in the other sports. No relationship between calcium consumption and BMD was found in the present study.

International Journal of Body Composition Research 2003, Vol. 1 No. 3: 117–122

16 Adequacy of initial weight restoration in anorexia nervosa: effect on total body nitrogen, total body potassium and bone mineral density after 6–10 years

G. Gross, J.D. Russell, P.J. Beumont, S. Touyz, P. Roach, A. Aslani, R.D. Hansen and B.J. Allen

Departments of Psychological Medicine (GG, JDR, PJB), Psychology (ST) and Clinical Nursing (RDH), The University of Sydney, Australia; Centre for In Vivo Body Composition, Royal North Shore Hospital, Sydney, Australia (PR, AA, RDH, BJA); St George Cancer Care Centre, Sydney, Australia (BJA); Department of Psychology, University of Trier, Germany (GG).

This study reports the follow-up of 61 female patients hospitalized between 1989 and 1992 for treatment of anorexia nervosa. Using in-vivo neutron-capture analysis, total body nitrogen (TBN) had been measured at the commencement of nutritional rehabilitation and after re-feeding. At 6-10 year follow-up, outcome information

was gathered from 50 patients (82%). TBN was re-measured in 39 subjects, as was bone mineral density (BMD) using dual-energy x-ray absorptiometry (DXA). Total body potassium (TBK) was measured in 41 subjects using a whole body counter. TBN was restored in the majority of patients, as indicated by an average nitrogen index of 0.98. However, TBK was reduced ($P<0.01$) compared to a group of age-matched normal females derived from the literature, and BMD was sub-optimal in all participants who had a DXA measurement. A close relationship ($r=0.76$, $P<0.01$) was found between TBN and BMD, supporting the contention that osteopenia in anorexia nervosa may be related to loss of TBN and depletion of the protein matrix of bone. BMD, but not TBN or TBK, was reduced ($P<0.05$) in those patients who had a BMI of less than 19 after re-feeding. The results suggest that BMD outcome is influenced by adequate initial weight restoration, unlike TBN and TBK, which over an extended period of time maintain their function as a current indicator of weight adequacy rather than an integrated measure of nutrition.

International Journal of Body Composition Research 2003 Vol. 1 No. 3: 123–128

17 Changes in body composition when young pigs are restricted to near maintenance dietary intake

A.D. Mitchell[1], A.M. Scholz[2] and V.G. Pursel[1]

[1]USDA, Agricultural Research Service, Beltsville, MD, USA; [2]University of Munich, Oberschleissheim, Germany.

A study was conducted to investigate the changes in body composition that occur when young rapidly-growing animals are subjected to an acute period of restricted dietary intake that results in little or no change in body weight. At 60 kg, a total of 74 pigs were scanned by dual-energy X-ray absorptiometry (DXA). Subsequently, 49 pigs were restrictively fed for 56 days to maintain body weight and 25 pigs were fed ad-libitum. After 56 days all pigs were again scanned by DXA. During the 56-day study restricted pigs gained only 4.3 ± 3.8 kg (mean ± SD) while the pigs on ad-libitum intake gained 49.9 ± 2.2 kg. DXA analysis revealed that during this time, the restricted pigs lost 0.78 ± 1.08 kg of body fat while gaining 4.9 ± 3.6 kg of lean and 160 ± 144 g of bone mineral (BMC). Bone mineral density (BMD) decreased slightly (–0.01 g/cm^2, $P>0.05$, compared to initial scan). By comparison, the ad-libitum-fed pigs gained 16.8 ± 2.5 kg of fat, 32.4 ± 2.4 kg of lean and 679 ± 151 g of BMC, and BMD increased by 0.18 g/cm^2. Relative to the initial measurement, the fat content of the restricted pigs decreased by 7.5% while that of the ad-libitum-fed pigs increased by 151%. As a percentage of total body weight, the BMC increased in the restricted pigs, but decreased in the ad-libitum-fed pigs. Based on linear regression analysis of data obtained from the restricted pigs, it is predicted that 60 kg pigs maintained at zero weight gain over a period of 8 weeks would be expected to lose 1223 g of fat and gain 1077 g of lean and 146 g of BMC. These results provide a model for changes in body composition during restricted growth that might occur as a result of malnutrition or disease.

International Journal of Body Composition Research 2004, Vol. 1 No. 4: 131–136

18 Comparison between air-displacement plethysmography and dual energy X-ray absorptiometry in 176 Chinese adolescents

Y. Li, Q. Zhang, W. Du, A. Liu, H. Pan and G. Ma

National Institute for Nutrition and Food Safety, Chinese Center for Disease Control and Prevention, Beijing, China.

In order to assess the reliability of Air Displacement Plethysmography (BOD POD) in measuring body fat of Chinese adolescents, and to compare the reliability and validity of BOD POD with dual-energy X-ray absorptiometry (DXA) in assessing body fat, 176 healthy Chinese adolescents (85 boys, 91 girls; 12–15 yr; BMI 13.6-31.4 kg/m^2) living in Beijing were selected to participate in a body composition study. Same-day test-retest reliability was assessed in a subsample of 55 subjects (27 boys, 28 girls) and eight of them finished the BOD POD and DXA repeated test the same day. Comparison between the BOD POD and DXA was finished in all subjects. %BF was highly correlated between the first and second trials (r=0.98, $P<0.01$) and the test-retest coefficients of variation for %BF measured by BOD POD and DXA were not significantly different (4.2%±2.8% and 3.0%±3.1% for BOD POD and DXA, respectively), indicating a good reliability. The mean difference in %BF (BOD POD – DXA) was –2.1 ± 3.9 (BOD POD: 22.7%BF; DXA: 24.9 %BF), with a 95% confidence interval of –9.9 to 5.7 %BF. There was a significant difference between the two methods for assessing body fat of girls (–3.8±3.1), but not for boys (–0.4±4.0). The regression equation ($\%BF_{DXA}$ = 2.60 + 0.98 $\%BF_{BOD\ POD}$, r^2 = 0.80, SEE = 3.9) was significantly different from the line of identity ($\%BF_{DXA} = \%BF_{BOD\ POD}$). Intercept and slope significant difference was from 0 and 1 respectively. Further analysis including gender and age as covariates in the regression model showed that gender was significantly independently associated with $\%BF_{DXA}$ ($P < 0.001$), and explained an additional 5% of the variance in $\%BF_{DXA}$. It is concluded that BOD POD is a reliable and valid method for determining %BF in Chinese adolescents.

International Journal of Body Composition Research 2004 Vol. 1 No. 4: 137–145

19 Comparison of foot-to-foot impedance with air-displacement plethysmography to evaluate body composition in African women

[1]**A. Gartner**, [2]A. Dioum, [1]B. Maire, [1]F. Delpeuch and [3]Y. Schutz

[1]Nutrition Unit, UR 106 (WHO Collaborating Centre for Nutrition), IRD (Institut de Recherche pour le Développement), Montpellier, France. [2]Equipe de Nutrition, Laboratoire de Physiologie, Département de Biologie Animale, Faculté des Sciences et Techniques, Université Cheikh Anta Diop de Dakar, Sénégal, West Africa. [3]Institute of Physiology, Faculty of Medicine, University of Lausanne, Switzerland.

The new foot-to-foot impedance (FFI) device, the *Bodymaster*™ (SEB, France), provides a precise method for estimating lean or fat mass within a large range of body composition, but the influence of ethnicity has yet to be accounted for. The first objective of this study was to test the validity of body composition estimated from the FFI method compared with whole body densitometry performed by air displacement plethysmography (ADP) in African women. The second objective was to derive new prediction equations to estimate lean body mass (LBM) and percentage body fat (%BF) in African women from FFI results. A total sample of 170 African women from Dakar (Senegal, West Africa), volunteered for the study. Mean (SD) age was 30.6 y (8.7), weight 63.4 kg (15.2) and BMI 23.4 kg/m^2 (5.2). Body composition values estimated by FFI were compared to those measured by ADP. The higher specific density of lean body tissue in black subjects as compared to Caucasian subjects was taken into account for the calculation of %BF from body density. Estimations from FFI showed a bias (mean difference) of 2.4 kg LBM, ie 6%, (P<10^{-4}) and –3.5 %BF, ie 10%, (P<10^{-4}) and errors (SD of the bias) of 2.7 kg LBM and 4.2 %BF. In order to correct for the bias, specific predictive equations were developed. With the FFI result as a single predictor, error values were of 2.6 kg LBM and 4.3 %BF in the prediction group (n=112), and of 2.6 kg LBM and 4.1 %BF in the cross-validation group (n=58). The addition of anthropometrical predictors was not necessary. The study found that the FFI analyser slightly but significantly overestimated LBM, and underestimated %BF in African women, suggesting that the ethnic factor may jeopardize its accuracy. However, after correction for the bias, using an independent sub-sample, it was easy to estimate the body compartments with reasonable accuracy in African women by using the FFI result in a single predictor equation.

International Journal of Body Composition Research 2004, Vol. 1 No. 4: 147–153

20 Body composition in Singapore Chinese elderly aged 60 to 79 years

[1]**Paul Deurenberg**, [2]Mabel Deurenberg-Yap, [2]Ching Ching Teo, [2]Swee Ai Ng, [3]Vina Doshi and [4]Carol Tan

[1]Nutrition Consultant, Singapore; [2]Health Promotion Board, Research and Information Management Division, Singapore; [3]Changi General Hospital, Singapore; [4]Ministry of Health, Singapore.

