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Relationship between weight, body composition, and bone mass in peritoneal dialysis

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SUMMARY

Patients in chronic dialysis show a decrease in total bone mass. The factors that determine this decrease are not well known. In normal populations weight and its compartments are important determinants of bone mass. We studied total bone mineral content (TBMC), a measure of bone mass, and body composition using DEXA densitometry in 65 patients (45 females and 20 males) who had been in peritoneal dialysis for a mean of 40.3 ± 23.2 months. Forty-eight patients (73.8%) had been previously in hemodialysis. The mean total time in dialysis for these patients was 76.8 months. As a group patients showed a very significant positive correlation between TBMC and weight, height, and lean body mass. A negative correlation was found between TBMC with the time in dialysis and iPTH. In men we found significant simple positive correlations between TBMC and weight, height and lean body mass. In women we found simple positive correlations of TBMC with weight, height and lean body mass and a negative correlation with iPTH. In the multiple regression analysis, lean body mass was the only body composition parameter that had a significantly positive correlation with TBMC in men; in women only height correlated positively with TBMC and iPTH continued to correlate negatively with bone mass. When we considered pre and postmenopausal women separately, bone mass was correlated positively with height and lean body mass and negatively with iPTH in postmenopausal women and only with height in premenopausal females. We conclude that the lean body mass compartment. is the most important component of weight that determines TBMC in peritoneal dialysis patients particularly in males and postmenopausal women. In postmenopausal women, secondary hyperparathyroidism seems to be particularly detrimental on bone mass.

Key words: Total bone mineral content. Peritoneal dialysis. Lean mass. Fat mass. Body weight.

RELACIÓN ENTRE PESO, COMPOSICIÓN CORPORAL Y MASA ÓSEA EN DIÁLISIS PERITONEAL

RESUMEN

Los pacientes en diálisis crónica muestran una disminución de su masa ósea. Los factores que determinan esta disminución no son bien conocidos. En las po-

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blaciones normales el peso y sus compartimientos son importantes determinantes de la masa ósea. Nosotros estudiamos el contenido mineral óseo total (CMOT), una medición de la masa ósea, y la composición corporal usando densitometria DXA en 65 pacientes (45 mujeres y 20 varones) que habían estado en diálisis peritoneal por un promedio de 40,3 ± 23,2 meses. Cuarenta y ocho pacientes (73,8%) habían estado previamente en hemodiálisis. El tiempo medio total en diálisis de estos pacientes fue de 76,8 meses. Como grupo los pacientes mostraron una correlación positiva muy significativa entre el CMOT y el peso, la altura, y la masa corporal magra. Se encontró una correlación negativa entre el CMOT y el tiempo en diálisis y la PTH intacta. En los hombres encontramos correlaciones simples positivas significativas entre CMOT y el peso, la altura, y la masa corporal magra. En las mujeres encontramos correlaciones simples positivas entre el CMOT con el peso, la altura y la masa corporal magra y una correlación negativa con la PTH intacta. En el análisis de regresión múltiple, la masa corporal magra fue el único parámetro de composición corporal que tuvo una correlación significativa positiva con el CMOT en hombres; en las mujeres solo la altura se correlacionó positivamente con el CMOT y la PTH intacta continuó correlacionando negativamente con la masa ósea. Cuando consideramos las mujeres pre y posmenopáusicas por separado, la masa ósea se correlacionó positivamente con la altura y la masa ósea magra y negativamente con la PTH intacta en las mujeres posmenopáusicas y solo con la altura en las mujeres premenopáusicas. Nosotros concluimos que la masa corporal magra es el compartimiento más importante del peso corporal que determina el CMOT en los pacientes en diálisis peritoneal particularmente en hombres y mujeres posmenopáusicas. En las mujeres posmenopáusicas, el hiperparatiroidismo secundario parece ser particularmente deletéreo para la masa ósea.

Palabras clave: Contenido mineral óseo total. Diálisis peritoneal. Masa magra. Masa grasa. Peso corporal.

INTRODUCTION

Bone mass reduction is a frequent finding among dialysis patients, and it is more evident in those who have been on renal replacement therapy for a longer period of time.[1-5] There are several likely causes that explain this reduction in bone mass. One of them is the type of renal osteodystrophy that dialysis patients present. Several studies have found a negative correlation between mean bone mineral content, measured in different skeletal regions, and serum levels of parathyroid hormone,[6-8] suggesting that secondary hyperparathyroidism is an important factor in its production. However, other authors[9] claim that bone mass reduction is more frequently seen in patients with evidence of osteomalacia than in those with secondary hyperparathyroidism.

