Does Paracentesis of Ascites Influence Measurements of Bone Mineral or Body Composition by Dual-Energy X-Ray Absorptiometry?

Kent Valentin Haderslev, Ole Lander Svendsen, and Michael Staun

Measurements of bone mineral content (BMO) and density (BMD) by dual-energy x-ray absorptiometry (DXA) may be affected by changes in soft tissue overlying bone. Furthermore, the accuracy error for body composition determined by DXA may be high in the trunk region due to the complex bone geometry. Our objective was to evaluate the impact of paracentesis on measurements of bone mineral and body composition by DXA. DXA (Norland XR-36; Norland, Fort Atkinson, WI) scans were performed in six patients with cirrhosis of the liver before and after treatment of ascites by paracentesis. There were no significant differences in the spinal BMC (change [Δ] = 0.04%) and BMD (Δ = −0.9%) ($P > .05$), nor in total body BMC ([TBBMC] Δ = 1.9%) and BMD ([TBBMD] Δ = 0.4%) ($P > .05$). The median volume of ascites drained (6.8 L; range, 1.6 to 14.7) was not significantly different from the median change in total (5.8 kg; range, 2.0 to 16.1) or trunk lean tissue mass ([LTM] 5.8 kg; range, 1.9 to 11.9) ($P > .05$). The changes in body weight correlated with the changes in trunk LTM ($r = .93$, standard error of the estimate [SEE] = 1.8 kg, $P = .007$). Total and regional fat mass were not changed significantly by the paracentesis. We conclude that measurements of total body and spinal bone mineral by DXA are unaffected by large changes in the soft tissue composition and height of the trunk. Furthermore, the change in body composition induced by ascites drainage was accurately determined as a change in total body and trunk LTM on a group level.

PREVIOUS STUDIES have shown that diet-induced weight loss in obesity may result in a decrease in the bone mineral content (BMC) measured by dual-energy x-ray absorptiometry (DXA) in the lumbar spine (L_2-L_4), as well as total body BMC (TBBMC).[1-6] This has caused concern, since low BMC is associated with an increased risk of osteoporotic fractures.[7] DXA is a noninvasive, safe, and accurate method for measuring BMC, and has also been proposed as a convenient method for body composition analysis.[8-11] However, the accuracy of bone mineral measurements depends on the mass, thickness, and composition of the soft tissue overlying bone.[11-15] The observed decrease in BMC measured by DXA in relation to weight loss could therefore possibly be an artifact caused by changes in the mass and composition of soft tissue. Previously, Svendsen et al[11] simulated a change in soft tissue mass by placing nearly 10 kg porcine lard on healthy human subjects. This resulted in a false increase in TBBMC. However, others[5] have found no effect of adding lard on BMC measurements in similar studies. These conflicting results may be due to the fact that DXA instruments from two different manufacturers were used. Thus, instruments from different manufacturers (Norland, Hologic, and Lunar Radiation) produce different BMC and body composition results, since they use different technology for energy separation and algorithms for adjustment of differences in the composition, mass, and height of soft tissue.[16,17]

Measurement of the changes in total body lean tissue mass (LTM) and fat tissue mass (FTM) by DXA has been shown to be precise and accurate.[11,18] However, the error for the measurement of changes in LTM and FTM by DXA in the trunk region may be higher.[19,20] Accurate and precise measurement of soft tissue composition in this region is important, as abdominal/trunk fatness constitutes a significant health risk.[21,22] The Norland company (Fort Atkinson, WI) has recently introduced a modification of their DXA instrument that may overcome the accuracy problems of differences in soft tissue composition and height. Thus, the Norland XR-36 DXA scanner has a dynamically changing samarium filter instead of a constant filtration of the x-ray beam.[23]

Patients with cirrhosis of the liver often have localized intraabdominal accumulation of fluid (ascites), which can exceed 10 L. An important therapeutic approach is drainage. By this procedure, the height and soft tissue composition of the abdomen, and thus the lumbar spine region, is changed. The purpose of the present study was to evaluate whether measurements of spinal bone mineral density (BMD), BMC, TBBMC, and total body BMD (TBBMD) by the Norland XR-36 remain stable after paracentesis. In addition, we sought to determine the accuracy of measurements of the change in body composition of the trunk due to the removal of ascites.

