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Possibilities of use bioelectrical impedance analysis as measuring technique in prevention of osteoporosis

ERNA DAVIDOVIĆ CVETKO[1]
INES DRENJANČEVIĆ[2]
NEBOJŠA NEŠIĆ[1]
JASMINKA MILAS AHIĆ[3]

[1] Department of Physiotherapy,
College of Applied Sciences Lavoslav Ružička
in Vukovar, Vukovar, Croatia

[2] Department of Physiology and Immunology,
School of Medicine of the University
„Josip Juraj Strossmayer" of Osijek,
Osijek, Croatia

[3] Internal Medicine Clinic,
University Hospital Centre of Osijek
Osijek, Croatia

Correspondence:
Erna Davidović Cvetko
Department of Physiotherapy
College of Applied Sciences Lavoslav Ružička in
Vukovar, Vukovar, Croatia
E-mail: erna@vevu.hr

Abbreviations:
B.M.I. – body mass index (result of BIA)
BIA – bioelectrical impendance analysis
BMC – bone mineral content (result of DXA)
BMD – bone mineral density (result of DXA)
D.F.TOTAL – dual femur total
DXA – dual energy x-ray absorptiometry
L.B.M. – lean body mass (result of BIA)
L1-L4 -L1-L4 – spine
M.B.F. – mass of body fat (result of BIA)
S.L.M. – soft lean mass (result of BIA)

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Abstract

Background and Purpose: *Bioelectrical impendance analysis (BIA) and dual energy X-ray absorptiometry (DXA) are the two most common methods used for body composition analysis. The aim of this study was to investigate if there is a correlation between results of body analysis by BIA and results of DXA measurements at usual sites for diagnosis of osteoporosis. If the correlation is found than it could mean that BIA might be used to point the need for extra DXA measurements, and earlier diagnosis of osteoporosis. MATERIAL AND METHODS: 27 young adults (11 males and 16 females) aged 19-23 years were measured by BIA instrument for body composition analysis, and by DXA instrument for BMD and BMC at the L1-L4 vertebrae of the lumbar spine postanteriorly and the proximal femur („hip"). Correlation coefficients were calculated to examine linear relationship of results of two methods.*

Results: *Mineral content obtained by BIA correlates with BMC (result of DXA) at all three measured sites. When analyzed by sex, correlation was found only among female subjects, while in males there was no correlation. Correlation of other results of BIA and BMD or BMC (DXA) showed similar situation. T-scores correlated positively with results of BIA within the female subgroup of the sample.*

Conclusions: *According to obtained results we cannot conclude that results of BIA body composition analysis could be indicative for problems in bone metabolism, or state of bone density and bone mineral content, although some correlations are present.*

INTRODUCTION

Osteoporosis, a state of low bone mass and increased risk of fracture *(1)* is a problem of older adults that affects society through many aspects; starting with affecting the quality of life of people with osteoporosis *(2, 3)*, and all the way to economic aspects considering working disabilities and expenses of special health care *(4, 5)*. Considering this there is a need for developing new ways of prevention of osteoporosis as well as for early detection of potential problems. Usual method for diagnosis of osteoporosis is dual energy x-ray absorptiometry (DXA), which is used to measure bone mineral content and bone mineral density usually at two sites: the first four vertebrae of the lumbar spine posteroanteriorly, and the proximal femur („hip"), including the femoral

neck and the trochanteric areas and total hip *(6, 7)*. Osteoporosis is defined if bone mineral density (BMD) values at this sites are at least 2,5 SD below the population average in young healthy individuals *(1)*. DXA is using x-rays at two energy levels and subtracting the differences in absorption by soft tissue and bone mineral content; bone mineral content is determined *(7)*. It is considered „gold" standard method in osteoporosis diagnosis, and also in body composition analysis *(8)*. In last decades other methods were developed in the area of body composition analysis and became more used than DXA because of their simplicity and low costs. Among them Bioelectrical impendance analysis(BIA) is one of most commonly used *(8)*. This method is based on the conduction of applied electrical current to organism, and differences in conduction of different types of body components *(9)*. It is in wide use in analysis of body composition, which is very important for health and wellbeing. The results of Sierpowska *et al. (10)* suggest that electrical and dielectric properties may provide information on mechanical status of trabecular bone, because they depend on bone density. We were interested to find out if this density and mineral content of bones in lumbar spine and hips have influence on results of impendance for the whole body. The aim of this study was to investigate if there is a correlation between results of body analysis by BIA and results of DXA measurements at usual sites for diagnosis of osteoporosis. If the correlation is found than it could mean that BIA might be used to point the need for extra DXA measurements, and earlier diagnosis of osteoporosis.