Many studies have shown that, in normal subjects, the body weight is an important determinant of bone mass[10] and that a greater body weight is associated with a greater rate of skeletal mass and a lower rate of bone loss.[11] Since this effect occurs in all weight ranges and only in obese subjects, the influence of body weight on bone mass is relevant for all subjects. Moreover, a low weight is considered an important risk factor for a low bone mass.[12] In spite of this well established relationship between body weight and bone mass, it is not yet clear which body compartment, lean body mass (as an expression of muscular mass) or fat mass (adiposity), is the one that has a greatest effect on bone mass. Dual X Ray absorptiometry (DEXA) allows the non invasive assessment of bone mass and of body compartments simultaneously and with great accuracy.[13] In stable patients on dialysis, DEXA seems to be superior to other non invasive methods such as bioelectrical impedance or measurements of skin folds thickness and arm circumference for determining body composition.[14]

In this study, we decided to investigate the relationships between the lean and fat body mass compartments and total bone mineral content (TBMC),

as an expression of bone mass, determined by DEXA, in a group of stable patients on peritoneal dialysis.

MATERIAL AND METHODS

Subjects

We studied 65 patients (45 females and 20 males) from two dialysis units that were on peritoneal dialysis for a mean time of 40.3 ± 23.2 months. Mean age for females was 53.2 ± 13.1 years, and for males 48.3 ± 13.1 years. Fifteen women were premenopausal and 30 postmenopausal. Forty-eight patients (73.8%) had previously been on hemodialysis for a mean time of 49.5 months (range: 2-314 months). Total time on dialysis for female patients was 63.2 ± 41.2 months, and for male patients 82.9 ± 67.8 months. Forty patients were on outpatient continuous peritoneal dialysis (OCPD) and 25 were dialyzed with a cycling device (APD). Patients had not been admitted to the hospital within the last 3 months; 7 had previously been transplanted; and five had received parathyroidectomy. According to the EDTA classification, etiology for their renal failure was: chronic glomerulonephritis 29%, diabetic nephropathy 18.4%, polycystic renal disease 13.8%, obstructive uropathy 6.1%, hypertensive nephrosclerosis 3.7%, tubulointerstitial nephritis 1.5%, miscellaneous 4.5%, and unknown 23%. Patients on OCPD were dialyzed using 1.5-2.0 liters bags with 4 changes per day. Calcium in peritoneal baths was 3.5 mEq/L in 89.2% of patients and 2.5 mEq/L in the remaining. For serum phosphorus management, 89% of patients were receiving calcium-based phosphorus chelators (essentially calcium carbonate); only 4% received aluminum hydroxide; 37% of patients were on low calcitriol doses.

All patients gave their written informed consent to participate in the study and the investigation was approved by the teaching and ethical committees from the participating institutions.

Methods

Total bone mineral content (TBMC) was measured by dual X ray absorptiometry (DEXA) using a DPX-L densitometer (Lunar, Madison, WI). The variation coefficient for this parameter, with patient's turnover in our laboratory, is 0.8%.[15] TBMC is expressed in grams of hydroxyapatite. Body compartments (lean and fat body masses) determinations were also obtained by densitometry and expressed in kilograms for each compartment. Intact parathyroid hormone measurements were done by radioimmunometric assay (Nichols, San Juan Capristano, CA, USA); normal range: 23-65 pg/mL.

In all patients, height and weight anthropometrical measurements were done. Weight was evaluated in kilograms by means of an arm scale and height in centimeters by means of a stadiometer.

Statistical analysis

All statistical analyses were done with CSS software: Statistica (StatSoft, Inc, Tulsa, OK, USA). Results are expressed as means ± SD. We compared anthropometrical parameters and measurements of body composition between males and females by Student's t test for non-paired data. In order to calculate correlation coefficients, we performed simple and multiple correlations by using anthropometrical measurements (height and weight), and body composition determinations (lean and fat body masses), age, intact PTH, and time on dialysis as independent variables, and TBMC as the dependent variable. Results are shown for all patients as a whole group or as separated groups of men and women. Women were further analyzed by pre- and postmenopausal.

RESULTS

Men on peritoneal dialysis had essentially higher height, lean mass and TBMC than women, whereas women had total fat mass and a percentage of fat mass significantly greater than men (Table 1).