SUBJECTS AND METHODS

Patients

The study was performed with six patients, five males and one female, with biopsy-proven cirrhosis of the liver. Four patients had alcohol-induced cirrhosis, one had cirrhosis due to chronic hepatitis C, and one had cryptogenic cirrhosis. All patients had ascites that could be diagnosed clinically. The study was performed in accordance with the Declaration of Helsinki II and with approval from the Ethical Committee of Copenhagen. Informed written consent was obtained from each patient before inclusion.

Study Protocol

Patients were weighed on a scale accurate to within 0.1 kg (with the subjects wearing light clothes), and the height was measured by a wall-mounted stadiometer to the nearest 0.1 cm. With the patient in the standing position, anthropometric data for waist and hip circumferences were obtained using a standard measuring tape. The abdominal sagittal diameter was measured as the largest supine anteroposterior diameter around the umbilicus under maximum expiration and relaxation to the nearest 0.5 cm with a slide-gauge designed for that purpose. Measurements were performed twice, and the mean values were used for the calculations. Each subject then underwent DXA scans of the lumbar spine (L_2-L_4) and total body with the ascites present in the peritoneal

From the Department of Gastroenterology and Hepatology, Rigshospitalet, Copenhagen University Hospital, Copenhagen; and the Center for Clinical and Basic Research, Ballerup, Denmark.

Submitted April 30, 1998; accepted August 8, 1998.

Address reprint requests to Kent Valentin Haderslev, MD, Department of Gastroenterology CA2121, Copenhagen University Hospital, Rigshospitalet, Blegdamsvej 9, DK-2100 Copenhagen, Denmark.

0026-0495/99/4803-0018$10.00/0

cavity. Following this, ascites was removed by paracentesis with standard sterile technique using a plastic indwelling catheter. For every 2 L ascites removed, 100 mL 20% human albumin was infused intravenously during the paracentesis procedure. The fluid intake, urinary volume, amount of intravenous albumin, and volume of removed ascites fluid were recorded. After the paracentesis, all measurements were repeated immediately. All measurements in one subject were performed consecutively on the same day.

Chemical Fat Extraction

The fat content of ascites fluid was analyzed in patients no. 5 and 6. The total fat fraction was measured by chemical fat extraction according to the method used by Folch et al.[24]

DXA

Measurements of body composition were performed with the Norland XR-36 DXA densitometer (Norland, Fort Atkinson, WI) with the subject supine. The host software was revision 2.5.2., and the scanner software revision 2.0.0. Regional analyses separating the body into a trunk region and a peripheral region, ie, the arms, legs, and head, were made according to the Operators Manual. DXA estimates of body composition are based on a three-compartment model measuring BMC, FTM, and LTM. Precision errors for body composition measurements by the Norland XR-36 densitometer have recently been reported by Hendel et al.[25] They were 2.2% for TBBMC, 2.7% for FFM, and 2.6% for fat mass. To reduce beam-hardening effects, the Norland XR-36 uses a dynamically changing samarium filtration. This is achieved by rapidly switching between eight different combinations of samarium filter sheets during the scan, depending on the thickness and composition of the tissue. The filtration can be changed very rapidly (<11 milliseconds).[23] The purpose of the dynamic filter change is to equalize the intensity of the x-ray beam to any absorber thickness, thereby reducing the influence of beam hardening.

Statistical Analysis

All results are shown as the mean ± SD unless the data were not normally distributed, for which the median and range are shown instead. Student's *t* test for paired observations was used to compare changes between repeated measurements of paired variables. The Wilcoxon signed-rank test for paired observations was used when data were not normally distributed. A *P* value less than .05 was considered statistically significant. The strength of the relationship between variables was tested by linear regression analysis. Changes in spinal BMC/BMD and TBBMC/TBBMD were compared by the Bland-Altman method with calculation of the 95% limits of agreement in individual subjects. The Microsoft EXCEL statistical program was used for all analyses.