Body composition was measured in 23 Singapore Chinese elderly females and 17 Singapore Chinese elderly males, aged 60–79 years. Weight, height, waist and hip circumference, four skinfolds (biceps, triceps, subscapular, supra-iliac) and hand-to-hand impedance were measured and formulas from the literature were used to predict percentage body fat (%BF). Total-body water was measured using deuterium oxide dilution and %BF was calculated assuming a fat-free mass hydration of 0.73. Body fat was also measured using dual energy X-ray absorptiometry (DXA). Males were taller and heavier than females, but their body mass index (BMI) was not different. Body fat from all methods was higher in females than in males and all measures of %BF were highly intercorrelated. In males and females %BF from deuterium oxide and from DXA were not different from each other, but were lower compared to body fat estimated from hand-to-hand impedance, BMI and skinfolds thickness, using the Durnin & Womersley equation. A prediction equation based on skinfolds developed in Singaporean adults gave comparable results compared to %BF from deuterium oxide or from DXA. It is concluded that the deuterium oxide methodology and DXA give identical values and that, at a population level, the Singapore skinfold prediction equation can also be used to obtain valid estimates of %BF. Impedance predictions and predictions based on BMI needs adaptation. Generally, all predictive methods had high individual biases (compared to deuterium oxide) and individual values obtained with these methods should be interpreted with care.

International Journal of Body Composition Research 2004, Vol. 1 No. 4: 155–160

21 Measurement of body and liver fat in small animals using peripheral quantitative computed tomography

Tim R. Nagy and Maria S. Johnson

Division of Physiology and Metabolism, Department of Nutrition Sciences, and the Clinical Nutrition Research Center, The University of Alabama at Birmingham, Birmingham, AL 35294-3360, USA.

Peripheral quantitative computed tomography (pQCT) was used to determine percent body fat (%BF) in mice, and relative liver fat in lemmings fasted for 0, 6, 12 or 18 h to induce a wide range of liver fat content. Accuracy of the pQCT was determined by comparing pQCT-derived fat to that from chemical extraction using 30 male mice (whole body) and 26 female lemmings (liver only). To determine whether pQCT could measure changes

in liver fat (%) in live animals, two groups of lemmings were scanned on 4 consecutive days under anesthesia. Controls (n = 3) had ad-libitum access to food, whereas the fasted group (n = 5) was deprived of food for 18 h before being measured on day 2 and then refed. The coefficient of variation (CV) for determining %BF in mice using the pQCT was 3.9% (±1.8 SD). Percentage body fat determined by pQCT significantly overestimated percentage fat as measured by chemical extraction (14.5 ± 3.2 vs 12.3 ± 2.9% respectively, P<0.01, mean ± SD). However, %BF by pQCT was highly related to chemical extraction %BF (r = 0.95, P<0.001). The liver attenuation values from pQCT were highly related to % liver fat (r = 0.98, P<0.001) in lemmings. The technique showed excellent precision with a CV of 0.3 ± 0.1%. The two groups (control vs fasted) did not differ in their percent liver fat on day 1 (5.4% vs 5.8%). On day 2 the fasted group had a significantly higher percent liver fat than controls (5.9% vs 17.3%; P<0.05). Following refeeding, there were no significant group differences in percent liver fat on days 3 and 4. Our data indicate that pQCT has good accuracy and precision for determining %BF and liver fat in small animals and can be used to track changes in liver fat over time.

International Journal of Body Composition Research 2004, Vol. 1 No. 4: 161–167

---

22 Total-body protein mass in adults: development of a dual-energy X-ray absorptiometry prediction model

[1]**ZiMian Wang**, [1]Stanley Heshka, [2]Lucian Wielopolski, [1]F. Xavier Pi-Sunyer, [1]Richard N. Pierson Jr and [1]Steven B. Heymsfield

[1]St. Luke's-Roosevelt Hospital Center, Columbia University College of Physicians and Surgeons, New York; [2]Medical Department, Brookhaven National Laboratory, Upton, New York, USA

Protein is a large body component of biological importance, which remains difficult to quantify using affordable and practical methods that can be applied in clinical settings. The aim of the present study was to develop and cross-validate a total-body protein (TBPro) prediction model from fat-free mass (FFM) measured by dual-energy X-ray absorptiometry (DXA). For this, a total of 148 adult subjects (116 men and 32 women) were randomly separated into two groups, model-development and cross-validation. Total-body protein mass, measured using in-vivo prompt g-neutron activation analysis, was set as the dependent variable and FFM, age, and sex as potential independent variables in the prediction model. A TBPro prediction model was developed and cross-validated, with the final equation: TBPro (kg) = 0.156 x FFM (kg) – 0.028 x Age (yr) + 0.55 x Sex + 2.77; r = 0.91, P<0.001; SEE = 0.86 kg; Sex = 0 for women and 1 for men. It is concluded that this TBPro prediction model, using widely available DXA and biological measures, should provide a useful method of estimating total-body protein for body composition research.

International Journal of Body Composition Research 2004, Vol. 2 No. 1: 3–13

---

23 Percentage body fat in Irish adults measured by bioelectrical impedance analysis compared with waist circumference measurements and body fat estimated from prediction equations

C.M. Murphy[1], M.A. Galvin[1], A. Flynn[1], S.N. McCarthy[2] and M. Kiely[1]

[1]Department of Food and Nutritional Sciences, University College Cork, Ireland; [2]Department of Clinical Medicine, Trinity Centre for Health Sciences, St James's Hospital, Dublin 8, Ireland.

The aim of this study was to compare percentage body fat (%BF) measured by bioelectrical impedance analysis (BIA) with %BF derived from published prediction equations and to assess waist circumference as an alternative measurement of body fatness in a representative sample of 18 to 64-y-old Irish adults. Percent body fat was measured using the Bodystat 1500 impedance analyser and standard procedures were used to measure weight, height and waist circumference in 1098 (495 men; 603 women) 18 to 64-yr-old adults who participated in the North South Ireland Food Consumption Survey (NSIFCS). Anthropometric data for each individual were applied to five age- and sex-specific prediction equations to estimate %BF. Mean %BF from BIA was significantly lower (P<0.005) than mean %BF estimated by the equations, with two exceptions: van Loan & Mayclin (1987) in women aged 18–64 y and Womersley & Durnin (1977) in women aged 18–50 y. The mean difference (Bland & Altman technique) between %BF from BIA and %BF from the equations was lower in women (–1.5%) than in men (–4.7%). %BF was highly correlated (P<0.001) with %BF from the equations (r=0.70–0.97). The %BF from BIA was most similar to %BF from the van Loan & Mayclin (1987) equation (mean difference ± SD: men –3.6±1.9%; women –0.2±2.6%) and was least similar to %BF from the Deurenberg et al. (1991) equation using impedance (mean difference: men –7.1±1.7%; women –5.0±2.2%). Agreement between quartiles of %BF and quartiles of waist circumference was not strong (men 43–70%; women 40–68%). The study highlights the difference in %BF between methods to determine body composition and the need to validate the BIA method in the population group of interest. The waist circumference measurement is not a suitable alternative to assess the body fatness of this population group.

International Journal of Body Composition Research 2004, Vol. 2 No. 1: 15–22

24 The use of bioelectrical impedance analysis to estimate total body water in children with cerebral palsy and non-disabled children

K.L. Bell[1,2] and P.S.W. Davies[1]

[1]Children's Nutrition Research Centre, Department of Paediatrics and Child Health, University of Queensland, Royal Children's Hospital, Brisbane, Queensland, Australia. [2]Queensland Paediatric Rehabilitation Service, Royal Children's Hospital, Brisbane, Queensland, Australia.

Measurement of body composition in children with cerebral palsy (CP) is essential since under-nutrition as well as overweight and obesity are frequently reported. Bioelectrical impedance analysis (BIA) is a quick, non-invasive, and precise technique for the assessment of total body water (TBW) that lends itself to use in such children. Validation studies have been conducted in various populations including healthy, non-disabled children and non-ambulatory children with spastic quadriplegic CP. The aim of the current study was to evaluate the use of BIA to predict TBW in ambulatory children with CP and non-disabled children. Impedance was measured with a Bodystat 1500 in 15 ambulatory children with CP and 16 non-disabled controls, aged 5–12 years. TBW was predicted from impedance using previously published equations and the Bodystat algorithm. TBW was measured using oxygen-18 and standard procedures as the reference method. The Bodystat algorithm overestimated TBW with the largest bias (5.8 ±1.1 kg for the children with CP; 4.6 ± 1.5 kg for the control group). The Kushner equation predicted TBW with the least bias (0.3 ± 1.3 kg for the children with CP; –0.6 ± 1.3 kg for the control group); however, the limits of agreement remained large (–2.3–2.9 kg for the CP group, –3.2–2.0 kg for the control group). There was no statistically significant relationship between the bias and TBW except for the Bodystat algorithm, indicating that in the other equations the bias was consistent across the range of measurements. The ability of BIA to predict TBW in children with CP and non-disabled children depends on the equation chosen.

International Journal of Body Composition Research 2004, Vol. 2 No. 1: 23–29

25 The relationship between mammographic density and body composition

Z. Chen,[1] L.K. Staten[1], G. Maskarinec[2], L. Arendell[1], R. Bruhn[1], J.K. Nicholas[1] and J. Marshall[1,3]

[1]Mel and Enid Zuckerman Arizona College of Public Health, University of Arizona; [2]Cancer Research Center of Hawaii, University of Hawaii; [3]Roswell Park Cancer Institute, Buffalo, New York, USA.

