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Weight, Body Composition and Fat Distribution Changes of Czech Women in the Different Reproductive Phases: a Longitudinal Study

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Abstract: Women tend to gain weight with age, especially fat mass which shows also regional changes. A cross-sectional study was done on 213 Czech women with the conclusion that there is a progressive weight increase up to the menopause, an increase in absolute and relative fat contribution and fat centralisation up to the postmenopause and these changes seemed to occur even before the weight increase occurs. The same cohort was examined the same way after 3 years for further analysis. The aim was the assessment of weight gain, body composition and fat distribution changes in four age groups representing the reproductive phases in Czech women in 3-year period. 146 healthy Czech women aged 20–65 were classified according to four reproductive phases: fully reproductive women (n=34, mean age 26.96, SD 4.47), pre-menopausal women (n=34, mean age 42.23, SD 2.78), menopausal women (n=45, mean age 51.56, SD 2.61) and postmenopausal women (n=33, mean age 59.55, SD 2.82). Body weight, body composition and fat distribution were determined using classical anthropometric methods in 2000 and 2003. BMI increased significantly in all the groups except for the premenopausal group and was the greatest in the menopausal group. Increase in fat percentage was significant in the fully reproductive ($p<0.001$) and menopausal women ($p<0.001$), there was no change in the postmenopausal group. Waist, WHR, hip and subgluteal thigh circumference increase significantly in the menopausal group ($p<0.01$, $p<0.05$, $p<0.05$, $p<0.001$ respectively). The highest mean values of waist, WHR and even abdominal circumference remain in the postmenopausal group. Changes of all 14 skinfolds and the sum of the peripheral and central skinfolds are shown; the sum of peripheral skinfolds shows the same values at the end of the study while the sum of central skinfolds increases from the fully reproductive to the postmenopausal women. These results permit us to state the following conclusions: the greatest weight gain in the menopausal group suggests weight gain acceleration around menopause. Body fat mass increase terminates in the early postmenopause. Fat centralisation was proved in the menopausal women with still preserved fat deposition in the gluteofemoral area, which was also apparent in the postmenopausal group, however, the postmenopausal women show the highest values of central fat indicators.

Introduction

Changes in body weight, body composition, fat distribution, metabolic and endocrine parameters and the mutual relationships of these anthropometric and laboratory characteristics through the different reproductive phases of women's life have been studied very intensively but usually only some parameters are studied at a time and there are not many studies on Central European women. It is well known that these changes are influenced by many factors like ethnicity or lifestyle [1, 2]. The premenopausal period can denote all the reproductive years before the onset of the menopause or more specifically it means the period starting several years before the cessation of reproductive functions before the

onset of climacterial symptoms but with the first endocrine signs of climacterium, which start around the age of 40. The perimenopause starts with the first symptoms of climacterium and finishes 1 year after the menopause. The menopause is defined as the last physiological endometrial bleeding and can be assessed retrospectively after 1 year of absence of bleeding. Most Czech women experience the menopause between the ages of 45 and 55, usually between 48 and 52 with a median age of 51 [3]. Another recent study of 1629 Czech women from different regions showed an average age for the menopause of 47.85 years with no significant difference between the regions [4].

Body weight usually increases from the fully reproductive years up to early postmenopause [5], opinions on the influence of the menopause on weight increase are not concordant. Some cross-sectional studies found postmenopausal women heavier compared to premenopausal [6, 7] but most studies did not prove the influence of the menopause on body weight increase independently of age [8, 9, 10]. Longitudinal studies following initially premenopausal women did not prove any significant difference in body weight increases in the women who became postmenopausal and those who remained premenopausal [11, 12]. A retrospective study on French women showed an even increase of 10 kg in women aged 20 to 56 without any acceleration in menopausal years and around the age of 50 the average BMI reached the value of 25, the border between normal weight and overweight [5]. Data on the Czech population indicate this increase is greater compared to other European countries [13, 14], with lowest BMI values in the capital of Prague [15].

In aging women lean body mass decreases and fat mass increases [16], lean body mass does not change much in premenopausal years and decreases in the postmenopause [17] and this decrease correlates with the years after the menopause [18]. However these studies used modern imaging methods such as DEXA or computed tomography to assess lean body mass, bone and muscle mass and not classical anthropometry.

Fat centralisation occurs in menopausal and postmenopausal periods, most studies have proved its relation to the menopause or years since the onset of the menopause [8, 17, 18, 19] but some studies have proved that fat mass increase and centralisation is related only to age without any influence of the menopause [6] and there is already evidence of fat centralisation in premenopausal women [20]. Fat distribution changes through reproductive phases were proved to be related to regional changes in lipoprotein lipase activity caused by the decrease of estrogens to androgens ratio [21]. Central obesity is defined as WHR over 0.85 and is considered to be an independent cardiovascular risk factor and, besides, this leads to complex metabolic changes known as metabolic syndrome X, a very important cardiovascular risk factor, whose prevalence increases in postmenopausal women [22]. Both weight increase and fat centralisation can be partly counterbalanced by increased physical activity [17].