MATERIALS AND METHODS

Twenty seven young and healthy students (11 men and 16 women) aged 19-23 years participated in this study, which was approved by the ethic committee at Faculty of medicine in Osijek, Croatia. All subjects were healthy, not regular consumer of any drugs or supplements in last year. For female subjects additional inclusion criteria was regular menstrual cycle, with absence of hormonal disbalance, and no consumption of hormonal therapy within the last year.

All subjects were measured in the morning after overnight fasting, by BIA instrument GAIA 359 (Jawon Medical, Korea) for body composition analysis, according to the manufacturer's instructions. The subject stands with her or his soles in contact with the foot electrodes and grabs the hand electrodes. With these electrodes impendance was measured and in the BIA software body components analysis was calculated. Results of BIA that were examined in this study include mineral mass, protein mass, mass of body fat, soft lean mass and lean body mass.

Bone mineral density (BMD) and bone mineral content (BMC) was measured by DXA (Lunar Prodigy 64575 G.E.S. S.A) at the L1-L4 vertebrae of the lumbar spine posteroanteriorly, and the proximal femur („hip"), including the femoral neck and the trochanteric areas and total hip. Three points results were obtained from this measurement: L1-L4 spine, dual femur total and neck mean. In

TABLE 1

Results of BIA and DXA that meet the requirements for normal distribution.

	Whole sample, n=27				Men, n=11				Women, n=16			
	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum
D.F.TOTAL BMC	38.304	8.5208	25.350	57.970	44.582	8.1499	27.560	57.970	33.372	4.8377	25.350	42.450
D.F.TOTAL BMD	1.132	0.1564	0.812	1.499	1.189	0.2020	0.812	1.499	1.087	0.09434	0.962	1.251
L1-L4 BMC	74.914	13.4250	46.550	100.100	78.020	12.2473	59.620	98.920	72.473	14.2398	46.550	100.100
L1-L4 BMD	1.286	0.1273	0.963	1.484	1.234	0.1338	0.963	1.439	1.327	0.1097	1.170	1.484
NECK MEAN BMC	5.813	1.0923	4.040	8.200	6.540	1.0690	4.100	8.200	5.241	0.7243	4.040	6.380
NECK MEAN BMD	1.149	0.1620	0.786	1.474	1.170	0.1882	0.786	1.474	1.132	0.1432	0.918	1.382
L.B.M.	53.020	13.3018	25.900	82.200	62.70	14.2501	25.900	82.200	45.443	5.4709	35.000	53.000
Minerals	4.096	0.8825	2.600	6.300	4.809	0.7476	3.900	6.300	3.536	0.4893	2.600	4.200
S.L.M.	50.536	11.4714	32.400	76.300	61.518	6.8078	52.300	76.300	41.907	5.0051	32.400	48.800

D.F.TOTAL BMC =dual femur total bone mineral content (DXA)
D.F.TOTAL BMD =dual femur total bone mineral density (DXA)
L1-L4 BMC =L1-L4 spine bone mineral content (DXA)
L1-L4 BMD =L1-L4 spine bone mineral density (DXA)
NECK MEAN BMC =neck mean bone mineral content (DXA)
NECK MEAN BMD =neck mean bone mineral density (DXA)
L.B.M. =lean body mass (BIA)
Minerals (BIA)
S.L.M. =soft lean mass (BIA)

TABLE 2

T-scores of femur and spine assessed by DXA.

	Whole sample, n=27			Men, n=11			Women, n=16		
	Median	Minimum	Maximum	Median	Minimum	Maximum	Median	Minimum	Maximum
D.F.TOTAL T-SCORE	0.700	-2.000	2.800	0.900	-2.000	2.800	0.500	-0.400	1.900
L1-L4 T-SCORE	0.600	-2.100	2.500	0.100	-2.100	1.800	0.850	-0.100	2.500
NECK MEAN T-SCORE	0.600	-2.200	3.100	0.900	-2.200	3.100	0.450	-0.900	2.100

D.F.TOTAL T-SCORE =dual femur total T-score
L1-L4 T-SCORE =L1-L4 spine T-score
NECK MEAN T-SCORE =neck mean T-score

TABLE 3

Pearson's correlation coefficients for mineral content (result of BIA) and results for BMD and BMC from DXA.