The purpose of this study was to investigate associations between mammographic density measurements and various body composition indices. The participants (n =79) were healthy Hispanic and non-Hispanic white women age 49+ years. Mammographic density was assessed for both breasts using a computer-assisted method. Body composition, including total and regional body fat and lean soft tissue mass as well as bone mineral density (BMD), was measured using dual-energy X-ray absorptiometry. Odds ratios (OR) and 95% confidence intervals (95% CI) of having high % mammographic density (50th percentile as the cutoff) by different body composition categories were calculated using logistic regression analysis. Percent mammographic density was inversely related to % body fat (P = 0.013, trend test). In comparison to women in the lowest tertile of % trunk fat, the ORs of having high % mammographic density were 0.40 (95%CI = 0.13, 1.25) and 0.11 (95% CI = 0.03, 0.39) respectively for women in the second and third tertiles of % trunk fat. Women with higher % trunk lean soft tissue were four to seven times more likely to have high % mammographic density (P<0.05). The relationships between BMD and % mammographic density were not statistically significant. It is concluded that body soft tissue compositions are significantly related to % mammographic density. Future studies should take this association into consideration when using mammographic density as a marker of breast-cancer risk.

International Journal of Body Composition Research 2004, Vol. 2 No. 1: 31–36

26 Reliability of body circumference and skinfold measurements by observers trained in groups

Jack Wang[1], Glenn Bartsch[2], Sai Subhasree Rahgavan[3], Teresa Yurik[2], Grace Peng[2], Li Chen[2], Dale LeSueur[2], Judith C Shlay[4], for the Terry Beirn Community Programs for Clinical Research on AIDS (CPCRA).

[1]Body Composition Unit of St. Lukes-Roosevelt Hospital, Columbia University College of Physicians and Surgeons, New York, NY, USA; [2]CPCRA Statistical Center, University of Minnesota, Minneapolis, MN, USA; [3]Harlem Hospital, Columbia University College of Physicians and Surgeons, New York, NY, USA; [4]Denver Community Programs for Clinical Research on AIDS, University of Colorado Health Sciences Center, Denver, CO, USA.

Anthropometry is suitable for studies involving large samples and multiple sites, allowing estimations of body fat content and distribution from models that utilize body circumferences and skinfolds. However, the technique requires well-trained observers and the use of standardized measurement instruments and protocols. As part of the multicenter metabolic study conducted by the Community Program for Clinical Research on AIDS

(CPCRA 061), 26 nurses from clinical centers across the United States were trained in groups using a standardized training program consisting of reviewing illustrations on measurement protocols, observing demonstrations by a trainer, and practicing measurements for four body circumferences (BC) and five skinfolds (SF) on at least ten volunteers using the trainer's readings as the standards. Criteria for passing the training was that the average of the absolute percent difference (%AD) between the readings of the trainer and the trainee on another five volunteers were ≤2% for BC and ≤20% for SF. Nineteen trainees passed the training with the overall mean of %AD being 1.9% for BC and 17.9% for SF. This study established a model for training observers in groups with 73% of trainees achieving skills similar to that of individually-trained observers for performing anthropometric measurements.

International Journal of Body Composition Research 2004, Vol. 2 No. 1: 37–43

---

27 Proof-of-principle to measure potassium in the human brain: a feasibility study

L. Wielopolski[1], L.M. Ramirez[1], P.K. Coyle[2], Z.M. Wang[3] and S.B. Heymsfield[3]

[1]Brookhaven National Laboratory, Upton, NY; [2] University Hospital at Stony Brook, Neurology Department, Stony Brook, NY; [3]St Luke's/Roosevelt Hospital, New York, NY, USA.

We describe the results of a proof-of-principle to measure the potassium content in the human brain using the natural radioisotope ^{40}K that is in equilibrium with the stable isotopes of potassium, ^{39}K and ^{41}K. A fixed relationship exists between radioactive potassium and the total potassium in the brain, which in turn reflects the brain's cell mass and intracellular water compartment. Accordingly, we explored whether measurements of brain potassium could serve as possible indicators of intracellular cerebral edema. We designed, built, and then calibrated our system using a spherical phantom containing KCl salt dissolved in water at levels comparable to those in the human brain. Emitted radiation was detected using sodium iodide (NaI) and high-purity germanium (HP-Ge) detectors. Our results with phantoms and with five volunteers demonstrate the feasibility of measuring potassium at the levels normally present in human brain tissue. We plan to extend the system to detect the onset of brain edema in patients with multiple sclerosis.

International Journal of Body Composition Research 2004, Vol. 2 No. 1: 45–48

---

28 Does the combination of hand-to-hand and foot-to-foot impedance measurements improve the prediction of body composition in African women?

A. Gartner[1], A. Dioum[2], F. Delpeuch[1], B. Maire[1] and Y. Schutz[3]

[1]Nutrition Unit, UR 106 (WHO Collaborating Centre for Nutrition), IRD (Institut de Recherche pour le Développement), Montpellier, France; [2]Equipe de Nutrition, Laboratoire de Physiologie, Département de Biologie Animale, Faculté des Sciences et Techniques, Université Cheikh Anta Diop de Dakar, Sénégal, West Africa; [3]Institute of Physiology, Faculty of Medicine, University of Lausanne, Switzerland.

Hand-to-hand (HHI) or foot-to-foot (FFI) impedance methods are both easy to use and inexpensive, and they offer a rare opportunity to evaluate body composition in Africa. However, the standard algorithm supplied with each device is not valid in African subjects. We explored whether a combination of both methods may be valuable for improving the prediction of body composition in 170 African women as measured by air-displacement plethysmography (ADP). Simply taking the arithmetic mean of estimations from FFI and HHI still gave a marked and significant bias. Estimated values were regressed against the reference value from ADP. The mean of the two predicted values, or another predicted value combining HHI and FFI results in the same regression, suggested that there is no clear advantage to using the two methods together. The use of these field methods could gain in value if they were to provide raw impedance values, thus allowing to develop new predictive equations combining arm and leg impedance in order to track both limbs.

International Journal of Body Composition Research 2004, Vol. 2 No. 2: 51–60

---

29 Accuracy, reproducibility and normal total body potassium (TBK) ranges measured using the renovated whole body 40K counter of St Luke's-Roosevelt Hospital

Benjamin Schneider, Jack Wang, John C. Thornton, John Arbo, Mary Horlick, Steven B. Heymsfield and Richard N. Pierson, Jr.

Body Composition Unit, Department of Medicine, St Luke's-Roosevelt Hospital Center, Columbia University College of Physicians and Surgeons, New York, USA.

Whole body ^{40}K counting is a reliable and non-invasive method for measurement of the body cell mass, a parameter of body composition, which is of central importance in studies of nutritional physiology. The 4p liquid scintillation ^{40}K counter at St Luke's-Roosevelt Body Composition Unit was installed in 1967 and was renovated and recalibrated in 1994. This study reports the counting efficiency, accuracy, and reproducibility of the current system, and presents normal TBK ranges in healthy subjects. Counting efficiency was measured using 19

calibration standards (30 to 210 lb) with known potassium content, accuracy was measured using 14 phantoms with known potassium content (41–206 lb), and reproducibility was measured by repeat counting of 12 human subjects (37 to 205 lb). The renovated 4p liquid scintillation system provided improvements in efficiency, accuracy, and reproducibility, and extended the range in which body potassium can be measured down to 40 lb, r = 0.998 by intraclass correlation and mean CV of 2.3%, a marked improvement for human body composition studies. TBK data in healthy volunteers (n=1367; 676 females and 700 males, ages 3–90 years) are presented to show normal TBK ranges. The TBK in males peaked at age 27.5, 4500 mEq, and decreased to 2250 mEq by age 80 years (a decrease of 430 mEq per decade). For females, the TBK peaked at age 22, at 2450, and decreased to 1700 mEq at age 80 (a decrease of 130 mEq per decade).

International Journal of Body Composition Research 2004, Vol. 2 No. 2: 61–67

---

30 Monte Carlo modeling – an essential tool in whole-body counter design

R.J. Shypailo and K.J. Ellis

USDA/ARS Children's Nutrition Research Center, Department of Pediatrics, Baylor College of Medicine, Houston, TX 77030, USA

The re-building of the Children's Nutrition Research Center whole- body counter (WBC) required system construction without a low-background shielded room. Weight and size limitations necessitated development of shielded detectors rather than a shielded room. Modeling various detector and shield arrangements allowed us to evaluate a greater number of system designs than could be efficiently measured empirically. A Monte Carlo simulation program (MCNP-4B2; Los Alamos National Laboratory) was used to examine several WBC designs. The ^{40}K gamma peak region was assessed in simulations representing background and subject sources. Three evaluation types were performed: (1) optimal shielding thickness, (2) counter design assessment, including detector placement and counter shape, and (3) empirical testing, including background surveys and tests of relative detector positioning. MCNP performed well in predicting relative system response. Optimal shield thickness for ^{40}K counting was determined to be 7–8 cm of lead or equivalent. An enclosed (cylindrical) counter design was found to be necessary to achieve system precision of 1.5% or better. It is concluded that weight and size limitations influence the design considerations in developing a whole-body gamma counter. These constraints require advanced system testing that could not have been completed without the use of Monte Carlo modeling tools. The counter design chosen should perform at a precision of less than 1.5% for a total body potassium counting time of 15 minutes, and have a weight of less than 8200 kg with a footprint of 1.2 m x 2.4 m.

International Journal of Body Composition Research 2004, Vol. 2 No. 2: 69–74

---

31 The prediction of fat-free mass from bioelectrical impedance analysis in children and adolescents with cystic fibrosis

A.J. Murphy[1], H.M. Buntain[2] and P.S.W. Davies[1]

[1]Children's Nutrition Research Centre, Department of Paediatrics and Child Health, University of Queensland, Royal Children's Hospital, Brisbane; [2]Department of Respiratory Medicine, Royal Children's Hospital, Brisbane, Australia.

