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The variability of body composition characteristics in pre- and postmenopausal women from Slovakia

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Abstract: Various changes in body composition and body fat distribution are accompaniments of biological ageing, presented mostly in the middle age and significantly notable during the menopause transition.
This study aimed to examine the effect of menopausal status on body composition characteristics in 368 apparently healthy women aged 38–61 years. Bioelectrical parameters were measured with a bioimpedance monofrequency analyser (BIA 101) and bioelectric impedance vector analysis (BIVA) was used to analyse tissue electric properties. Data dealing with menopausal status and symptoms as well as life style variables were obtained by the Menopause specific questionnaire.
Statistical analysis adjusted for age did not show differences either in the body composition characteristics or in the nutrition and obesity indices between pre– and post–menopausal women. Regression analyses pointed on statistically significant effect ($p<0.05$) of physical exercise on Xc (B=2.353), FM % (B=–1.746) and MM % (B=1.201), of hypertension on R (B=–22.381), FM % (B=4.468), MM % (B=–2.306), of smoking on Xc (B=1.835), FM % (B=–1.227), MM % (B=0.767), of muscle and joint ache on the FM % (B=1.923) and on MM % (B=–1.061). The age had impact on Xc (B=–13.468) and on the phase angle (B=–1.320).
To conclude, in our study group of pre- and postmenopausal Slovak women, age, health and life style factors seem to have more important effect on the body composition characteristics than menopausal status alone.

Key words: bioelectric impedance, resistance, reactance, fat mass index, menopause

Introduction

The body composition is changing during the whole human life and is affected by numerous covariate factors. The major impact on the body composition has ageing, gender and health status. In women's life, menopausal transition is also significantly associated with deleterious changes in body composition,

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weight status and body fat distribution (Toth et al. 2000, Kirchengast 2004). Particularly, the weight gain, increase in fat mass, central adiposity and reduction of fat-free mass were observed in various longitudinal or cross-sectional studies of women (Toth et al. 2000, Kirchengast 2004, Ho et al. 2010). After the menopause, fat distribution in women become more central, android and visceral (Svendsen et al. 1995; Trémollieres et al. 1996; Kanaley et al. 2001). Other studies showed that shifting of fat from peripheral subcutaneous level to intra-abdominal level is not influenced by the menopause status, but due to ageing and age-related decrease in sex steroid hormones associated with menopause (Shimokata 1989, Haarbo et al. 1991). In the study of Kanaley et al. (2001), the physical activity was significant predictor of percent visceral fat responsible for greater abdominal fat in postmenopausal women. Even if the women body fat distribution changes are caused by menopause, age or physical activity, the higher values of fat mass remain to be risk factor for hypertension, diabetes, cardiovascular diseases and increased risk of premature death.

To measure underlying changes in body composition, many authors consider only basic anthropometric values as weight, waist circumference or body mass index (BMI). Some researchers do no regard the BMI as adequate and sensitive value because the index does not actually measure percentage of body fat (Heymsfiels and Matthews 1994, Guo et al. 1999, Wells 2000). Instead, variables of body composition are considered as better predictors. Moreover, Van Itallie et al. (1990) and Kyle et al. (2003) found that fat free mass and fat mass indices standardized by the body height are even more accurate than the fat or fat free mass. For studying nutritional status, body cell mass index (BCMI) seems to sensitive predictor and could detect malnutrition also in subjects with normal or high BMI (Talluri et al. 2003).

The primary purpose of this study was to examine the effect of menopausal status on body composition characteristics, to analyse mean values of obesity and nutrition indices and to find major confounders influencing the body impedance parameters in Slovak midlife women.

Subjects and methods

Sample

A total of 368 women, ranging between 38 and 61 years of age, were investigated. Subjects were recruited from different localities in the western, southern and middle parts of Slovakia, via cooperation with local medical doctors. The women were interviewed during their routine medical checkups and investigated with respect to their health, anthropometrical and lifestyle aspects. Only apparently healthy women and those who signed "Informed Consent" were considered for the purpose of the study. The participants completed the Menopause-specific questionnaire, designed by Kaczmarek (2005) and validated in Polish studies. This included questions regarding socio-demographic information, lifestyle factors, reproductive-history aspects, health status and menopausal complaints. The women were divided into two groups according to their menopausal status as pre- and postmenopausal by the definition of Kaczmarek (2007) and WHO (1996). Women were considered post-menopausal if they reported 12 consecutive months of amenorrhoea for which there were no other obvious pathological or physiological cause.

