Eklem Hastalıkları ve Cerrahisi
Joint Diseases and Related Surgery

Original Article / *Çalışma - Araştırma*

Eklem Hastalık Cerrahisi
2012;23(2):77-81

Bioelectrical impedance analysis of basal metabolic rate and body composition of patients with femoral neck fractures versus controls

Femur boyun kırıklı hastalar ile kontrollerde bazal metabolik hız ve vücut kompozisyonunun biyoelektrik impedans analizi

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Objectives: In this study, we aimed to compare basal metabolic rate and body composition in patients with femoral neck fractures and controls.

Patients and methods: Sixty-eight consecutive patients with femoral neck fractures (36 males, 32 females; mean age 73.9±7.1 years, range 65 to 93 years) and 71 controls (33 males 38 females; mean age 72.1±5.9 years; range 65 to 90 years) were prospectively analyzed. The controls were matched with the patients in terms of sex, age, and body mass index. The findings were assessed by bioelectrical impedance analysis (BIA).

Results: The phase angle, body capacitance, resistance, reactance, body cell mass, lean body mass, basal metabolic rate, and intracellular water values of the patients were found to be significantly lower, compared to the controls. Extracellular mass, fat mass, extracellular mass/body cell mass and extracellular water levels were significantly higher in the patients, compared to the controls. There was no significant difference between the patient and control group in terms of the total body weight/lean body mass ratio.

Conclusion: Although it is not clear whether these physiological changes are an exact cause of a predisposition for simple falls, the assessment of basal metabolic rate and body composition by BIA may be a useful adjunctive tool for the evaluation of physiological changes in the routine health screening of elderly people.

Key words: Adult; bioelectrical impedance analysis; body composition; elderly; femoral neck fractures.

Amaç: Bu çalışmada femur boyun kırıklı hastalarda ve kontrollerde bazal metabolik hız ve vücut kompozisyonu karşılaştırıldı.

Hastalar ve yöntemler: Altmış sekiz femur boyun kırığı olan hasta (36 erkek, 32 kadın; ort. yaş 73.9±7.1 yıl; dağılım 65-93 yıl) ve 71 kontrol (33 erkek ve 38 kadın; ort. yaş 72.1±5.9 yıl; dağılım 65-90 yıl) ileriye dönük olarak değerlendirildi. Kontroller cinsiyet, yaş ve vücut kütle indeksi olarak hastalarla eşleştirildi. Bulgular, biyoelektrik impedans analizi (BİA) yöntemi ile değerlendirildi.

Bulgular: Faz açısı, vücut kapasitansı, direnç, reaktans, vücut hücre kütlesi, yağsız vücut kütlesi, bazal metabolik hız ve hücre içi su değerleri hastalarda kontrol grubuna oranla anlamlı düzeyde düşük bulundu. Hücre dışı kütle, yağ kütlesi, hücre dışı kütle/vücut hücre kütlesi ve hücre dışı su değerleri hastalarda kontrollere oranla anlamlı düzeyde yüksek bulundu. Toplam vücut ağırlığı/yağsız vücut kütlesi oranlarında ise her iki grup arasında anlamlı bir fark gözlenmedi.

Sonuç: Bu fizyolojik değişikliklerin basit düşmeye eğilimin kesin nedeni olup olmadığı kesin olarak bilinmese de, ileri yaş kişilerin rutin sağlık tarama programlarında BİA yöntemi ile bazal metabolik hız ve vücut kompozisyonunun değerlendirilmesi, fizyolojik değişimlerin değerlendirilmesinde yararlı bir yardımcı araç olabilir.

Anahtar sözcükler: Erişkin; biyoelektrik impedans analizi; vücut kompozisyonu; ileri yaş; femur boyun kırığı.

Hip fractures often lead to impaired mobility, excess morbidity and mortality, and loss of independence.[1] Each year, more than 1.7 million patients worldwide are hospitalized and treated for a hip fracture, consuming large amounts of resources.[2] The optimal treatment method for these fractures is still controversial.[3] About 15-33% of patients die within one year after a hip fracture.[4,5]

• *Received: January 18, 2012 Accepted: April 16, 2012*
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Malnutrition is common in patients with hip fractures and affects protein and energy metabolism.[6] The mass of the human body can be partitioned into two main compartments: fat-free mass, also called lean body mass, and fat mass. The assessment and quantification of body cell mass (BCM), which is the metabolically-active component of lean body mass, is the single best predictor of a subject's nutritional status.[7] Because BCM decreases during the physiological ageing processes, it is particularly important in elderly subjects.[8]

Body composition, including body fat mass and lean body mass in hip-fractured elderly patients has been assessed by several studies, but to our knowledge, this is the first controlled report examining the basal metabolic rate and detailed body composition in patients with femoral neck fractures. We hypothesize that, because the majority of hip fractures in the elderly are due to a simple fall, the determination of basal metabolic rate and body composition are important. Bioelectrical impedance analysis (BIA) is a non-invasive, inexpensive, rapid, portable, reproducible and safe technique.[9]

The purpose of the present study was to compare basal metabolic rate and body composition as measured by BIA in patients with femoral neck fractures and controls to determine whether a physiological change is present in these patients.