The aim of this study was to assess the validity of a number of bioelectrical impedance analysis (BIA) equations for the estimation of fat-free mass (FFM) in children and adolescents with cystic fibrosis (CF). The study involved 57 children and adolescents (27 females) with CF, aged between 5.3 and 17.9 years. Impedance measurements were taken and then converted to FFM using five selected equations. FFM measurements from dual energy X-ray absorptiometry (DEXA) were used as the comparison values. The bias, limits of agreements and correlation for four of the BIA equations were considered unacceptable when compared against the method of DEXA. From the equations examined, the equation of Houtkooper et al (bias = –0.3±1.7 kg; r=0.16) was considered the most suitable to determine FFM in children and adolescents with CF, however it was not deemed appropriate to be used interchangeably with DEXA measurements to monitor FFM in an individual. It is strongly recommended that disease-specific prediction equations are developed and tested for use in this population.

International Journal of Body Composition Research 2004, Vol. 2 No. 2: 75–77

---

32 Validity of skinfolds in comparison to DXA for estimating adiposity in Aboriginal Australian women

C. Raja[1], R. Hansen[2], S. Colagiuri[3] and B.J. Allen[1,2]

[1]Centre for Experimental Radiation Oncology, Cancer Care Centre, St. George Hospital, Kogarah, NSW 2217; [2]Centre for In Vivo Body Composition, Royal North Shore Hospital, St. Leonards, NSW 2265 Australia; [3]Department of Endocrinology, Prince of Wales Hospital, Sydney, NSW 2031, Australia.

There is a need for anthropometric equations to estimate adiposity in the field for Aboriginal Australian women. Twenty-four Aboriginal urban dwelling women were measured for height, weight, skinfolds and body fat. Total

fat (kg) and body fat percentage (%BF) were obtained directly from dual energy X-ray absorptiometry (DEXA) scans. Skinfolds (biceps, triceps, subscapular and supra-iliac) were measured and the Durnin and Womersley equation was used to estimate %BF. The mean (SD) age of the women was 47 (14) years and the average body mass index (BMI) was 30.8 (7.8) kg/m^2. Biceps, triceps, subscapular and supra-iliac skinfold were significantly correlated with measured %BF by DEXA (r = 0.83 to 0.89; P<0.001). Age was significantly correlated with both %BF estimated from skinfolds (r = 0.76, P<0.001) as well as %BF measured by DEXA (r = 0.68, P<0.01). Individual skinfolds and the sum of four skinfolds were highly correlated with %BF from DEXA, but the Durnin and Womersley equation underestimated %BF compared to DEXA. After correction of the Durnin and Womersley equation (%BF = 1.2* %BFD&W – 8.2), the SEE of predicted %BF was 3.2% with an explained variance of 0.88. It is concluded that the corrected anthropometric skinfold model can be applied in field studies as an alternative measure of total fat in Abroriginal Australian women.

International Journal of Body Composition Research 2004, Vol. 2 No. 2: 79–81

---

33 Changes in body composition during upper gastrointestinal cancer surgery

A. Aslani, B.A. Cooper, A. Sevette and R.C. Smith

Royal North Shore Hospital, St Leonards, NSW 2065, Australia.

Changes in weight and body composition are expected after most major abdominal surgery. Excess fluid retention especially may result in major morbidity in the post-operative patients. Loss of weight, itself, has been generally addressed by administration of appropriate intervention procedures. However, the components of the weight change has to be determined if an efficient and effective intervention procedure is to be successfully administered. Total body protein, body fat and body water of 15 patients undergoing major upper gastrointestinal (GI) surgery were measured pre-operatively and two weeks post-operatively. Total body protein (TBP) was measured using the in-vivo neutron capture analysis (IVNCA) technique and total body water (TBW) using the isotope dilution technique. The nitrogen index (NI) was calculated from TBP and total body fat (FM), percentage body fat (%BF), fat-free mass (FFM) as well as the body mass index (BMI) from anthropometric measurements. Although there was a general increase in weight post-operatively, the majority of BC parameters (TBP, NI, FM, %BF, FFM and BMI) decreased, with the exception of TBW, which increased from 33.6 l to 38.1 l. The findings suggest that, in this group of surgical patients, the increase in weight observed post-operatively is due to an increase in the TBW. The findings also demonstrate the need to validate bedside techniques to measure the crucial TBW, which may be essential to the overall recovery and survival of this group of patients.

International Journal of Body Composition Research 2004, Vol. 2 No. 2: 83–90

---

34 In-vivo body composition measurements in cancer and surgery

Alireza Aslani[1] and Ross C. Smith[2]

[1]Department of Nuclear Medicine, [2]Department of Surgery (University of Sydney),
Royal North Shore Hospital, St Leonards, NSW 2065, Australia.

Body composition measurements have been used for over 50 years to help define the nutritional deficiencies that result from illness, acute surgical stress and to guide therapies to correct these deficiencies. Direct measurement of body protein using in vivo neutron capture studies has been of great value in studying groups of surgical patients undergoing different therapeutic protocols. Understanding the errors of these measures helps to understand the meaning of the results obtained and the group sizes necessary to make meaningful comparisons. Losses of about 10 pe rcent of protein stores are needed to determine deficiencies in individual patients. Such losses do occur and have been shown to be predictive of complications of surgery, chemotherapy and renal dialysis. Bedside measures of Bioelectrical impedance analysis have yet to be incorporated in clinical practice although they have been shown to be able to measure fluid retention. Given that fluid retention and protein loss are related to poor outcome of different treatments the time is ready to introduce these measures into clinical practice.

International Journal of Body Composition Research 2004, Vol. 2 No. 3: 93–98

---

35 Hyperkalemia in advanced diabetes: potassium retention or cell transport adaptation? A case control study with body composition analysis

Mark L. Graber, Walton W. Shreeve, Ruimei Ma, Jean Richards and Richard N. Pierson, Jr.

Northport VA Medical Center, Northport, NY; Department of Medicine, SUNY at Stony Brook, NY; Brookhaven National Laboratory, Upton, NY and The Body Composition Unit, St Lukes/Roosevelt Hospital Center, New York, NY, USA.

Hyperkalemia in diabetes is not uncommon, and has been thought to reflect renal retention of potassium. The goal of this study was to test this hypothesis by measuring total body potassium in hyperkalemic diabetic

patients and normokalemic diabetic controls. We measured total body potassium (whole body counting of ^{40}K), total body sodium, calcium, and chloride by neutron activation analysis, total body carbon by inelastic neutron scattering, and total body water from the distribution of $^{3}H_20$. Measurements were made in 17 diabetic controls (mean plasma K = 4.47 mEq/l) and 14 diabetic patients with hyperkalemia (K = 5.26 mEq/l). All subjects were adult male Type II diabetic patients of comparable age, duration of disease, glycemic control, and end-organ complications. Total body potassium normalized by fat-free mass, total body water, or urinary creatinine was essentially identical (or slightly reduced) in the hyperkalemic subjects compared to controls. Additionally, the hyperkalemic diabetics were found to have significantly decreased body weight (77.2 kg hyperkalemics vs 92.9 kg control, $P<0.001$; BMI 26.7 vs 30.4 kg/m^2, $P = 0.002$), and decreased fat-free mass (59.0 vs 66.2 kg, $P < 0.05$). It is concluded that the findings argue against the traditional belief that the hyperkalemia of advanced diabetes is solely renal in origin. We suggest that a fundamental defect in this disorder is a generalized derangement of cellular ion transport, resulting in cellular potassium depletion and a shift of potassium from the cell to the extracellular space. This elevates plasma potassium directly, and by depleting intracellular potassium contributes to decreased renal potassium secretion. In light of these findings of unchanged or reduced total body potassium in hyperkalemic diabetics, the routine use of diuretics to treat these patients may need to be re-examined. In addition, the findings demonstrate a novel observation in this syndrome, decreased fat and fat-free body mass.

International Journal of Body Composition Research 2004, Vol. 2 No. 3: 99–106

---

36 Longitudinal measurements of total body water and body composition in healthy volunteers by online breath deuterium measurement and other near-subject methods

Barbara Engel BSc[1], Patrik Spanel PhD[2,3], David Smith DSc, FRS[2], Ann Diskin PhD[2] and Simon J. Davies MD, FRCP[1,2]

[1]Department of Nephrology, University Hospital of North Staffordshire, Stoke-on-Trent; [2]Institute of Science and Technology in Medicine, Keele University, Stoke-on-Trent, UK; [3]V. Cermák Laboratory, J. Heyrovský Institute of Physical Chemistry, Academy of Sciences of the Czech Republic, Dolejskova 3, 182 23, Prague 8, Czech Republic.

Rapid quantification of breath deuterium abundance by flowing afterglow mass spectrometry (FA-MS) enables accurate measurement of total body water (TBW), which combined with other techniques such as bioelectrical impedance analysis (BIA) and anthropometrics enables near-subject assessment of body composition. This study assessed the comparative reproducibility and inter-relationship of these methods in healthy subjects over 12 months. Detailed bedside composition was performed in 22 subjects, (10 male) aged 28–79 with body mass index (BMI) ranging from 21–38 at baseline and again at one year. Techniques included FA-MS deuterium dilution, BIA, skin-fold thickness (SFT) and soft tissue ultrasound measurement of fat and muscle depth. Short-term reproducibility for each method was established. Within and between technique comparisons of measurement were made from Pearson's linear regression, coefficient of variation (CV) and Bland-Altman analysis. Weight and TBW estimated by FA-MS, BIA and SFT at baseline and one year later were highly correlated (R^2 = 0.96–0.98), slope 1.02–1.03, CV = 4.5–11.6%. Systematic errors between the different methods in determining TBW were effectively identical at baseline and after one year. There was a tendency for subjects to gain weight during the study period, due to an increase, predominantly in younger women, of body water (FA-MS and SFT) and loss of upper body fat (ultrasound). BIA was relatively insensitive to these changes. It is concluded that over a 12-month period, TBW determined by FA-MS deuterium breath analysis has reproducibility similar to conventional weighing. The stability of between method errors would suggest that these techniques might be used in conjunction with each other in the longitudinal determination of body composition and so detect relatively subtle changes. The value of including an absolute determinant of TBW by FA-MS that is independent of the need to employ population derived equations, appears to be of value in the near-subject determination of body composition as required in clinical practice.