Anthropometric and health status analyses

All anthropometrical parameters were measured by professional anthropologists and the same instruments were used throughout the study. Anthropometric measurements were taken using the standard anthropometric techniques. Values of BMI below 24.9 kg/m^2 and values of waist to hip ratio (WHR) below 0.80 were considered as optimal. Masked insufficiency was calculated as BMI>25.00 kg/m^2 together with BCMI<8.00 kg/m^2. Masked obesity was defined as BMI<25.00 kg/m^2 together with fat mass percentage, FM%>30.00, following Fukuoka et al. (2012). Women were diagnosed as hypertensive if the hypertension was mentioned in their anamnesis or detected by systolic BP over 140 mmHg and/or diastolic BP≥90 mmHg. We have considered two categories of smoking variable (never and occasionally/regularly) and physical performance (no excise and occasionally/regularly). From the most frequent menopausal symptoms the following were considered for statistical analysis: hot flushes, night sweats, depression and muscle and joint ache.

Bioelectric impedance analysis (BIA)

Body composition variables were obtained using a bioelectric impedance analyzer (BIA 101, Akern S.r.l.) at a signal frequency of 50 kHz, with constant excitation current at 800 μA and four-electrode arrangement. The BIA measurements were carried out in the morning after overnight fasting and at least 12 hours after physical training. Detailed variables of body composition were obtained by the software Bodygram programme (Version 1.21, Akern S.r.l). Reference values were used for the age and sex specific group given by the programme (Talluri 1998).

Fat mass index and fat free mass index were calculated by Van Itallie et al. (1990) and categorisations of FM, FMI and FFMI for corresponding BMI values were done by Kyle et al. (2003).

Bioelectric impedance vector analysis (BIVA)

The BIVA method was used to allow graphic comparison of variability in the corresponding groups. It presents the 95% probability confidence ellipses and mean impedance vectors with statistic evaluation by Hotelling T^2-test (Piccoli et al. 2002). Main variables of the impedance are resistance (R) and reactance (Xc) across ionic solutions of soft tissue interface and cell membranes. The R and Xc were standardized by subject's height in metres (R/H and Xc/H), to eliminate the effect of conductor length on the bioelectrical parameters, in order to define the impedance vectors.

Statistical analysis

The normality assumption hypothesis was tested by the one-sample Kolmogorov-Smirnov test, and simple comparison of the data between the subgroups was analyzed using the Mann-Whitney U-test, used for data not normally distributed while the Independent Samples T-test was utilized for data with a normal distribution. Differences in the anthropometric and body composition characteristics, between premenopausal and postmenopausal women were tested using Univariate analysis of variance, with age as the covariate. A multiple linear regression model (method Enter) was used to evaluate the simultaneous contributions of different variables on body composition parameters. The values not normally distributed were transformed by logarithm. Statistical analysis was performed using SPSS for Windows (Version 17.0, Chicago, IL) and data were expressed as mean ± SD and a *p*-value less than 0.05 was considered statistically significant.

Results

Table 1 shows basic anthropometric parameters in pre- and postmenopausal women. Mean values of studied variables, except for the body height, were higher in the group of post-menopausal women. After adjustment for age, the differences were not statistically significant ($p>0.05$). The same table presents also indices describing the nutritional and health status of studied groups. Higher mean values of BMI, WHR, FMI and FFMI in postmenopausal group than in premenopausal women reached again no statistical significance after controlling for age. Thus, the difference in the mean values are not affected by the menopausal status.

Based on combined values of the BCMI and BMI indices we have identified 43 (19.4%) premenopausal and 42 (28.8%) postmenopausal women with masked insufficiency, respectively. On the other side, the combination of the BMI and FM (%) values showed masked obesity in 57 (25.7%) premenopausal and 30 (20.6%) postmenopausal women, respectively.