PATIENTS AND METHODS

This prospective controlled study was conducted at the Department of Orthopedics and Traumatology and the Department of Biophysics at Harran University Research Hospital between October 2009 and May 2011. The local ethics committee approved the study, and informed consent was obtained from all the participants. Sixty-eight consecutive patients suffering from femoral neck fractures that were a result of a simple fall (32 females, 36 males; mean age 73.9 years; range 65 to 93 years) were included in this study. Patients with pathologic fractures, diabetes mellitus, renal disease, severe medical illness, chronic drug use which may affect the body fluid balance and a history of previous hip fracture requiring surgery with metal prosthesis were excluded from the study. The control group consisted of 21 volunteers (38 females; 33 males; mean age 72.1 years; range 65 to 90 years) who were selected from completely healthy adults. These controls were matched with regard to age, gender and body mass index (BMI). Bone mineral density (BMD) was evaluated in all patients an average of 4-6 weeks after surgery and controls by dual energy X-ray absorptiometry (DXA). T-scores of the unaffected femoral neck in patients were used for comparison.

Bioelectrical impedance analysis of patients and controls was performed using a Biodynamic 450 (Biodynamics Corp., Seattle, WA, USA) analyzer after 10 minutes of rest. In all patients, BIA was performed immediately after admission to our clinic, prior to surgery. Three hours before the measurements, the subjects did not consume any liquids or solids. The same operator performed the analysis for all subjects by placing two electrodes on the right hand and right foot of the subject in supine position. Electrodes were placed on hair-less skin of the hands and feet. The body weight of patients was measured during hospitalization using a folding stretcher and its empty weight was subtracted from the total. With the BIA, phase angle, body capacitance, resistance, reactance, BCM, extracellular mass (ECM), lean body mass, fat mass, the ECM: BCM ratio, BMI, basal metabolic rate, intracellular water, extracellular water and the total body weight: lean body mass ratio were measured, as described elsewhere.[10] In addition, a blood albumin and lymphocyte levels were measured to evaluate nutritional status in both groups.

Statistical analysis was performed with SPSS for Windows 16.0 version (SPSS®, Chicago, IL, USA) computer program. Continuous variables were expressed as mean ± standard deviation (SD). The normality of distributions was evaluated with a one-sample Kolmogorov-Smirnov test. Chi-square test and Student's t-test were used for group comparisons. For correlation analysis, a Pearson's correlation test was used. A two-tailed p value <0.05 was considered to be statistically significant.

RESULTS

There were no significant differences in age, BMI, BMD, gender (female/male ratio), blood albumin and lymphocyte levels between patients and controls (p>0.05; Table I). As can be seen in Table II, phase angle, body capacitance, resistance, reactance, BCM, lean body mass, basal metabolic rate, and intracellular water values of the patients were found to be significantly lower than those of the healthy controls. On the other hand, ECM, fat mass, the ECM/BCM ratio and extracellular water levels were significantly higher in patients than in controls (p<0.05). With respect to the total body weight: lean body mass ratio, there was no significant difference between patients and controls (p>0.05). Furthermore, BCM was highly correlated with lean body mass (r=0.657, p<0.001), and BMI was moderately correlated with fat mass (r=0.357, p=0.003) in patients (Figure 1a, b). There was no significant difference in bone mineral density between patients and controls (p>0.05).

TABLE I

Demographic, hematologic and bone mineral density results of patients and controls

	Patients		Controls		*p*
	n	Mean±SD	n	Mean±SD	
Age (year)		73.9±7.1		72.1±5.9	0.107
Body mass index (kg/m^2)		30.7±3.2		29.4 ±2.6	0.671
Gender					
Female	32		38		0.554
Male	36		33		0.554
Bone mineral density		-0.9±1.6		-0.7±1.6	0.303
Albumin (gr/dl)		3.4±0.9		3.6±1.0	0.167
Lymphocyte		1.7±0.8		1.5±0.9	0.282

SD: Standard deviation.