RESULTS

The subjects' age, anthropometric characteristics, and body composition measurements by DXA before paracentesis are presented in Table 1. The changes in the scale weight, volume of ascites, total fluid loss, and anthropometric data after paracentesis are listed in Table 2. With the paracentesis procedure, the patients lost a median of 6.9 kg body weight and the abdominal sagittal diameter decreased by 22%. The fat content in ascites fluid was 0.1 and 0.2 g/L, respectively, corresponding to a fat content less than 0.05%.

Values for spinal BMC and BMD were not statistically significantly changed by the drainage of ascites ($P > .05$), with a mean change of 0.02 ± 1.59 g and −0.01 ± 0.06 g/cm^2, respectively (Table 2). Nor were there any significant effects on TBBMC and TBBMD, with a mean change of 56.5 ± 72.9 g and 0.004 ± 0.013 g/cm^2 ($P > .05$), respectively (Fig 1). Corresponding coefficients of variation (CV) for the repeated measurements before and after ascites drainage were 1.9% and 3.3% for spinal BMC and BMD and 2.1% and 0.9% for TBBMC and TBBMD. Correlations between the decreases in sagittal abdominal height and in hip and waist circumference and the differences in spinal BMD and BMC and TBBMC and TBBMD measurements were all nonsignificant ($P > .05$).

Table 1. Characteristics of Six Patients With Hepatic Cirrhosis and Ascites Formation Before Paracentesis

Characteristic	Mean ± SD
Age (yr)	56.2 ± 12.6
Weight (kg)	79.2 ± 13.4
Height (cm)	172.6 ± 6.8
Soft tissue mass (kg)	75.4 ± 13.0
FTM (kg)	19.0 ± 8.3
LTM (kg)	56.4 ± 12.4
Trunk FTM (kg)	8.6 ± 5.0
Peripheral FTM (kg)	10.4 ± 3.3
Trunk LTM (kg)	32.0 ± 8.0
Peripheral LTM (kg)	24.4 ± 5.5
TBBMC (kg)	3.0 ± 0.3
TBBMD (g/cm^2)	1.01 ± 0.01
Spinal BMC (g)	54.6 ± 9.1
Spinal BMD (g/cm^2)	1.10 ± 0.16
Waist circumference (cm)	108.3 ± 9.4
Hip circumference (cm)	97.5 ± 7.2
Abdominal sagittal diameter (cm)	28.8 ± 3.9

The changes in body composition measurements by DXA after paracentesis are shown in Table 3. The body weight by DXA, total LTM, and trunk LTM decreased significantly. These changes were not statistically different from the change in body weight measured by the scale ($P > .05$), ascites volume drained ($P > .05$), or total fluid loss ($P > .05$). The changes in peripheral LTM, total body FTM, peripheral FTM, and trunk FTM were not statistically significantly different from zero ($P > .05$). The measured change in body weight by DXA was highly correlated with the change in body weight by scale, ascites volume drained, and total fluid volume lost, with *r* values of about 1 and accuracy errors (standard error of the estimate [SEE] of the linear regression) less than 0.5 kg. Also, the measured changes in total LTM and trunk LTM by DXA were highly correlated with the change in body weight by scale, ascites volume drained, and total fluid volume lost, with *r* values greater than .9 but with a higher accuracy error (SEE, 1.8 to 2.4 kg). There were no significant correlations between changes in total FTM and trunk FTM and changes in anthropometric measurements, total fluid loss, or ascites volume drained ($P > .05$) (Table 4).

DISCUSSION

To assess the effect of large changes in soft tissue mass on BMC and BMD measurements by DXA, previous studies have used a model in which packets of lard or ground beef are placed on healthy subjects. However, these experiments have been criticized as not representing appropriate physiological models. In the present study, a large change in soft tissue mass was induced by drainage of ascites fluid from the peritoneal cavity.