The mean values of bioelectric impedance variables are shown in the Table 2. Two groups of women differed significantly in percentage of TBW, ECW, ICW, FM, FFM, MM and absolute amount of FM (kg). However after adjustment for age, no significant differences were re-

Table 1. Anthropometric characteristic, obesity and nutrition indices in pre- and post-menopausal Slovak women

Variable	Pre-menopausal n=222	Post-menopausal n=146	*p*	*p**
Age (y)	45.55 ± 4.01	53.09 ±4.19	<0.001	
Height (cm)	164.31 ± 5.90	162.649 ±5.49	0.006	ns
Weight (kg)	70.73 ± 14.15	73.219 ±14.46	ns	ns
Waist circum. (cm)	81.93 ± 13.68	87.459 ±12.82	<0.001	ns
Hip circum. (cm)	102.11 ± 10.08	104.63 ±9.92	0.018	ns
BMI (kg/m^2)	26.19 ± 5.11	27.64 ± 5.00	0.001	ns
WHR	0.80 ± 0.08	0.83 ± 0.07	<0.001	ns
FMI	9.74 ± 4.12	10.95 ± 4.11	0.006	ns
FFMI	16.45 ± 1.23	16.69 ± 1.15	0.007	ns
BCMI (kg/m^2)	7.36 ±0.74	7.42 ± 0.68	ns	ns

Notes: FMI – fat mass index, FFMI – fat free mass index, BMI – body mass index, WHR – waist to hip ratio, BCMI – body cell mass index, * – adjusted for age, ns – the difference was not statistically significant

Table 2. Body composition characteristics in pre- and post-menopausal Slovak women

Variable	Pre-menopausal n=222	Post-menopausal n=146	*p*	*p**
R (ohm)	554.18 ± 67.54	544.66 ± 65.50	ns	ns
Xc (ohm)	63.05 ±10.23	61.64 ± 9.84	ns	ns
PA	6.50 ±0.89	6.46 ± 0.82	ns	ns
Na/K	0.92 ±0.12	0.90 ± 0.12	ns	ns
BCM (kg)	21.03 ±2.43	20.81 ± 2.25	ns	ns
BCM (%)	47.27 ±1.97	47.07 ± 1.92	ns	ns
TBW (l)	34.46 ±4.31	34.54 ± 4.21	ns	ns
TBW (%)	49.51 ±5.01	47.95 ± 4.97	0.004	ns
ECW (l)	15.27 ±2.49	15.55 ± 2.51	ns	ns
ECW (%)	44.19 ±2.75	44.90 ± 2.70	0.015	ns
ICW (l)	19.19 ±2.21	18.99 ± 2.06	ns	ns
ICW (%)	55.82 ±2.76	55.10 ± 2.70	0.014	ns
FM (kg)	26.25 ±10.93	29.00 ± 11.20	0.008	ns
FM (%)	35.76 ±8.09	38.29 ±8.01	0.003	ns
FFM (kg)	44.48 ±4.61	44.21 ± 4.45	ns	ns
FFM (%)	64.24 ±8.09	61.71 ± 8.01	0.003	ns
MM (kg)	26.20 ±3.02	25.98 ± 2.83	ns	ns
MM (%)	37.77 ±4.69	36.22 ± 4.63	0.002	ns
BMR (kcal)	1413.88 ±116.33	1400.78 ± 105.69	ns	ns

Notes: R – resistance, Xc – reactance, PA – phase angle, Na/K – sodium – potassium exchange, BCM – body cell mass, TBW – total body water, ECW – extra cellular water, ICW – intracellular water, FM – fat mass, FFM – fat free mass, MM – muscle mass, BMR – basal metabolic rate, * – adjusted for age, ns – the difference was not statistically significant

Table 3. The prevalence of considered independent variables affecting impedance and body composition parameters in Slovak women

Variable	Yes		No	
	n	%	n	%
Hypertension	131	35.6	237	64.4
Smoking	119	32.3	249	67.7
Physical activity	236	35.5	130	64.5
Depression	132	36.7	228	63.3
Hot flushes	168	53.2	191	46.8
Night sweats	171	47.6	188	52.4
Ache in muscles and joints	230	63.9	130	36.1

corded. In the same table, the main impedance characteristics (resistance, R; reactance, Xc; and phase angle, PA) also did not differ significantly between the pre- and post-menopausal women. It indicated also bioimpedance vector analysis (BIVA), standardising the resistance and reactance with the body height, as 95% confidence ellipses overlapped. The impedance vectors of these two groups

Table 4. Regression analysis of selected confounder effects on impedance and body composition parameters in Slovak women