OC and HRT were not proved to have any significant effect on body weight [23, 24]. Some short term studies have proved HRT influence on a decrease in fat centralisation [15, 25], however recent placebo-controlled studies have not proved any influence of HRT on central adiposity markers [23, 24], but HRT influence on protection from the loss of lean body mass components was proved by modern imaging methods [23].

In 2000 a middle-sized sample of healthy Czech women divided into four age groups best representing the different reproductive periods was examined by classical anthropometry and the results were published as a cross-sectional study with the following conclusions:

1. Total body weight increases up to the menopause and there is a progressive increase in absolute and relative fat proportion up to the postmenopause.
2. Relative contribution of muscle and bone mass decreases with age, but an absolute decrease in these components was not proved by classical anthropometry.
3. There is already a progressive age-related fat centralisation in premenopausal years.

Even if it was not the main aim of the study, OC/HRT influence was analysed and no influence on body weight or body composition was not found, only OC seemed to be associated with lower WHR in premenopausal women ($p<0.05$), however, the sub-divided groups were too small and this hypothesis needs to be confirmed on larger samples [26]. In 2003 the same group was examined again in the same areas – 146 women were examined after a 3 year interval and formed the sample of this longitudinal study, the aim of which is to complete and confirm the results of the cross-sectional study, to try to determine the loss of lean body components after menopause, and to trace the changes in body shape even before the increase of BMI and fat mass. This is to be done by using classical anthropometric measurements. We will also look for OC or HRT influence on body shape, but with the limitation of rather small numbers of patients in further divided groups. Besides the anthropometric measurements, endocrine and metabolic laboratory parameters were also recorded for all the women in the same time and their mutual relationship with anthropometric data will be published in a separate article elsewhere and in the present article only anthropometric data are analysed as 3-year longitudinal study.

Material and Methods

This study was drawn to analyse changes in body weight, body composition and fat distribution through the different periods of women's life. Age intervals best representing the four reproductive phases in the Czech population were established: fully reproductive women aged 20–35, premenopausal women aged

38–45, menopausal women aged 48–55 and postmenopausal women aged 55–65. The study protocol was reviewed and accepted by the Ethics Committee of the General University Hospital in Prague.

Women were accepted by the closest possible method to random choice: women were outpatients of gynaecological consultations in Prague who came for regular gynaecological check-ups and subjects were accepted during a period of 4 months among women who came to the health centre on 3 regular days of the week. All women were asked to participate in the study and out of them all women between 20–65 years of age, with BMI below 35 who had not been treated for diabetes, cardiovascular diseases, lipid metabolism impairment, endocrine impairments or other serious diseases and had given informed consent to participate in the study were accepted. Women taking medication, which can modify body composition, were not included; however OC and HRT had no influence on the choice of sample thus representing the real situation of healthy Czech women. The aim was to have about 50 women in each group; however, this was not achieved in the premenopausal and postmenopausal groups which were less represented in the health centre. In 2003 all the participants were called back, out of 213 women, 146 (68.5%) were found who still lived in Prague and were willing to continue with the study. The loss was most important in the fully reproductive group (41.4%) mainly due to moving from Prague or their lack of time, in the other older groups the loss was less than 30 % mainly due to their lack of time, in some cases due to serious illnesses and death in 1 case. The sample for the longitudinal study thus had the following baseline pattern: fully reproductive women (n=34, mean age 26.96, SD 4.47), premenopausal women (n=34, mean age 42.23, SD 2.78), menopausal women (n=45, mean age 51.56, SD 2.61) and postmenopausal women (n=33, mean age 59.55, SD 2.82). Questionnaires and medical consultations were used to determine the health status, current medication and medical history of the sample. OC/HRT users are identified according to the information we obtained in 2003, the great majority of OC/HRT users had already been used OC/HRT in 2000. Blood was taken for endocrine and metabolic parameters in women still having their cycle in the early follicular phase, between day 1 and day 7 since the beginning of their period. Follicle-stimulating hormone (FSH), luteinizing hormone (LH) and estradiol as markers of reproductive phases were measured in serum samples with a RIA method (Institute of Clinical and Experimental Medicine) and are the only laboratory parameters presented in this article. Other endocrine and metabolic parameters will be published in a later article (in the press) including the methods of assessment.

However, in order to best describe the established age groups, hormonal profiles were used only for description of the real reproductive phases inside the groups at the beginning and after 3 years of follow-up and the entire age

groups were analysed and the allocation to the groups was based only on age intervals in which women were initially accepted. FSH over 40 IU/l was used as a hormonal marker of the menopause. Out of 34 women in the fully reproductive period there were 23 (67%) on oral contraception (OC), no woman showed hormonal signs of the menopause. Out of 34 in the premenopausal period 10 (29%) were OC users, 1 (2.9%) was initially menopausal and 2 (5.9%) women experienced the menopause during the 3-year period, out of 45 menopausal women 20 (44%) were on hormonal replacement therapy (HRT), 19 (42.2%) of them were initially menopausal and 14 (31.1%) experienced the menopause during the 3-year follow-up. Out of 33 women in the postmenopausal period 11 (33%) were HRT users, 26 (78.8%) were initially menopausal, 5 (15.2%) became menopausal during the follow-up period and 2 women had no hormonal signs of the menopause but the menstrual data reported menopause and they were HRT users.