DISCUSSION

This is the first controlled study in the English literature to use BIA to determine basal metabolic rate and detailed body composition in femoral neck-fractured elderly patients. The study found basal metabolic rate, phase angle, body capacitance, resistance, reactance, intracellular water, BCM (the single best predictor of nutritional status) and lean body mass (which includes skeletal muscle) to be significantly lower, and fat mass and extracellular water to be significantly higher, in patients with femoral neck fractures due to simple fall as compared to controls.

Elderly patients with hip fractures are often malnourished at the time of their fracture and their nutritional status may hinder recovery.[11] As a result, malnutrition, body composition changes and immobility are associated with mortality and postoperative complications such as delayed wound healing, infections and decubitus ulcers in patients with hip fractures.[12] Duncan et al.[13] showed that by improving a patients' nutritional status, the intake of energy and protein during hospitalization could increase and the mortality rate could decrease. Hip fracture patients require more energy, essential nutrients and fluid intake after the accident to account for surgery and rehabilitation.[6] Hoekstra et al.[14] found that although a multidisciplinary nutritional care strategy increases the intake of energy, protein, vitamin D, zinc and calcium in the immediate postoperative period compared to standard nutritional care, the multidisciplinary intervention could not prevent decline in quality of life or nutritional status. A change in body liquid mass may cause various disorders and

TABLE II

Basal metabolic rate and body composition parameters in patients and controls

	Patients	Controls	t value	*p*
	Mean±SD	Mean±SD		
Phase angle (degree)	6.0±2.2	7.2±1.7	-3.650	<0.001
Body capacitance (pF)	649.8±230.7	773.4±305.7	-2.683	0.008
Resistance (ohm)	590.7±107.1	654.3±145.4	-2.925	0.004
Reactance (ohm)	68.1±19.3	74.7±17.2	-2.133	0.035
Body cell mass (kg)	20.3±5.7	24.2±7.4	-3.437	0.001
Extracellular mass (kg)	23.7±6.0	20.5±5.8	3.181	0.002
Lean body mass (kg)	44.0±8.0	47.2±9.8	-2.061	0.041
Fat mass (kg)	31.1±9.6	27.8±7.0	2.301	0.023
ECM/BCM (kg)	1.3±0.5	0.9±0.3	4.690	<0.001
Body mass index (kg/m^2)	25.9±4.4	27.0±4.9	-1.434	0.154
Basal metabolic rate (calorie)	1373.2±250.2	1490.8±281.9	-2.595	0.010
Intracellular water (liter)	17.5±5.1	20.7±5.9	-3.375	0.001
Extracellular water (liter)	14.7±4.8	12.2±4.7	3.046	0.003
TBW/lean body mass (liter/kg)	73.4±2.8	74.3±3.8	-1.604	0.111

SD: Standard deviation; pF: Pico farat; kg: kilogram; ECM: Extracellular mass; BCM: Body cell mass; TBW: Total body weight.