Table 2. Changes in Anthropometric Measurements and Spinal and Total Body Bone Mineral After Paracentesis in Six Patients With Hepatic Cirrhosis

Subject No.	ΔBody Weight (kg)	Ascites Volume (L)	Total Fluid Loss (L)*	ΔWaist Circumference (cm)	ΔHip Circumference (cm)	ΔAbdominal Sagittal Diameter (cm)	ΔBMD Spine (g/cm2)	ΔBMD Spine (g)	ΔTBBMD (g/cm2)	ΔTBBMC (g)
1	−14.5	−14.7	−14.4	−12.5	0.0	−10.0	0.104	2.68	0.011	5
2	−2.2	−2.5	−2.4	−9.0	1.5	−2.0	−0.026	−0.49	−0.017	−30
3	−5.4	−5.6	−5.3	−8.0	−3.0	−7.0	−0.033	−0.51	0.023	161
4	−9.2	−10.1	−9.1	−10.0	−1.0	−6.5	−0.028	0.69	0.009	14
5	−8.4	−8.0	−8.0	−12.0	−3.5	−8.0	−0.039	−0.11	0.001	74
6	−2.8	−1.6	−2.3	−4.0	0.0	−5.0	−0.037	−2.13	−0.001	115
Median	−6.9†	−6.8†‡	−6.7†‡	−9.5†	−0.5	−6.8†	−0.010§¶	0.02§¶	0.004§¶	56.5§¶

Abbreviation: Δ, change.

*Total fluid loss = (ascites volume + urinary volume) − (oral intake + intravenous fluid given).

†Significantly different from zero ($P < .05$).

‡Not significantly different from change in scale weight ($P > .05$, paired *t* test).

§Not significantly different from zero.

¶Data expressed as the mean value.

This experimental setup may be considered better for the study of the impact of changes in soft tissue overlying bone, but the model has not been used with the DXA technique previously. We found that DXA using the Norland XR-36 is able to compensate for large changes in soft tissue height and composition when measuring spinal BMC and BMD and TBBMD and TBBMC. The absolute differences before and after paracentesis were indeed very small and did not reach statistical or clinical significance. In fact, the CVs for repeated measurements before and after ascites drainage were comparable to the normal precision errors for repeated measurements by DXA in healthy subjects.[25,26] The attenuation of ascites fluid is different from that of fat tissue, and our results do not necessarily apply to changes in FTM as well. Nevertheless, it seems reasonable to assume that DXA (with the Norland XR-36) may also compensate for changes in FTM in the trunk. Therefore, our data indicate that the reported bone loss observed with diet-induced weight loss in obesity is correct. Thus, as suggested by Jensen et