International Journal of Body Composition Research 2004, Vol. 2 No. 3: 107–113

---

37 Prediction of total body skeletal muscle mass from fat-free mass or intra-cellular water

Paul Deurenberg[1], Angelo Pietrobelli[2], ZiMian Wang[3] and Steven B. Heymsfield[3]

[1]Nutrition Consultant, Singapore; [2]Verona University Medical School, Pediatric Unit, Verona, Italy; [3]Obesity Research Center, St Luke's-Roosevelt Hospital, College of Physicians and Surgeons, Columbia University, New York, NY, USA.

Skeletal muscle mass (SMM) is the largest single contributor to body composition at the tissue level, yet its measurement is not very common and requires radiological techniques like magnetic resonance imaging (MRI), computer tomography (CT), ^{40}K counting and/or in-vivo neutron activation analysis for total body nitrogen. Today MRI and CT are regarded as reference methods. SMM predicted from anthropometry or bioelectrical impedance has a large prediction error and is only valuable for groups of subjects. Based on chemical data of

the reference man and on data of the chemical composition of muscle tissue, two formulas were developed to assess SMM from fat-free mass (FFM) or from intra-cellular water (ICW). The formulas (SMM (kg) = 0.566*FFM; SMM (kg) = 1.34*ICW) were validated on individual and group data reported in the literature and were also compared with SMM data calculated from 24 h creatinine excretion in a group of healthy males and females. Published individual SMM data measured by CT (34.4 ± 6.2 kg) in 17 healthy male subjects were not significant different from SMM calculated from ICW (34.7 ± 6.1 kg) and only slightly lower than SMM calculated from FFM (35.1 ± 5.5 kg). Reported group SMM data obtained by MRI in various age groups (20 years to >70 years) of both sexes were not different from SMM calculated from ICW. Skeletal muscle mass (kg) from ICW could be calculated as 1.024 ¥ SMM_{MRI} – 0.8, with an explained variance of 0.99 and a standard error of estimate of 0.4 kg. The slope and intercept were not significantly different from one and zero respectively. In a group of 8 males SMM from FFM or from ICW was not different from SMM obtained from 24 h creatinine excretion, but in females the SMM calculated from ICW was slightly lower compared to SMM from creatinine. This bias might be due to a different than assumed water distribution over the extra and intra-cellular space in women compared to man. It is concluded that the calculation formulas provide a reliable tool to assess SMM at a group level. However, before they can be used with confidence in individuals, direct validation against reference methods like MRI is needed.

International Journal of Body Composition Research 2004, Vol. 2 No. 3: 115–124

---

38 Comparison of body composition methodologies: determining what is most practical for the hospital, research laboratory or remote field study

Bert B. Boyer[1,2], Moonseong Heo[3], David B. Allison[4], Nicole T. Liebenstein[1], Irene S. Cho[1], ZiMian Wang[1] and Steven B. Heymsfield[1]

[1]Obesity Research Center, St. Luke's-Roosevelt Hospital, Columbia University College of Physicians and Surgeons, New York; [2]University of Alaska Fairbanks, Center for Alaska Native Health Research, Institute of Arctic Biology, Fairbanks, AK; [3]Department of Psychiatry, Westchester Division, Weill Medical College of Cornell University, New York; [4]Department of Biostatistics and Center for Research on Clinical Nutrition, University of Alabama at Birmingham, Birmingham, USA.

The study objective was to compare the accuracy of portable and hospital or laboratory-based body composition methods, as well as to evaluate reference methods that may be necessary for the development of population-specific phenotyping equations in field-study settings. Subjects were healthy adults of mixed ethnicity from the greater New York metropolitan area. Adiposity was evaluated by whole-body magnetic resonance imaging (MRI), dual energy x-ray absorptiometry (DXA), underwater weighing (UWW), air displacement plethysmography (ADP), isotope dilution (ID), bioimpedance analysis (BIA), and anthropometry (ANTH). Anthopometric measurements included height, weight, and skinfolds. MRI was selected as the reference for assessing total body adiposity. Pearson correlation coefficients with MRI-derived adipose tissue mass and fat mass measured by the other methods were: DXA (r=0.98, n=251), ADP (r=0.98, n=73), UWW (r=0.96, n=216), ID (r=0.95,n=248), ANTH (r=0.94, n=235), and BIA (r=0.92, n=218). Pearson correlations of %fat with MRI adiposetissue estimates resulted in the same order. Similar results were obtained from concordance correlation coefficients between methods for both adipose tissue % and mass as well as from Bland-Altman analysis. For mass estimates, the MRI-DXA correlation was not significantly different from the MRI-ADP correlation but it was different from the MRI-ID, MRI-UWW, MRI-ANTH, and MRI-BIA correlations at $P<0.05$ based on the bootstrap method. Nevertheless, the MRI-DXA concordance correlation coefficient was significantly different from the others. In conclusion, DXA fat measurements are the most highly correlated with and concordant to MRI estimates of adipose tissue mass. Although ADP may be the only other comparable method with MRI, DXA and ADP may not be practical for field studies. In our discussion, we compare and contrast options for field studies where more transportable methods are essential, and where cultural isolation of the population being studied may impact the comfort level of participants, the quality of phenotypes collected, and ultimately, the overall participation rate.

International Journal of Body Composition Research 2004, Vol. 2 No. 3: 125–130

---

39 Accuracy of dietary energy reporting in young New Zealand men and women: relationships to body composition, physical activity level and ethnicity

[1]**E.C. Rush**, [2]L.D. Plank, [1]M. Laulu, [3]E. Mitchelson and [4]W.A. Coward

[1]Body Composition and Metabolism Research Centre, Auckland University of Technology; [2]Department of Surgery, University of Auckland; [3]School of Health Science, Unitec, Auckland, New Zealand; [4]MRC, Human Nutrition Research, Cambridge, UK.

Accurate determination of energy and nutrient intake in free-living people is a vital component of nutritional studies exploring the relationships between diet and disease. Our objective was to examine accuracy of reported energy intake in young adults and the potential factors that may affect accuracy. Total energy expenditure (TEE), by the doubly-labelled water technique, and resting metabolic rate (RMR), by indirect calorimetry, were measured in 78 women (39 European, 12 Maori, 27 Pacific Island) and 29 men (10 European, 10 Maori, 9

Pacific Island) aged 18-27 y. Total body water was determined from the ^{18}O dilution space and used to calculate percentage body fat (%BF), assuming a constant (73%) hydration of the fat-free mass. Energy intake was assessed from self-reported 7-day diet diaries. The ratio of TEE to RMR was calculated as an index of physical activity level. Reported energy intake averaged 77 ± 23 (SD) % of TEE and there were no gender or ethnicity differences. This proportion was significantly lower for obese than non-obese European women (0.62 ± 0.13 vs 0.86 ± 0.25, $P = 0.0004$) but did not differ between these groups in Maori and Pacific women or in men. Higher activity was associated with more under-reporting of energy intake. PAL and %BF were negatively correlated (r = -0.68, $P<0.0001$) in men and Maori women (r = -0.62, $P = 0.031$) but uncorrelated in European and Pacific Island women. We found significant under-reporting of energy intake in young adults across three ethnic groups. Higher under-reporting was associated with higher %BF and BMI in European women.

International Journal of Body Composition Research 2004, Vol. 2 No. 4: 133–139

---

40 Potassium-related total body protein and body cell mass models: validation studies in patients with chronic diseases

ZiMian Wang[1], Daniel Stroud[2], Steven B. Heymsfield[1], and Boyd J. G. Strauss[2]

[1]Obesity Research Center, St. Luke's-Roosevelt Hospital, Columbia University College of Physicians and Surgeons, New York, USA; and [2]Body Composition Laboratory, Monash Medical Centre, Department of Medicine, Monash University, Victoria, Australia

Total body protein (TBPro) and body cell mass (BCM) prediction models, based on total body potassium (TBK) measured by whole-body ^{40}K counting, were developed and validated in healthy adults. However, the applicability of these models in healthy subjects across different laboratories and in patients with chronic diseases is unknown. The aim of this study was to cross validate the TBPro and BCM prediction models in healthy Australian adults and in patients with liver disease and to cross validate the TBPro prediction model in patients with growth hormone (GH) deficiency and chronic renal failure. Subjects were healthy adults (n = 43) and patients with liver disease (n = 151), GH deficiency (n = 39), and chronic renal failure (n = 17). Total body nitrogen (TBN) was measured by *in vivo* neutron activation analysis (IVNA), TBK by whole-body ^{40}K counting, total body water by deuterium dilution, extracellular water by sodium bromide dilution, and bone mineral by dual-energy X-ray absorptiometry. TBPro and BCM were calculated from TBN and a TBK-independent IVNA model as the reference, respectively. There was no significant difference in TBPro estimates between TBN and TBK models in healthy subjects, but the TBK model overestimated TBPro by (mean ± SD) 0.6 ± 0.9 kg and 0.9 ± 0.8 kg for the patients with liver disease and chronic renal failure (both $P < 0.001$), and underestimated TBPro by 0.4 ± 0.9 kg for the patients with GH deficiency ($P < 0.01$). There was no significant difference in BCM estimates between multi-component IVNA and TBK models in healthy subjects and patients with liver disease, although a large bias between the two methods was observed in the patients with liver disease. The present study results support the use of TBK-based TBPro and BCM prediction formulas in healthy subjects and in patients with selected chronic clinical conditions.