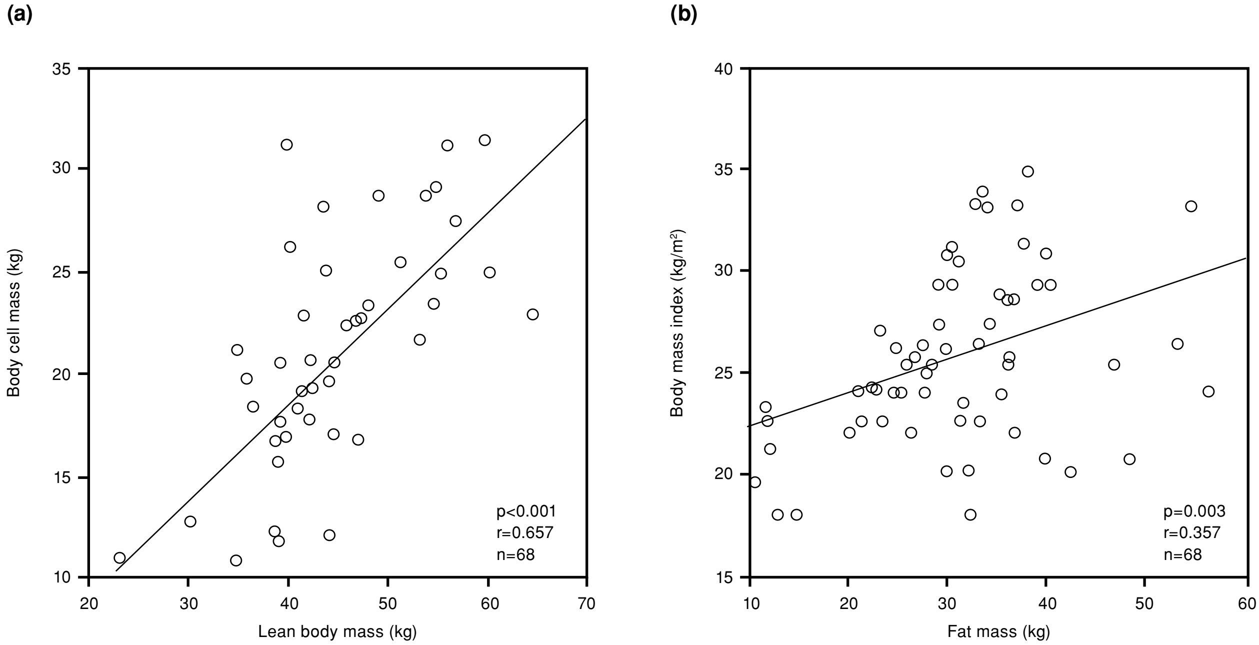

Figure 1. (a) The correlation between body cell mass and lean body mass, and **(b)** between body mass index and fat mass.

reduced intracellular liquid intake may alter the osmotic structure of cells.[10] Nutritional status and body composition have been evaluated using various methods in elderly people.[12,15]

Bioelectrical impedance analysis has been well-suited to determine body composition in several studies because its relatively inexpensive equipment is portable and can be used bedside, is noninvasive, simple, fast and easy to operate, and measurement has little inter-observer error and requires minimal cooperation from the subject.[9,10] This technique is based on the principle that various tissues have different conductive and resistive properties at different frequencies of an electrical current. Several authors have stated that BIA is capable of performing rapid upright electrical measurements and body weight.[16] Tan et al.[17] reported the characteristics of BIA for rapid whole-body and segmental resistance and reactance measurements. Resistance is related to body water because more water is stored in lean body mass. Therefore, a higher value indicates healthier lean tissue. Reactance is the ability of cells to store energy (related to body capacitance). In the present study, increases in fat mass and decreases in lean body mass may be related to decreased body resistance in patients with femoral neck fractures. Abnormal tissue conductivity may be correlated with changes in lean body mass and fat mass. The relationship between body composition changes in elderly people and the tendency for a simple fall is an unknown area that needs further investigation. Our findings suggest that decreases in lean body mass, which includes skeletal muscle, may be correlated with simple falls in elderly people. It should be noted that BIA measurements could be affected by both BMI and age. Therefore, in this study, we matched controls with regard to BMI and age.

Body liquid volume is important in elderly people, as energy and oxygen transmission to skeletal muscle and vital organs such as the brain, heart and lungs is carried out through body liquids. In this study, we found decreased intracellular water and increased extracellular water in patients compared to controls. This may cause weakness in skeletal muscle and difficulty balancing. In addition, phase angles were found to be decreased, which may have resulted from the deterioration of cellular integrity. This finding is consistent with our results that reflect decreased intracellular water and increased extracellular water in elderly patients.

Body cell mass, which consists of skeletal muscle, is the metabolically active component of lean body mass.[7] Wang et al.[8] stated that there was a significant correlation between BCM and lean body mass. Likewise, in this study we found a significant correlation between BCM and lean body mass as well as between BMI and fat mass. These findings demonstrated decreased skeletal muscle mass and increased fat mass in patients.

Basal metabolic rate decreases with increasing age, and an increase in sympathetic nervous system activity has also been shown to increase basal metabolic rate.[18]

In the present study, there was a significant decrease in the basal metabolic rate in patients compared to controls. We think that in addition to ageing, decreasing sympathetic nervous system activity also influences this result. Physical exercise may help improve the basal metabolic rate in these patients.

Our study has several limitations. First, nutritional status and liquid consumption can affect the measurement results of BIA. Second, reliability of the test was not carried out for the study. Third, measurement of body composition was performed only by BIA; other methods were not used to compare the results.

In conclusion, obtained results indicate that basal metabolic rate and skeletal muscle mass, that allows the movement of the locomotor system, were decreased and fat mass was increased in the patient group as compared to controls. To reduce the cost of medical treatment and provide a healthier life, the use of BIA for routine screening would be helpful in the management of elderly people. Further controlled clinical studies with larger sample sizes are needed to elucidate whether these alterations are consistent and clinically relevant.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

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