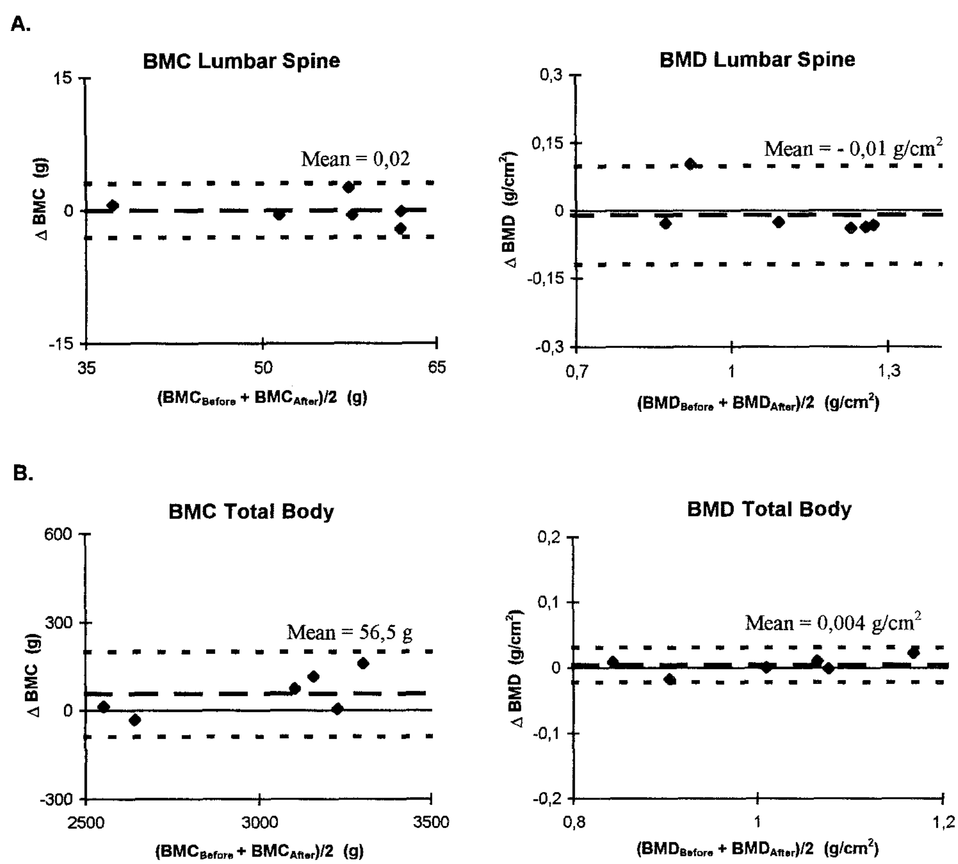

Fig 1. Lack of agreement between BMC and BMD measurements before and after paracentesis in 6 patients with hepatic cirrhosis.

Table 3. Changes in Body Composition Measurements (Kg) by DXA After Paracentesis in Six Patients With Hepatic Cirrhosis

Subject No.	ΔBody Weight	ΔTotal Body LTM	ΔPeripheral LTM	ΔTrunk LTM	ΔTotal Body FTM	ΔPeripheral FTM	ΔTrunk FTM
1	−13.6	−16.1	−4.2	−11.9	2.5	−0.4	2.9
2	−2.2	−2.2	−0.4	−1.9	0.0	−0.9	0.9
3	−5.2	−2.0	−0.1	−1.9	−3.0	−1.9	−1.1
4	−9.3	−8.3	0.2	−8.5	−0.9	−0.5	−0.4
5	−8.0	−9.7	−0.6	−9.1	1.8	−1.2	3.0
6	−2.4	−3.2	−0.1	−3.1	0.9	6.3	−5.4
Median	−6.6*	−5.8*	−0.3†	−5.8*	0.5†	−0.7†	0.3†
CV‡	—	—	5.1	—	6.9	18.8	23.3

Abbreviation: Δ, change.

*Not significantly different from changes in body weight by scale ($P > .05$, paired t test).

†Not significantly different from zero ($P > .05$, Wilcoxon signed-rank test).

‡CV for measurements before and after paracentesis.

al,[5] such bone loss can be regarded as a physiological readjustment toward normal.

The ability of DXA to assess accurately the composition of soft tissue in the trunk region has been questioned.[19,20] Assessment of soft tissue composition by DXA is possible only in pixels that do not contain bone. Evaluation of soft tissue composition in pixels with bone mineral and soft tissue is performed by extrapolating the calculated values for soft tissue composition in adjacent bone-free pixels to the pixels with bone. The trunk contains a high degree of pixels with bone present because of the complex bone geometry in the trunk, which leaves relatively fewer bone-free pixels for the calculation of soft tissue composition in this region. Measurement of fat and lean tissue may therefore be less accurate in the trunk versus the extremities, which have a more simple bone geometry and a relatively higher number of bone-free pixels. Studies by Milliken et al[19] and Snead et al[20] showed that although the mass of added packets of soft tissue placed on the trunk was accurately measured, the composition of FTM and LTM of the packets was not. However, in a similar study design, Gotfredsen et al,[23] using the Norland XR-36, found that DXA measured the soft tissue composition of the trunk region accurately. Differences in the results of these studies could be due to the fact that different DXA instruments from different manufacturers were used, ie, Lunar DPX-L, Hologic QDR-1000/W, and Norland XR-36.

Expectedly, the fat content of ascites fluid was negligible. Ascites fluid consists primarily of water and only a small fraction of protein. Water and protein are found almost solely in the LTM, which by DXA is the sum of all chemically fat-free soft tissue elements. Thus, theoretically, removal of ascites should result in an equal decrease in LTM without any change in FTM or BMC. Since ascites fluid is located in the trunk region, the changes should occur entirely in the trunk LTM. We found a very high agreement between the median loss of body weight, ascites volume drained, and total fluid loss, on the one hand, and the median change in weight and total and trunk LTM measured by DXA on the other, whereas the measurements of total and regional FTM were not significantly affected by the paracentesis. Furthermore, the correlations between the change in weight by DXA and the actual weight loss by scale, total fluid loss, and volume of ascites fluid drained were excellent, with an accuracy error less than 0.5 kg, whereas the accuracy error was somewhat higher for the measurements of total and trunk LTM, namely about 2.0 to 2.5 kg. However, this is similar to the accuracy error for measurements of the absolute total body LTM reported previously.[11] DXA was, however, less effective at resolving changes in weight into changes in LTM and FTM in individual subjects.