		Minerals (result of BIA)		
		Whole sample	Men	Women
D.F.TOTAL BMC	Correlation Coefficient	0.755	0.427	0.726
	Significance Level P	<0.001	0.190	0.003
	n	27	11	16
D.F.TOTAL BMD	Correlation Coefficient	0.474	0.288	0.565
	Significance Level P	0.017	0.390	0.035
	n	27	11	16
L1-L4 BMC	Correlation Coefficient	0.587	0.615	0.739
	Significance Level P	0.002	0.044	0.003
	n	27	11	16
L1-L4 BMD	Correlation Coefficient	0.029	0.445	0.522
	Significance Level P	0.889	0.170	0.055
	n	27	11	16
NECK MEAN BMC	Correlation Coefficient	0.672	0.217	0.785
	Significance Level P	<0.001	0.522	0.001
	n	27	11	16
NECK MEAN BMD	Correlation Coefficient	0.366	0.222	0.709
	Significance Level P	0.072	0.511	0.005
	n	27	11	16

D.F.TOTAL BMC = dual femur total bone mineral content (DXA)
D.F.TOTAL BMD = dual femur total bone mineral density (DXA)
L1-L4 BMC = L1-L4 spine bone mineral content (DXA)
L1-L4 BMD = L1-L4 spine bone mineral density (DXA)
NECK MEAN BMC = neck mean bone mineral content (DXA)
NECK MEAN BMD = neck mean bone mineral density (DXA)

these points BMD, BMC and T-scores were measured. All the scanning and analyses were done by the same operator. The scanner was calibrated daily, its performance being monitored using the quality assurance protocol.

Statistical analysis was performed using statistical software MedCalc 10.2.2.0. For testing normal distribution D'Agostino-Pearson test was used. Descriptive data for variables with normal distribution were presented with mean, standard deviation and range. Pearson's correlation coefficients were calculated and tested for significance of linear relationship among continuous variables with normal distribution, and for not normally distributed Spearman's coefficients were calculated. Significance level was set at $p<0,05$.

RESULTS

Results of BIA and DXA measurements for normally distributed variables are presented in Table 1. Mean values

TABLE 4

Pearson's correlation coefficients for SLM and LBM (results of BIA) and results for BMD and BMC from DXA.

		S.L.M. (BIA)			L.B.M. (BIA)		
		Whole sample	Men	Women	Whole sample	Men	Women
D.F.TOTAL BMC	Correlation Coefficient	0.755	0.310	0.780	0.526	-0.022	0.779
	Significance Level P	<0.001	0.354	0.001	0.007	0.949	0.001
	n	27	11	16	27	11	16
D.F.TOTAL BMD	Correlation Coefficient	0.418	0.153	0.593	0.257	-0.066	0.593
	Significance Level P	0.038	0.653	0.025	0.215	0.847	0.025
	n	27	11	16	27	11	16
L1-L4 BMC	Correlation Coefficient	0.541	0.720	0.785	0.412	0.219	0.785
	Significance Level P	0.005	0.012	0.001	0.041	0.518	0.001
	n	27	11	16	27	11	16
L1-L4 BMD	Correlation Coefficient	-0.095	0.475	0.503	-0.168	-0.048	0.507
	Significance Level P	0.651	0.140	0.067	0.421	0.888	0.064
	n	27	11	16	27	11	16
NECK MEAN BMC	Correlation Coefficient	0.709	0.254	0.805	0.455	-0.134	0.806
	Significance Level P	<0.001	0.450	0.001	0.022	0.694	<0.001
	n	27	11	16	27	11	16
NECK MEAN BMD	Correlation Coefficient	0.276	0.118	0.668	0.178	-0.062	0.675
	Significance Level P	0.182	0.730	0.009	0.395	0.855	0.008
	n	27	11	16	27	11	16

S.L.M. =soft lean mass
L.B.M. =lean body mass

of T-scores with ranges are presented in Table 2. T-scores varied for results in all 3 sites, but in range of normal, healthy bones. Only one male subject was with T-score below -1, pointing osteopenia, all others males and females had T-scores pointing healthy bones. Median height for men was 180 cm (range 175-192 cm), and for women 170 cm (range 149-180 cm). Weight for men was median 79 kg (range 67- 110.8 kg), while median weight for women was 61.7 kg (range 44.1-74 kg). Body mass index (BMI) in the group varied from 18.6 to 34.6, with median value of 22.3. These values suggest that most of subjects are in area of normal weight according to WHO *(11)*. For women median BMI was 22.15, with range 18.6-23.8, and for men median BMI was 22.9, with range 20.7-34.6. Fatness as one of commonly used obesity index, calculated as current weight-standard weight/standard weight*100 were for women median 0.7 (min -15.3, max 8.4), and for men median 4.1 (min -5.8, max 57.2). Both indexes show that women were underweight to normal, and men normal to obese. Most of subjects were normal weight, except one male subject who was obese, and two females who were underweight.