Dependent variables	Independent variables	Unstandardized Coefficients		95% Confidence Interval for B		*p*
		B	Std. Error	Lower Bound	Upper Bound	
R (ohm)	Hypertension	–22.381	7.561	–37.254	–7.509	0.003
Xc (ohm)	Age	–13.468	5.110	–23.518	–3.418	0.009
	Physical exercises	2.353	0.823	0.735	3.971	0.004
	Smoking	1.835	0.724	0.411	3.258	0.012
PA	Age	–1.320	0.444	–2.194	–0.445	0.003
FM (%)	Physical exercises	–1.746	0.633	–2.990	–0.501	0.006
	Smoking	–1.227	0.557	–2.322	–0.132	0.028
	Muscle and joint ache	1.923	0.867	0.218	3.629	0.027
	Hypertension	4.468	0.878	2.742	6.194	<0.001
MM (%)	Physical exercises	1.201	0.369	0.476	1.926	0.001
	Smoking	0.767	0.324	0.130	1.405	0.019
	Muscle and joint ache	–1.061	0.505	–2.055	–0.068	0.036
	Hypertension	–2.306	0.511	–3.311	–1.300	<0.001

Notes: R – resistance, Xc – reactance, PA – phase angle, FM – fat mass, MM – muscle mass

did not differ significantly what was proved by the Hotelling T^2-test (T^2=0.5, F=0.3, p=0.773, Mahalanobis D=0.08) (Figure not shown).

To find out confounding factors associated with the bioelectric and body composition variables of women, we selected eight independent variables for regression analysis: age, physical exercise, smoking, hypertension and four symptoms of menopausal transition with the highest prevalence in the group: depression, hot flushes, night sweats, ache in muscles and joints. Table 3 presents the prevalence of these variables in the whole sample.

Table 4 shows results of regression analysis in the whole sample. Only independent variables with statistically significant effect (p<0.05) on the impedance parameters are displayed. Among the most frequent factors belong hypertension, smoking and physical exercises. The next figures display the whole body impedance of women with and without the above mentioned risk factors.

Figure 1 shows mean impedance vectors with 95% confidence ellipses

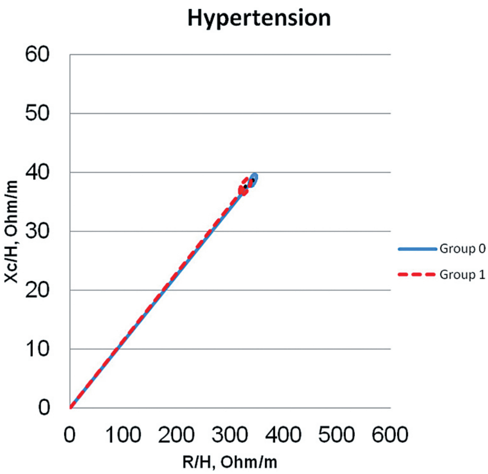

Fig. 1. Bioelectric impedance analysis of women with and without hypertension in the whole sample

Notes: Group 0 – women without hypertension, Group 1 – women with hypertension

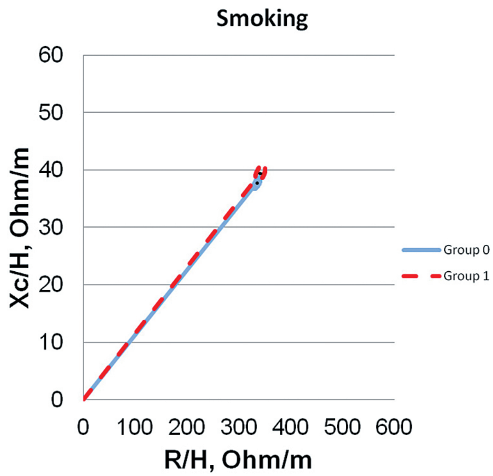

Fig. 2. Bioelectric impedance analysis of smoking and non-smoking women
Notes: Group 0 – no smoking women, Group 1 – smoking women

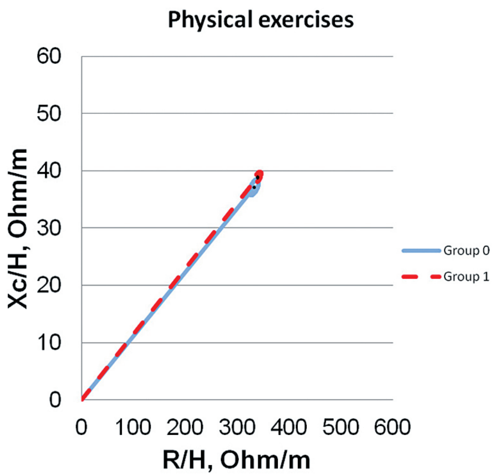

Fig. 3. Bioelectric impedance analysis of women with and without physical exercises
Notes: Group 0 – women without physical exercises, Group 1 – women providing physical exercising

of women with (group 1) and without hypertension (group 0). The size of the ellipses was influenced by the variability of the vector components and the group size. Though the ellipses partially overlapped and suggested homogeneity of two groups, the Hotelling's T^2 test showed significant difference between their bioelectrical characteristics (T=10, F=5, p=0.0074, D=0.34). The shorter vector of hypertensive women indicates larger amount of body water, what also means greater amount of fat-free mass. The higher values of phase angle could indicate more intra-cellular water and higher body cell mass, a compartment composed essentially of skeletal muscle.