International Journal of Body Composition Research 2004, Vol. 2 No. 4: 141–148

---

41 Use of a reference four-component model to evaluate the ability of alternative methods and prediction techniques to estimate body composition in Type 2 diabetes and its changes following insulin treatment

IC Packianathan[1,2], NJ Fuller[3], DB Peterson[4], A Wright[5], WA Coward[5] and N Finer[1,2]

[1]Wellcome Trust Clinical Research Facility and Department of Endocrinology and Diabetes, Addenbrookes Hospital, Cambridge; [2]Department of Diabetes and Endocrinology and Centre for Obesity Research, Luton and Dunstable Hospital, Luton; [3]MRC Childhood Nutrition Research Centre, Institute of Child Health, London; [4]Department of Diabetes and Metabolism, Royal London Hospital, London; [5]Stable Isotope Group, MRC Human Nutrition Research, Elsie Widdowson Laboratory, Cambridge, UK.

Aim of the study was to assess the ability of various techniques to estimate body composition in Type 2 diabetes before treatment, after 6 months of insulin treatment, and the changes following such therapy. Body composition (body fat, fat-free mass, total body water and total body protein) was assessed, at baseline and again after 6 months, using a number of techniques in 19 Type 2 diabetes patients (mean age, 60 (SD 8.3) yr; BMI, 25.3 (3.3) kg/m^2), poorly controlled despite maximal oral hypoglycemic agents, receiving insulin (mean dose 40 (12.2) units/day). A four-component model was used as reference to assess the validity of these alternative techniques with bias and 95% limits of agreement. The three-component model was the most valid and least variable technique before and after insulin treatment and for assessing changes in body composition. Deuterium dilution, dual energy X-ray absorptiometry and air displacement plethysmography were less reliable, but were better predictors of absolute body composition and changes therein than bio-electrical impedance analysis or predictions based on anthropometry, which were misleading on both a group and an individual basis. It is concluded that, apart from the 3-component model, none of the methods were capable of either accurate or precise assessments of body composition before and after insulin therapy. Similarly changes in body composition were not tracked accurately or precisely using empirical techniques.

International Journal of Body Composition Research 2004, Vol. 2 No. 4: 149–154

42 Comparison of methods of body water determination in gastrointestinal cancer patients undergoing surgery

Alireza Aslani[1], Bruce A Cooper[2], Andre Sevette[3], Ross D Hansen[4] and Ross C Smith[3]

[1]Department of Nuclear Medicine, [2]Department of Renal Medicine, [3]Department of Surgery, [4]Gastrointestinal Investigation Unit, Royal North Shore Hospital, Pacific Highway, St Leonards, NSW 2065, Australia.

Excess fluid retention can result in major morbidity in surgical patients. Understanding the degree of fluid retention will help to determine better strategies for fluid management. The aim of this study was, therefore, to identify the most efficient method of total body water (TBW) estimation in gastrointestinal cancer patients undergoing surgery. The TBW of 39 gastrointestinal cancer patients (19 females) was measured using the reference standard deuterium oxide dilution technique (TBW_{D2O}) and compared to estimates derived via several equations: bioelectrical impedance analysis (Kushner, Pullicino, and Fredrix) equations; Watson's equations; 73.2% of fat-free mass; and 58% body weight. All measurements were carried out concurrently. Analysis of variance and post-hoc tests showed that the 58% body weight method overestimated TBW_{D2O} by 6.7 ± 10.1 kg (P= 0.002). The Fredrix, then the Kushner equations (mean overestimation of TBW_{D2O} = 0.5 ± 7.4 kg and 1.2 ± 7.5 kg respectively; both P> 0.5) produced the narrowest limits of agreement and the least bias. These results indicate that the Fredrix equation may be an accurate, less time-consuming alternative to TBW_{D2O} in determining TBW for groups of gastrointestinal cancer surgery patients. However, due to relatively wide limits of agreement, such measurements are probably of limited value for individual patient assessment.

International Journal of Body Composition Research 2004, Vol. 2 No. 4: 155–163

43 X-ray fluorescence analysis for determination of iodine concentration in the thyroid: A methodological study

M. Hansson[1], G. Berg[2], A. Larsson[3], E. Nyström[4], and M. Isaksson[1]

[1]Department of Radiation Physics, Göteborg University, Sweden; [2]Department of Oncology, Sahlgrenska University Hospital, Sweden; [3]Department of Buildings and Services, Göteborg University, Sweden; [4]Department of Medicine, Sahlgrenska University Hospital, Sweden.

Knowledge of the amount of iodine stored in the thyroid may contribute to the understanding of thyroidal diseases. Hence, there is a need for non-invasive methods for assessment of the iodine pool *in vivo*. X-ray fluorescence (XRF) is such a method and the objective of the present study was to perform a methodological evaluation of the XRF technique *in vitro*, with emphasis on the influence of the analysed volume. A well-calibrated system with ^{241}Am as irradiating source was used. Porcine thyroids were measured with XRF and neutron activation analysis (NAA), to evaluate the accuracy of the system. An analysed volume small enough to fit within a lobe gave too low detector signal and an analysed volume completely enclosing a lobe resulted in a larger background and a higher radiation dose. For *in vivo* studies an analysed volume where the irradiating beam was fitted inside a thyroid lobe and the detected pulses originated from a volume well enclosing the irradiated thyroid was preferable. Such geometry gave a lower radiation dose and also a detector signal essentially only depending on the sample concentration and diameter. The iodine concentration of the thyroids measured with XRF and NAA showed a good agreement (r=0.93) and for the ^{241}Am source an average minimum detectable concentration (MDC) of 0.06 mg/ml gave the effective dose 6 μSv. Accordingly XRF, if well calibrated, is a suitable tool for *in vivo* determination of iodine concentration in the thyroid.

International Journal of Body Composition Research 2004, Vol. 2 No. 4: 165–173

44 Calibration models to measure body composition in taller subjects using DXA

Analiza M. Silva[1], Fátima Baptista[1], Claudia S. Minderico[1], Alexandra R. Rodrigues[1], Angelo Pietrobelli[2], Pedro J. Teixeira[1] and Luis B. Sardinha[1]

[1]Exercise and Health Laboratory, Faculty of Human Movement-Technical University of Lisbon, Portugal; [2]Pediatric Unit, Verona University Medical School, Italy.

The aim of this study was to assess the accuracy of DXA whole body composition measurements of bone mineral content (BMC), fat mass (FM) and lean soft tissue (LST), performed with knees bent compared to the standard position in subjects during a whole body scan. DXA was used to measure body composition in 104 Caucasian males and females. Comparison of means and linear regression analysis were used to test the performance of DXA measurements and to develop calibration models. For the entire sample, using the knees bent, BMC and FM were overestimated by ~2.6% and ~9.2%, respectively, while LST was underestimated by ~4.0% (P<0.001). The regression between $BMC_{KneesBent}$ and the standard position did not differ from the line of identity for (FM) and lean soft tissue (LST, P >0.05), while the slope differed from 1 for FM and LST (P <0.05). New

models were developed for BMC, FM and LST. For FM, the significant predictors were $FM_{KneesBent}$, age, lower limb fat mass (LLFM), and the knees bent height (KBH) while for LST, were $LST_{KneesBent}$, LLFM, age, and KBH. Finally, for BMC, $BMC_{KneesBent}$, age, LLFM, and LLFM x sex interaction were associated with the reference BMC. These findings show that body composition measurements with knees bent differ from the standard position. Hence, the recommendation of this technique in subjects taller than the DXA scan area should be accomplished by using correction models for BMC, FM, and LST developed for specific DXA instrument.

International Journal of Body Composition Research 2005, Vol. 3 No. 1: 3–4

---

45 An alternative way of measuring hand-to-foot single frequency bioempedance

I.F. Freitas Jr[1]; E.C. Rush[2], G. Kolt[2], A. Luke[3]

[1]UNESP – São Paulo State University, Department of Physical Education, Campus Presidente Prudente, Sao Paulo, Brazil; [2]Faculty of Health and Environmental Sciences, Auckland University of Technology, Auckland, New Zealand; [3]Department of Preventive Medicine & Epidemiology, Loyola University Medical School, Maywood, IL, USA.

This short communication presents the findings of a substudy of a larger group comparing the effect of change of position on bioelectrical resistance measurements.

International Journal of Body Composition Research 2005, Vol. 3 No. 1: 5–14

---

46 Ability of bioelectrical impedance to predict percentage fat mass in children of two different ethnic origins

VP. Wickramasinghe[1], GJ Cleghorn[1], KA Edmiston[1], AJ Murphy[1], RA Abbott[2] and PSW Davies[1]

[1]Children's Nutrition Research Centre, Department of Paediatrics and Child Health, University of Queensland, Brisbane, Australia. [2]School of Human Movement Studies, Queensland University of Technology, Australia.

Detailed analysis of body composition in children has helped to understand changes that occur in growth and disease. Bioelectrical impedance analysis (BIA) has gained popularity as a simple, non-invasive and inexpensive tool of body composition assessment. Being an indirect technique, prediction equations have to be used in the assessment of body composition. There are many prediction equations available in the literature for the assessment of body composition from BIA. This study aims to cross-validate some of those prediction equations to determine the suitability of their use on Australian children of white Caucasian and Sri Lankan origins. Height, weight and BIA were measured. Total body water was measured using the isotope dilution method (D_2O). Fat-mass (FM) and %FM were estimated from BIA using ten prediction equations described in the literature. Five to 14.99-year-old healthy, 96 white Caucasians and 42 Sri Lankan children were studied. The equation of Schaefer et al was the most suitable prediction equation for this group with the lowest mean bias for %FM assessment in both Caucasian (–1.0±9.6%) and Sri Lankan (1.6±5.2%) children and the fat content of the individuals did not influence the predictions by this equation. Impedance index (height^2/impedance) explained for 80% of TBW in white Caucasians and 93% in Sri Lankans and figures were similar for the prediction of FFM. We conclude that BIA can be used effectively in the assessment of body composition in children. However, for the assessment of body composition using BIA, either prediction equations should be derived to suit the local populations or existing equations should be cross-validated to determine their suitability before their application.