Pearson's Correlation coefficients for mineral content determined by BIA and results for BMD and BMC (DXA) in all three sites for all participants and analyzed by sex are presented in Table 3.

We found that there is linear correlation of mineral content and BMC in all three sites in whole sample, but when analyzed for sex different results were obtained; showing no correlation of mineral content and BMC in dual femur total and neck mean for male sex, while for female subjects correlation was obtained in all three sites. Similar results were obtained for correlations of mineral content and BMD in measured sites. Correlation of other results of BIA and BMD or BMC (DXA) show similar situation. Correlation is present in female subjects, and no correlation is found in men. These results are presented in Table 4.

For variables that do not meet parametric distribution Spearman's coefficients of correlation were calculated. Results presented in Table 5 show that there was no correlation between T-scores in measured sites and results of BIA, except for dual femur total and neck mean T-scores with BMI and MBF (mass of body fat). When analyzed for sex, in males there was no correlation, but for females correlation was obtained for T-score in neck mean and results of BIA.

DISCUSSION

Comparison of BIA and DXA is described in numerous papers, but it is mostly comparison of values for same variables determined by different methods to establish accu-

TABLE 5

Spearman's correlation coefficients between T-scores and results of BIA (BMI, MBF, minerals and weight).

		NECK MEAN T-SCORE			L1-L4 T-SCORE			D.F. TOTAL T-SCORE		
		Whole sample	Men	Women	Whole sample	Men	Women	Whole sample	Men	Women
B.M.I.	Correlation Coefficient	0.485	0.345	0.564	0.172	0.555	0.291	0.442	0.427	0.479
	Significance Level P	0.018	0.275	0.042	0.399	0.079	0.294	0.031	0.177	0.084
	n	27	11	16	27	11	16	27	11	16
M.B.F.	Correlation Coefficient	0.480	0.364	0.646	0.395	0.309	0.474	0.476	0.427	0.556
	Significance Level P	0.019	0.250	0.020	0.053	0.328	0.087	0.020	0.177	0.045
	n	27	11	16	27	11	16	27	11	16
Minerals	Correlation Coefficient	0.320	0.092	0.738	-0.122	0.500	0.494	0.270	0.225	0.662
	Significance Level P	0.117	0.772	0.008	0.552	0.114	0.075	0.186	0.477	0.017
	n	27	11	16	27	11	16	27	11	16
Weight	Correlation Coefficient	0.308	0.091	0.707	-0.109	0.464	0.511	0.273	0.209	0.676
	Significance Level P	0.131	0.774	0.011	0.593	0.143	0.065	0.181	0.508	0.015
	n	27	11	16	27	11	16	27	11	16

D.F. TOTAL T-SCORE = dual femur total T-score
B.M.I. =body mass index
M.B.F. =mass body fat

racy and precision of method *(12-16).*Results of these validations are usually confirmation of BIA method in body composition analysis *(17-22)*. Idea of this investigation was to find out if there is correlation between parameters that indicate bone health and results of body analysis by BIA. If it existed it would be very useful because it would mean that BIA could be used as cheaper and more available approach to take control of the bone health as well as health in general. Results that are presented here show correlations between results of mineral content determined by BIA and BMC in all three sites that are usually used in osteoporosis diagnosis. Our results are in compliance with results of Miyatake *et al. (23)* who obtained correlation between mineral content measured by BIA and by DXA at significant level (r=0,759, p=0,001). We also found correlation between mineral content (BIA) and BMD (DXA) in dual femur and neck mean, but no in L1-L4 spine. Results of BIA regarding soft lean mass and lean body mass correlated similar with BMC and BMD (DXA) like mineral content (BIA). We found no similar investigations in literature that could be used for comparison to our results. We also tried to correlate T-scores with different results of BIA, but only Spearman's correlation between neck mean T-score and mineral content, MBF and BMI was found in female group, while L1-L4 spine and dual femur total T-score did not correlate with results of BIA in any group. This research revealed interesting results that correlations are mostly obtained in female group, while in group of male subjects there were fewer correlations between results of BIA and DXA. This could be explained with differences in group characteristics. While female group is compact, with small differences in results of body composition analysis, and all subjects in category of normal body weight or slightly under normal weight according to BMI results (vary from 18,6 to 23,8), in male group there are more differences in BMI, with results varying from BMI values of 20,7 to 34,6, from normal to obese weight. According to presented results we cannot conclude that results of BIA body composition analysis could be indicative for problems in bone metabolism, or state of bone density and bone mineral content, although some correlations are present. These results could be helpful for potential investigation of correlation between results of examined methods. In future larger samples could be more useful, for comparison of differences in correlation with differences in sex, or in BMI.

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