Pure water may be measured as consisting of some fat (~5%) by DXA.[8] Woodrow et al[27] measured body composition by DXA in patients with renal failure treated with peritoneal dialysis. After drainage of the peritoneal dialysis fluid, the body weight was decreased by 1.8 kg. Comparable to our findings, the trunk LTM was very similar to the change in body weight. However, the change in total soft tissue mass was significantly greater than would be expected, and the difference was accounted for by a reduction in trunk FTM. Furthermore, Milliken et al,[19] using a Lunar DPX-L DXA scanner, showed that packets of water placed on the trunk of healthy subjects were measured to consist partly of fat (20%). Consequently, a small decrease in

Table 4. Linear Regression Between Changes in Body Weight and Fluids Versus Changes in DXA Measurements

Parameter	ΔDXA Weight (kg)	ΔTotal Body LTM (kg)	ΔTrunk LTM (kg)
ΔBody weight by scale (kg)			
r	1.00	.95	.93
SEE	0.3	1.9	1.8
P	<.001	.003	.007
	ΔDXA = 0.06 + 0.95 Δweight	ΔLTM = −1.20 + 1.15 Δweight	ΔTrunk LTM = 0.10 + 0.87 Δweight
Total fluid loss (L)			
r	1.00	.95	.92
SEE	0.3	2.0	1.9
P	<.001	.004	.009
	ΔDXA = 0.24 + 0.95 Δfluid loss	ΔLTM = −0.92 + 1.14 Δfluid loss	ΔTrunk LTM = 0.13 + 0.86 Δfluid loss
Ascites volume drained (L)			
r	1.00	.92	.90
SEE	0.5	2.4	2.1
P	<.001	.009	.014
	ΔDXA = 0.53 + 0.89 Δascites	ΔLTM = −0.38 + 1.04 Δascites	ΔTrunk LTM = 0.48 + 0.79 Δascites

trunk FTM could be expected when ascites fluid is removed from the abdominal region. Nevertheless, the small changes in trunk FTM were insignificant in our study. However, due to the small number of subjects in our study and the nonparametric nature of our data, this could be due to a lack of statistical power (type 2 error).

In summary, measurements of total body and spinal bone mineral by DXA (Norland XR-36) are unaffected by large changes in soft tissue composition and height in the abdominal region. Furthermore, the changes in body composition induced by ascites drainage seem to be accurately measured as changes in total body and trunk LTM on a group level, but with larger errors in single subjects.

ACKNOWLEDGMENT

The technical assistance of Jette Christiansen is greatly appreciated. Helmer Ring Larsen, MD, provided valuable assistance.