International Journal of Body Composition Research 2005, Vol. 3 No. 1: 15–24

---

47 A bioelectrical impedance analysis equation for predicting total body water and fat-free mass in children with Human Immunodeficiency Virus-1 in the pre-HAART and HAART eras

TH Joffe[1], S Welle[2], R Roubenoff[3], SL Gorbach[1], GA Weinberg[4], C Duggan[5], L Furuta[5], J Nicchitta[6], TM Lipinczyk[6,7] and TL Miller[6,7]

[1]Department of Family Medicine and Community Health, Tufts School of Medicine, Boston, MA; [2]University of Rochester School of Medicine, General Clinical Research Center, Rochester, NY; [3]Jean Mayer USDA Human Nutrition Research Center on Aging, Tufts University, Boston, MA; [4]University of Rochester School of Medicine, Division of Pediatric Infectious Diseases, Rochester, NY; [5]Children's Hospital, Division of Gastroenterology and Nutrition, Harvard Medical School, Boston, MA; [6]University of Rochester School of Medicine, Division of Pediatric Gastroenterology, Rochester, NY; [7]Miller School of Medicine at the University of Miami, Division of Pediatric Clinical Research, Miami FL, USA.

Bioelectrical impedance analysis (BIA) is commonly used to measure body composition, however limited studies of its usefulness in children with the human immunodeficiency virus (HIV) -1 infection exist. The objective of the study was to provide a BIA equation for predicting body composition in outpatient pediatric HIV populations, to compare performance of our equation to published equations derived from both non-HIV and HIV-positive pediatric populations and to evaluate performance of our equation developed in the pre-highly active

antiretroviral (HAART) era, in a separate HIV-positive pediatric population on HAART. Total body water (TBW) by deuterium dilution and BIA measures from 30 HIV-positive pediatric subjects in the pre-HAART era were used to develop an equation for estimating body composition. We evaluated 18 published pediatric BIA equations in our subjects using Bland Altman analysis, and the performance of our model in a separate HIV-positive pediatric population on HAART with dual energy X-ray absorptiometry (DXA) measures. Using multivariate techniques, we developed a predictive equation for TBW using height^2 and resistance in children off HAART that correlated well (r=.95) with FFM measures obtained by DXA in children receiving HAART. A number of published BIA equations developed in healthy children also provided good estimates of TBW or FFM in our subjects. In conclusion: We provide a new BIA equation for estimating body composition in children on or off HAART. Thus BIA measures in HIV-infected children without clinically apparent lipodystrophy are not affected by HAART, although fat distribution cannot be well-defined by BIA. Published models derived from HIV populations do not always out-perform those derived from healthy subjects.

International Journal of Body Composition Research 2005, Vol. 3 No. 1: 25–30

---

48 Comparison of the Lunar DPX-L and Prodigy dual-energy X-ray absorptiometers for assessing total and regional body composition

DM Huffman, NM Landy, E Potter, TR Nagy and BA Gower

Department of Nutrition Sciences, Division of Physiology and Metabolism, University of Alabama at Birmingham, AL, USA.

The purpose of this study was to assess the agreement of the Lunar DPX-L with the newer Prodigy dual-energy X-ray absorptiometer (DXA) for determining total-body and regional (arms, legs, trunk) bone mineral density (BMD), bone mineral content (BMC), fat mass (FM), lean tissue mass (LTM), total body mass (BM) and percentage fat. A total of one hundred and six apparently healthy males (n=34) and females (n=72) between the ages of 8–72 years were scanned consecutively on the DPX-L (software version 1.35) and Prodigy DXA (enCORE v. 3.6 software). Paired t-tests indicated significantly higher measures by Prodigy for BM (percent difference= 1.1%) and total-body BMD (2.2%), BMC (2.9%), FM (3.5%), and percent fat (2.8%; P<0.001), but not LTM (0.2%). Regional estimates of FM and bone tended to be overestimated by Prodigy relative to DPX-L. The percent difference was most pronounced for FM in the arms (14.2%) and trunk (8.5%), BMD in the legs (4.9%), LTM in arms (5.6%), and BMC in the trunk (5.9%); but all total-body and regional measures were strongly and significantly correlated (P<0.001). The method of Bland and Altman indicated that the Prodigy overestimated DPX-L for BM (r=0.343; P<0.001), and total-body measures of BMD (r=0.460; P<0.001), and BMC (r=0.321; P<0.001) at higher values, as indicated by the significant, positive association between difference (Prodigy-DPX-L) versus mean ((Prodigy+DPX-L)/2). Regionally, Prodigy overestimated DPX-L for BMD in the legs, BMC in the legs and trunk, and FM in the arms at higher values (P<0.001). In contrast, FM in the legs was underestimated by Prodigy relative to DPX-L at higher values (P<0.001), and no regional bias was observed for LTM. In conclusion, we recommend that correction equations be used for comparing BM, total-body BMD and BMC, and regionally for BMD in the legs, BMC in the legs and trunk, and FM in the arms and legs. The use of correction equations for other estimates is not required for making direct comparisons.

International Journal of Body Composition Research 2005, Vol. 3 No. 1: 31–39

---

49 Body composition estimation using leg-to-leg bioelectrical impedance: a six-site international cross-validation study

A. Boulier[1], W.C. Chumlea[2], A. De Lorenzo[3], M. Deurenberg-Yap[4], S.S. Sun[2], L. Léger[5] and Y. Schutz[6]

[1]Inserm U.695, Hôpital Bichat, Paris, France; [2]Lifespan Health Research Center, Wright State University, Dayton, OH, USA; [3]The Division of Human Physiology, University 'Tor Vegata', Roma, Italy; [4]Health Promotion Board, Singapore; [5]Dept. Kinésiologie, Université de Montréal, Montréal, Canada; [6]Dept. of Physiology, University of Lausanne, Switzerland.

Traditional body composition measurements using bioelectrical impedance are limited by maintaining a supine position for a long time and by use of specific population equations. In order to evaluate a rapid bioelectrical impedance method, an international, multiple centre and multiple ethnic group study was performed. 335 men and 501 women of various BMI (range: 12–44 kg/m^2) from seven countries were measured using Dual Energy X-ray Absorptiometry (DXA), hydrostatic weighing, deuterium oxide dilution (D_2O), skinfold thickness and results were compared to a 'leg-to-leg bio electrical impedance analysis method' (LL_{BIA}) which used a rectangular impulse at 114 kHz. The lowest differences (D, mean ± SD) in Fat Mass (FM) and Fat Free Mass (FFM) were found between LL_{BIA} and DXA (D_{FM}= -0.52 ± 3.67 kg, P<0.001 and D_{FFM} = 0.65 ± 3.50 kg, P<0.001). Standard errors of estimate (SEE) were close to those observed between the references (SEE_{FM} = 3.26 kg and SEE_{FFM} = 3.45 kg). The Bland and Altman method revealed a significant bias (P<0.001). Ethnicity explains 19% and 18% of

the differences observed ($P<0.001$) for FM and FFM). The length of the legs does not explain this variance ($P = 0.99$ for FFM). It is concluded that although specific equations for the heterogeneous populations studied (low to high BMI's) were not required for the LL_{BIA} method, ethnic differences must still be taken into account. The error involved can be tolerated for clinical and epidemiological studies, in particular when the body composition of groups are studied.

International Journal of Body Composition Research 2005, Vol. 3 No. 2: 43–47

50 Validation of self-reported versus measured height and weight among adult Singaporeans

S. A. Ng[1], R. S. Naidu[1], S. L. A. Tan[1] and M. Deurenberg-Yap[1,2]

[1]Research and Health Information Management Division, Health Promotion Board, Singapore; [2]National University, Singapore.

Respondents from the National Health Survey (704 males and 712 females, aged 17 to 75 years old) were selected via quota sampling. Respondents were asked to report their weight and height prior to standardised measurements. Aim of the study was to assess the accuracy of self-reported height and weight and the sensitivity and specificity of estimating obesity prevalence in Singaporean adults based on these indicators. Of all respondents 75.4% were aware of their height and weight. The elderly (60–75 years old) and those in the overweight (BMI between 25 and 30 kg/m^2) and obese (BMI = >30 kg/m^2) categories were less likely to be aware of their height and/or weight compared to other categories. Males and females underestimated their weight by a mean (SD) of 0.3 (3.0) kg and 0.4 (2.4) kg respectively. Females overestimated their height by a mean (SD) of 0.7 (2.9) cm. The discrepancy in the estimated BMI derived from self-reported height and weight was significant but small for females (–0.4 (1.3) kg/m^2). The sensitivity and specificity of estimated BMI for the overweight category were 81.4% and 91.5% for males and 71.7% and 95.8% for females. The sensitivity and specificity of estimated BMI for the obese category were 83.0% and 98.0% for males and 78.0% and 98.7% for females. The overall level of agreement between measured and estimated BMI was 0.77 for males and 0.77 for females using the Cohen's Kappa test. The prevalence of overweight and obese respondents was underestimated by 3.6 and 1.0 percent point respectively using the estimated BMI. It is concluded that self-reported height and weight were accurate indicators of actual measurements with small systematic errors. However, they were not suitable indicators for the assessment of prevalence of obesity in the Singaporean adult population due to a low level of awareness of height and weight values amongst the population and the underestimation of the true obesity prevalence.