Considering men and women as a whole group, TBMC was positively and very significantly correlated with weight ($r = 0.46$; $p < 0.001$), height ($r = 0.72$; $p < 0.0001$) and lean body mass ($r = 0.64$; $p < 0.001$); there also was a close correlation between height and lean body mass ($r = 0.72$; $p < 0.0001$). By contrast, TBMC was not correlated with fat body mass or its percentage. Also observed was a negative correlation between TBMC and total time on dialysis ($r = -0.26$; $p = 0.03$) and intact PTH ($r = -0.30$; $p = 0.02$); there was no correlation between age and TBMC. In the multiple correlation analysis for the whole group of patients, three variables continued to significantly correlate with TBMC: positively height and lean body mass, and negatively intact PTH (Table 2).

Table 3 shows the simple correlations of TBMC separately for males and females. Males only showed a simple significant positive correlation of TBMC with weight, height and lean body mass, the remaining variables not correlating. Females showed sim-

Table I. Anthropometrical and body composition parameters in women and men on peritoneal dialysis

Parameters	Females	Males	p level
n	45	20	
Weight (kg)	65.42 ± 14.7	72.49 ± 9.89	0.055
Height (cm)	155.12 ± 6.39	168.48 ± 7.59	< 0.0001
BMI	27.17 ± 5.77	25.65 ± 3.61	0.28
Fat mass (kg)	24.39 ± 11.20	17.13 ± 10.01	0.01
% fat mass	37.35 ± 9.63	23.86 ± 7.88	< 0.0001
Lean mass (kg)	38.05 ± 4.95	52.56 ± 5.63	< 0.0001
TBMC (g)	2066.24 ± 467.98	2664.82 ± 451	< 0.0001

TBMC: Total bone mineral content.

Table II. Multiple correlation analysis between TBMC and anthropometrical and clinical variables in patients as a whole

	Beta	P level
Weight (kg)	0.05	0.55
Height (cm)	0.54	< 0.0001
Lean mass (kg)	0.262	0.01
TTD (meses)	0.02	0.72
iPTH (pg/ml)	-0.28	< 0.001

TTD: Total Time on Dialysis.

ple significant positive correlations of TBMC with weight, height and lean body mass, and negative with intact PTH (fig. 1).

In men, in multiple regression analysis, only lean body mass continued to present a positive significant correlation with TBMC (Beta = 0.71; $p < 0.0001$); whereas in women as a group, TBMC had a very significant positive correlation with height (beta = 0.61; $p < 0.0001$), and negative with intact PTH (beta = -0.33; $p = 0.001$). When only postmenopausal women were considered, TBMC was very positively correlated with height (beta = 0.55; $p < 0.0001$) and with lean body mass (beta = 0.299; $p = 0.01$), and negatively with intact PTH (beta = -0.36; $p < 0.01$). In premenopausal women, TBMC was only correlated with height.

DISCUSSION

In the present study, we found that, in patients of both genders on peritoneal dialysis, weight and its lean body mass component were very significantly correlated with TBMC, whereas there was no correlation with fat compartment or its percentage. Thus, lean body mass seems to be the body compartment that has the greatest influence on determining body mass in patients on peritoneal dialysis.

Since lean body mass measured by densitometry is an estimate of the muscular compartment, and since good correlations have been found between regional muscular strength and regional BMD[16], it is likely that the good correlations found between lean body mass and TBMC show the importance of the mechanical action of muscles on the skeleton as a determinant of its mineral content. In a recent study, Woodrow et al.[17] found that patients with chronic renal failure had important reductions in their lean body mass, especially at the limbs, which was detectable by DEXA but not by other measurement methods such as the skin folds thickness. This lean body mass reduction, which expresses a muscular mass reduction, may explain the reduction in BMC that these authors found in a previous study. On the other hand, since lean body mass is also a good indicator of nutritional status, similar to serum albumin, it is likely that the good correlation found between lean mass and mineral content reflects the importance of nutritional status when determining the skeletal mass in these patients.