REFERENCES

1. Pritchard JE, Nowson CA, Wark JD: Bone loss accompanying diet-induced or exercise-induced weight loss: A randomised controlled study. Int J Obes Relat Metab Disord 20:513-520, 1996
2. Svendsen OL, Hassager C, Christiansen C: Effect of an energy-restrictive diet, with or without exercise, on lean tissue mass, resting metabolic rate, cardiovascular risk factors, and bone in overweight postmenopausal women. Am J Med 95:1993
3. Ramsdale SJ, Bassey EJ: Changes in bone mineral density associated with dietary-induced loss of body mass in young women. Clin Sci (Colch) 87:343-348, 1994
4. Avenell A, Richmond PR, Lean ME, et al: Bone loss associated with a high fibre weight reduction diet in postmenopausal women. Eur J Clin Nutr 48:561-566, 1994
5. Jensen LB, Quaade F, Sorensen OH: Bone loss accompanying voluntary weight loss in obese humans. J Bone Miner Res 9:459-463, 1994
6. Compston JE, Laskey MA, Croucher PI, et al: Effect of diet-induced weight loss on total body bone mass. Clin Sci (Colch) 82:429-432, 1992
7. Consensus Development Conference: Diagnosis, prophylaxis, and treatment of osteoporosis. Am J Med 94:646-650, 1993
8. Mazess RB, Barden HS, Bisek JP, et al: Dual-energy x-ray absorptiometry for total-body and regional bone-mineral and soft-tissue composition. Am J Clin Nutr 51:1106-1112, 1990
9. Haarbo J, Gotfredsen A, Hassager C, et al: Validation of body composition by dual energy x-ray absorptiometry (DEXA). Clin Physiol 11:4, 1991
10. Svendsen OL, Hassager C, Bergmann I, et al: Measurement of abdominal and intra-abdominal fat in postmenopausal women by dual energy x-ray absorptiometry and anthropometry: Comparison with computerized tomography. Int J Obes Relat Metab Disord 17:45-51, 1993
11. Svendsen OL, Haarbo J, Hassager C, et al: Accuracy of measurements of body composition by dual-energy x-ray absorptiometry in vivo. Am J Clin Nutr 57:605-608, 1993
12. Hansen MA, Hassager C, Overgaard K, et al: Dual-energy x-ray absorptiometry: A precise method of measuring bone mineral density in the lumbar spine. J Nucl Med 31:7, 1990
13. Svendsen OL, Hassager C, Skodt V, et al: Impact of soft tissue on in vivo accuracy of bone mineral measurements in the spine, hip, and forearm: A human cadaver study. J Bone Miner Res 10:868-873, 1995
14. Tothill P, Avenell A: Errors in dual-energy x-ray absorptiometry of the lumbar spine owing to fat distribution and soft tissue thickness during weight change. Br J Radiol 67:793, 1994
15. Hangartner TN, Johnston CC: Influence of fat on bone measurements with dual-energy absorptiometry. Bone Miner 9:71-81, 1990
16. Tothill P, Fenner JA, Reid DM: Comparisons between three dual-energy x-ray absorptiometers used for measuring spine and femur. Br J Radiol 68:810, 1995
17. Kistorp CN, Svendsen OL: Body composition analyses by dual energy x-ray absorptiometry in female diabetics differ between manufacturers. Eur J Clin Nutr 51:449-454, 1997
18. Going SB, Massett MP, Hall MC, et al: Detection of small changes in body composition by dual-energy x-ray absorptiometry. Am J Clin Nutr 57:845-850, 1993
19. Milliken LA, Going SB, Lohman TG: Effects of variations in regional composition on soft tissue measurements by dual-energy x-ray absorptiometry. Int J Obes Relat Metab Disord 20:677-682, 1996
20. Snead DB, Birge SJ, Kohrt WM: Age-related differences in body composition by hydrodensitometry and dual-energy x-ray absorptiometry. J Appl Physiol 74:770-775, 1993
21. Larsson B, Svardsudd K, Welin L, et al: Abdominal adipose tissue distribution, obesity, and risk of cardiovascular disease and death: 13 year follow up of participants in the study of men born in 1913. BMJ Clin Res Ed 288:1401-1404, 1984
22. Lapidus L, Bengtsson C, Larsson B, et al: Distribution of adipose tissue and risk of cardiovascular disease and death: A 12 year follow up of participants in the population study of women in Gothenburg, Sweden. BMJ Clin Res Ed 289:1257-1261, 1984
23. Gotfredsen A, Baeksgaard L, Hilsted J: Body composition analysis by DEXA by using dynamically changing samarium filtration. J Appl Physiol 82:1200-1209, 1997
24. Folch J, Lees M, Sloane Stanley GH: A simple method for isolation and purification of total lipids from animal tissues. J Biol Chem 497-509, 1965
25. Hendel HW, Gotfredsen A, Andersen T, et al: Body composition during weight loss in obese patients estimated by dual energy x-ray absorptiometry and by total body potassium. Int J Obes Relat Metab Disord 20:1111-1119, 1996
26. Johnson J, Dawson Hughes B: Precision and stability of dual-energy x-ray absorptiometry measurements. Calcif Tissue Int 3:174-178, 1991
27. Woodrow G, Oldroyd B, Turney JH, et al: Influence of changes in peritoneal fluid on body-composition measurements by dual-energy x-ray absorptiometry in patients receiving continuous ambulatory peritoneal dialysis. Am J Clin Nutr 64:237-241, 1996