International Journal of Body Composition Research 2005, Vol. 3 No. 2: 49–53 ©Smith-Gordon

51 Effect of occupation on the relationship between body fat percentage and body mass index in Indonesians

Paul Deurenberg[1], Syafri Guricci[2], Mabel Deurenberg-Yap[3], and Joseph GAJ Hautvast[4]

[1]Nutrition Consultant, Singapore; [2]School of Public Health, Gedung D Lt.II, University of Indonesia, Depok, Indonesia; [3]Research and Information Management Division, Health Promotion Board, Singapore; [4]Emeritus Professor, Department of Nutrition & Epidemiology, Wageningen University, The Netherlands.

Indonesians, like many Asian population groups, have a higher body fat percentage (%BF) for any given age, gender and body mass index (BMI) compared to Caucasians. Differences in body build are at least partly the reason for this, but also other factors, among which physical activity, are discussed. In the present study two groups with clear differences in occupation (as a surrogate for physical activity level) were studied with the main aim to see the impact of physical activity on the relationship between BMI and %BF. Eighty- six male white-collar workers (university personnel and government officials) and 52 harbour labourers participated in this body composition study. Weigh, height, skinfold thickness and total body impedance data were collected using standardized methods. %BF was predicted from skinfolds, impedance and BMI using published formulas. In addition total body water (TBW) was determined using deuterium oxide and fat-free mass (FFM) and %BF was calculated from TBW. The groups did not differ in age, or in height, but the white-collar workers were heavier (7.9 kg), had a higher BMI (2.5 kg/m^2), a higher BF% (12.8) and a slightly lower FFM (1.2 kg). The prediction of BF% from impedance was accurate, but skinfolds over predicted (2.2 ± 1.8) BF% in the blue-collar workers and slightly underestimated (0.6 ± 4.9) BF% in the white-collar workers. The relationship between BMI and BF% was different between the two groups, the blue- collar workers having 9.7 ± 0.8 (mean, SE) percent points less body fat for the same age and BMI (ANCOVA) than their counterparts. It is concluded that occupation (physical activity level) has a clear impact on the relationship between %BF and BMI.

International Journal of Body Composition Research 2005, Vol. 3 No. 2: 55–61 ©Smith-Gordon

52 Weight loss needed to maintain visceral adipose tissue during aging

G.R. Hunter[1,2], C. Lara-Castro[2], N.M. Byrne[4], S.O. Zakharkin[3], M.-P. St. Onge[2], D.B. Allison[3]

[1]Departments of Human Studies, [2]Nutrition Sciences, and [3]Biostatistics, University of Alabama at Birmingham, Birmingham, Alabama 25294; [4]School of Human Movement Studies, Faculty of Health, Queensland University of Technology, Brisbane Q4059, Australia.

Aging is associated with a re-distribution of fat mass to the viscera. Visceral adipose tissue (VAT) is closely associated with increased risk of diabetes and cardiovascular disease. Therefore, preventing increases in VAT with aging would reduce chronic disease risk. The purpose of this cross-sectional study in 228 Caucasian women, age 18 to 77 years, was to estimate weight losses required to prevent age-related increases in VAT. Computed tomography VAT and dual energy X-ray absorption % body fat were determined. Analysis of variance showed that body mass index (BMI, 3.0 kg/m^2, P<0.05) and weight adjusted for VAT (78.7 cm^2, P<0.01) increased but lean mass decreased (4.7 kg, P<0.01) with age. Linear piecewise (knot at 48 years) continuous regression (dependent variable weight and independent variables VAT and age) was used to estimate weight loss needed to maintain a constant VAT between 20 and 65 years. The estimated weight loss needed to maintain VAT at 40 cm^2 was 3.3 kg between 20 and 48 years and 5.5 kg between 50 and 65 years. BMI reductions were 0.9 kg/m^2 between 20 and 48 years and 1.1 kg/m^2 between 50 and 65 years. Equations were validated on a separate sample of 39 pre-menopausal and 29 post-menopausal women. It is estimated that a weight loss of almost 9 kg between ages of 20 and 65 is required to maintain low VAT in individuals in the middle to upper range of the normal BMI category. However, since a BMI of 21 kg/m^2 at 20 years of age corresponds to less than 40 cm^2 VAT, and that is the case at age 65 years, very lean individuals should only maintain their young adult body weight as they age to remain at low metabolic risk.

International Journal of Body Composition Research 2005, Vol. 3 No. 2: 63–68

53 Body composition and nutritional habits in professional ballet dancers

Marcella Malavolti[1], Marco Poli[1], Angelo Pietrobelli[1,2], Manfredo Dugoni[1], Ornella Trunfio[1] and Nino C. Battistini[1]

[1]Applied Dietetic Technical Sciences Chair, Modena and Reggio Emilia University; [2]Pediatric Unit, Verona University Medical School, Verona, Italy [2].

Object of this study was to study fat mass (FM), fat-free mass (FFM) and nutritional habits of professional ballet dancers. Our secondary aim was to evaluate daily energy intake and to compare nutritional habits with level of daily recommended consumption (LARN) or recommended dietary allowance (RDA). Twelve ballet dancers (seven males and five females), aged between 23-42 years were studied. All the subjects trained at least 5 h per day (mean ± SD: 8 ± 3). We used four different techniques to assess body composition: skinfold thickness measurements (TH), bio-electrical impedance analysis (BIA), air displacement plethysmography (BOD-POD) and dual energy X-ray absorptiometry (DXA). The latter was considered the criterion method. FM using DXA was 6.2 ± 2.0 kg and FFM 56.3 ± 12.4 kg in the total population. FM was 5.2 ± 1.1 kg and 6.9 ± 2.3 kg in females and males using DXA, respectively. FFM in females was 44.6 ± 4.8 kg and 64.7 ± 8.2 kg in males. Correlation between FM derived by skinfolds vs FM measured by DXA was significantly higher (r = 0.90) than between FM estimated by BIA (r = 0.54) and by BOD-POD (r = 0.48). Positive correlations were found between DXA FFM measurements and FFM anthropometry (r = 0.99), between DXA FFM and FFM estimated by BIA (r = 0.98) and between FFM measured by BOD-POD (r = 0.99). Total energy intake in male subjects was less than LARN or RDA (2464 ± 256 vs 3100 ± 379 kcal/day). On the other hand, total energy intake in female subjects was slightly higher than LARN or RDA (2439 ± 391 vs 2120 ± 130 kcal/day). This was probably due to a higher energy consumption from lipids in female subjects (32 ± 7% in males vs 36 ± 7% in females). Our results suggest that FM estimated by anthropometry is to be preferred to BIA in this specific population, possibly because the main part of FM in this specific population is only subcutaneous.

International Journal of Body Composition Research 2005, Vol. 3 No. 2: 69–72

54 Comparison of software versions for body composition analysis using the PIXImus dual-energy X-ray absorptiometer

M.S. Johnson, N.M. Landy, E.P. Potter and T.R. Nagy

Division of Physiology and Metabolism, Department of Nutrition Sciences, and the Clinical Nutrition Research Center, The University of Alabama at Birmingham, Birmingham AL 35294-3360, USA.

We have previously validated the use of dual-energy X-ray absorptiometry (DXA) for measuring body composition of mice using the GE-Lunar PIXImus and software version 1.42 [1]. Since that report, newer versions of the software have been released. The purpose of the present study was to compare results from our

original study with results analyzed using two newer versions of software (versions 1.44 and 1.45). Body composition data (lean tissue mass [LTM], fat mass [FM], bone mineral content [BMC], and bone mineral density [BMD]) were obtained from DXA scans of twenty-five, anesthetized male C57Bl/6J mice (6–11 weeks old; 19 to 29g). Relative to version 1.42, versions 1.44 and 1.45 significantly (P<0.001) overestimated LTM and BMD and underestimated FM and BMC. However, compared to carcass analysis, versions 1.44 and 1.45 significantly overestimated both FM and LTM and underestimated BMC. Results from 1.44 and 1.45 were highly correlated with carcass values for all body composition parameters. Prediction equations were developed for the two new software versions. Applying the prediction equation from 1.42, to the data obtained from 1.44 and 1.45 resulted in FM and LTM that were worse than if no equation was used. However, using their own developed equations resulted in data that were not significantly different than that from carcass analysis. These data suggest that software-specific equations are necessary for comparing DXA-derived data to that of chemical analysis.

International Journal of Body Composition Research 2005, Vol. 3 No. 2: 73–76

---

55 Body fat estimated from near-infrared interactance (Futrex 5000®) versus a four-component model in black men

D.R. Wagner[1], V.H. Heyward[2] and D.W. Lockner[3]

[1]Health, Physical Education, & Recreation Department, Utah State University, Logan, UT; [2]Center for Exercise and Applied Human Physiology, University of New Mexico, Albuquerque, NM; [3]Nutrition/Dietetics Program, University of New Mexico, Albuquerque, NM, USA.

The purpose of this study was to assess the validity of the near-infrared interactance (NIR) Futrex 5000® device as a method to estimate the percent body fat (%BF) of black men. This NIR study was unique in that a multicomponent (4C) model that corrected total body density (measured by hydrodensitometry) for total body water (determined by isotope dilution) and total body bone mineral (obtained from dual-energy x-ray absorptiometry) was used as the reference measure of %BF. On average, the Futrex 5000® NIR device underestimated the %BF of 30 black males, aged 19–45 y, by 1.9% BF (P < .05). Furthermore, the prediction error was high (*SEE* = 4.1% BF, *TE* = 4.5% BF), the 95% confidence interval was large (–10.1% BF to 6.3% BF) and the individual error in the NIR estimate exceeded ± 3.5% BF for 50% of the sample. The %BF estimates from the Futrex 5000® did not meet the established criteria for accuracy in body composition assessment, and we can not recommend it as a tool for estimating the %BF of black men.