Figure 2 shows mean impedance vectors with 95% confidence ellipses of non-smoking (group 0) and smoking women (group 1). The ellipses of the groups overlapped and no statistically significant differences were proved by Hotelling T^2 test (p=0.059). That means, smoking habit does not lead to differences in bioelectric properties between compared groups of women.

Figure 3 shows mean impedance vectors with 95% confidence ellipses of women with and without physical exercise. The vectors position of the women groups differed significantly as indicated by the value of the Hotelling T^2 test: T=6.1, F=3, p=0.0498, D=0.27. Physically active women had higher values of resistance, reactance, phase angle as well as longer impedance vector than those physically inactive.

Discussion

The results of the present study showed that menopausal status alone did not cause significant differences neither in the bioimpedance variables nor in the obesity and nutritional indices. Similarly, Buffa et al. (2004) had compared pre- and post-menopausal Sardinian women by BIVA method and the bioelectrical characteristics of both groups were similar, too. They assumed the reason could be low number of the sample and more detailed analyses should be done. Previous study of Tremollieres et al. (1996) which measured body composition by dual energy X-ray absorptiometry also found no differences in fat mass nor in a trend toward a greater fat mass in postmenopausal women. The results of studies by Shimokata et al. (1989) and Haarbo et al. (1991) pointed on other factors influencing the fat distribution changes, age and age-related variables. In the study of Kanaley et al. (2001), the level of physical activity accounts for the variability in the abdominal fat distribution in early postmenopausal women, while menopausal status and age did not play a significant role. Franklin et al. (2009) identified no change of body weight, BMI and waist circumference with menopause, but total abdominal fat, subcutaneous fat and visceral fat all significantly increased with menopause. These findings are in contrast to other studies (Aloia et al. 1991, Poehlman et al. 1993) that suggested the menopause transition is associated with a reduction in muscle mass, fat-free mass and, in particular, skeletal muscle mass and with increase of fat mass (Kirchengast 2004). As shown, the effect of menopausal status alone on the body composition changes is controversial and various other variables have impact on the body composition parameters.

In our study the regression analyses showed hypertension, smoking, physical exercises, muscle and joints pain and age as predictive variables influencing the reactance, resistance, fat mass and muscle mass. Hypertension was responsible for lower levels of resistance and muscle mass and higher levels of fat mass in percentages. Smoking appeared to have favourable effect on body composition as shown by the value of B coefficient; more frequent smoking increases muscle mass and decreases fat mass. Physical activity led to higher values of reactance and muscle mass and lower values of fat mass. Increasing age as another independent factor showed to have impact on decreasing levels of reactance and phase angle, what is general phenomenon of ageing (Norman et al 2012).

Lack of revealed differences between studied subgroups of women and no effect of menopausal status on the body composition parameters could be caused by the sample size. Another limiting factor could be categorisation of women by menopausal status. We are aware, that few peri-menopausal women were amalgamated with pre-menopausal ones what could contribute to an "bioimpedance homogeneity" of the groups. In addition, as apparently healthy women were analysed, no expressive differences should be expected.

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Author contribution

All authors participated on the data collection and subject's measurements. MC, DS and VC organized the investigations. ZD, LL, DS designed the paper structure. The statistical analysis was done by ZD and LL. ZD drafted and finalized manuscript. All authors read and approved the final version of the paper.

Conflict of interest

The authors declare that there is no conflict of interests.

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Abbreviations

BMI – body mass index, WHR – waist to hip ratio, BIVA – bioelectric impedance vector analyses, BIA – bioelectric impedance analyses / analyzer, R – resistance, Xc – reactance, FM – fat mass, FFM – fat free mass, MM – muscle mass, TBW – total body water, ECW – extracellular water, ICW – intracellular water, BCM – body cell mass, BMR – basal metabolic rate, PA – phase angle

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