An essential problem when interpreting studies that try to analyze the relationships between body compartments and bone mass is that different inves-

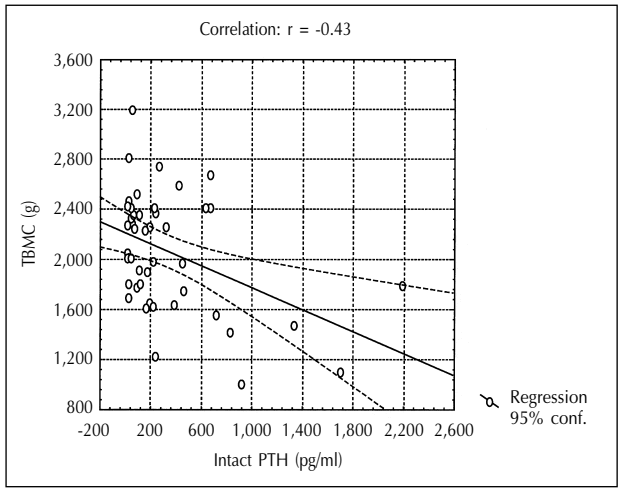

Fig. 1.—Correlation between TBMC and intact PTH in women.

Table III. Simple correlations between total bone mineral content (TBMC) and anthropometrical, corporal composition, and clinical parameters in patients of both genders

	COMT HOMBRES		COMT MUJERES	
	r	p	r	P
Age (years)	0.06	NS	-0.10	NS
Weight (kg)	0.49	0.02	0.32	0.03
Height (cm)	0.54	0.01	0.69	< 0.0001
Lean mass (kg)	0.71	< 0.001	0.34	0.02
Fat mass (kg)	0.05	NS	0.23	NS
% fat mass	-0.15	NS	0.25	NS
iPTH (pg/mL)	-0.08	NS	-0.43	< 0.01
TTD (months)	-0.12	NS	-0.25	NS

tigators have used different bone mass indexes. The parameter that DEXA measures very accurately is the bone mineral content (BMC). Another frequently used parameter is bone mineral density (BMD), which is BMC divided by the area of bone projection. Other parameters correct BMD by an estimation of bone volume (apparent bone mineral density) or by total height.

According to the specific bone mass parameter that is used as dependent variable in the correlation analysis with body composition compartments, different authors have reached different conclusions in normal people: studies using BMC find correlations with lean and fat body masses;[18,19] studies using BMD find better correlations with lean body mass;[20] finally, those using BMD corrected by bone size find better correlations with fat body mass.[21]

Most of the studies that have tried to correlate bone mass with body composition have been done in pre- or postmenopausal normal women, with or without hormone replacement. In one of these studies, Khosla et al.[19], using a multivariate analysis, found in pre- and postmenopausal women with hormone replacement, both lean and fat body masses were good predictors of TBMC, taking into account age and height. In postmenopausal women without hormone replacement, only lean bone mass was an important predictor of TBMC. In women on peritoneal dialysis in our study, TBMC was correlated with height, as an anthropometrical variable, and negatively with intact PTH. When pre- and postmenopausal women were analyzed separately, TBMC was positively correlated with height and lean body mass, and negatively with intact PTH in the 30 postmenopausal women without hormone replacement, whereas in premenopausal, only height was correlated with bone mass. Our study suggests that secondary hyperparathyroidism has a greater skeletal impact in postmenopausal women. Other studies[21] have also shown that there exists a preponderance of female gender in average bone mineral content loss at the distal radius bone in patients with OCPD.

Few studies have evaluated bone mass and body composition in healthy men. In a study from Reid et al., they found that BMD in normal men was correlated with weight and lean mass but not with fat mass. In our study, we have found that in male patients on peritoneal dialysis, TBMC is exclusively correlated with lean body mass.

The importance of assessing bone mass at different sites (such as lumbar spine, hip and distal radius) lies on the fact that T score-expressed values predict the fracture risk in postmenopausal women without renal failure. In the chronic renal failure population, the best site for performing bone mass assessments has not yet been precisely defined.[23]

In a previous study in patients on peritoneal dialysis, we did not find a relationship between the presence of bone fractures and bone mineral density measured at the hip or the lumbar spine,[24] whereas in hemodialyzed patients, Urena et al.[25] found that bone fractures were associated with time elapsed on hemodialysis and with a reduction in whole body bone mineral content expressed as a Z score.

From the present study, we conclude that, of body compartments, lean body mass is the main determinant in TBMC, especially in men and postmenopausal women. Since lean mass is an expression of muscular mass, the appropriate maintenance of the latter by means of programmed physical activity and appropriate nutrition is a desirable measure in order to maintain bone mass in patients on peritoneal dialysis. This study also highlights the importance of secondary hyperparathyroidism in reduction of the bone mineral content, especially in postmenopausal women.

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