Anthropometric measurement was done by the same investigator as in 2000: weight with medical scales to the nearest 0.1 kg with subjects wearing underwear only, height with anthropometer in standing position to the nearest 0.1 cm – body height, height of suprasternal, iliocristal, iliospinal, symphysion points from floor, widths with pelvimeter and kefalometer to the nearest 0.1 cm: biacromial and transversal thoracic width, bicristal and bispinal pelvic, sagittal thoracic diameter, humerus and femur epicondyles width, ankle and wrist width. Circumferences with a flexible tape to the nearest 0,1 cm: mesosternal thoracic circumference, abdominal circumference at the level of the umbilicus, waist at the minimal point between the xiphoid process and superior iliac crest, hip over the widest part of the hip region, relaxed arm, arm in contraction, forearm, thigh circumference under gluteal muscle, mid-thigh circumference and maximum calf circumference. 14 skinfold thicknesses with Best's callipers to the nearest 0.5 mm: on the face, below the chin, on the chest I and II, suprailiac, abdominal, over the patella, over the biceps, forearm I, over the triceps, sub scapular, on the calf I and II [27]. Measured data were processed by the anthropometric software – ANTROPO programme and the following quantities were used for further statistical analysis: total fat percentage by the Parizkova method [28], BMI: weight/height (in m^2), WHR: waist/hip circumference, absolute (in kg) and relative bone, muscle, fat and residue by Matiegka – values corrected by the difference between the real and calculated weight were used [27, 29]. Nowadays modern imaging methods such as DEXA are available for more appropriate assessment of lean body components; however, classical anthropometry was used in this study for its advantage of wide availability in clinical practice.

Statistical analysis was carried out in the department of statistics in the Institute of Clinical and Experimental Medicine. Age group comparison in time was done by analysis of variance with repeated measures and grouping factor, Wilcoxon sign-rank test, groups defined by age. OC or HRT influence on anthropometric

parameters were analysed by ANOVA2 and Mann-Whitney rank test, both final values and the differences between the final and baseline values of the measurements were tested for OC/HRT influence and the power of the tests was calculated. For non-Gaussian distributed variables logarithmic transformation was used.

Results

A sample of 146 Czech women with anthropometric details and other data collected twice at a 3 year interval was established, all data available from the corresponding author. Tables 1 and 2 show the changes in mean values of LH, FSH and estradiol and some somatometric parameters. Height decreases significantly in all the groups by around 0.5 cm, mostly in the postmenopausal group, maximum individual differences show an increase of up to 1.5 cm and a decrease of 3.0 cm. The changes are within a range of measurement error; the maximum decrease is in the postmenopausal group and is in concordance with skeletal aging.

Table 1 – Mean values (mean±SD) of anthropometric parameters in the fully reproductive and premenopausal women measured in 2000 and 2003, significance level of the difference in the mean values of two measurements of the same group is marked with *

Reproductive phase	Fully reproductive n=34		Premenopausal n=34	
Baseline age	26.96±4.47		42.23±2.78	
Year of measurement	2000	2003	2000	2003
FSH (UI/l)	7.3±2.2	6.3±3.7	11.3±12.7	22.2±31.4*
LH (UI/l)	6.3±3.6	5.7±4.1	6.6±5.0	11.8±16.1
Estradiol (pg/ml)	40.3±34.1	33.0±43.6	91.1±97.6	69.5±76.2*
Height (cm)	166.8±5.1	166.2±5.2**	165.5±7.1	165.1±7.2*
Weight (kg)	60.4±7.9	61.9±7.6	69.7±14.4	70.1±16.2
BMI (kg/m^2)	21.8±3.0	22.5±3.3*	25.4±4.5	25.6±4.9
Bone mass (kg)	8.4±0.8	8.2±0.83***	8.6±1.2	8.6±1.3
Muscle mass (kg)	20.8±3.0	20.0±2.9**	20.9±4.0	20.6±3.9
Fat mass (kg)	18.1±6.2	20.6±6.6**	26.8±9.7	27.1±11.5
Bone%	14.1±1.4	13.4±1.6***	12.6±1.4	12.6±1.7
Muscle%	34.6±4.4	32.5±4.2**	30.3±4.1	30.0±4.4
Fat% by Matiegka	29.5±6.9	32.8±7.0**	37.5±6.9	37.2±8.3
Fat% by Pařízková	22.4±5.3	25.0±4.4***	30.7±8.7	30.0±8.7
Abdomen (cm)	79.4±5.7	81.3±5.6	88.6±12.5	88.5±12.8
Hip (cm)	97.7±6.6	99.4±6.2*	102.8±9.2	102.9±10.0
Thigh subgluteal (cm)	58.9±5.0	62.5±5.0***	63.2±6.1	64.9±6.9**
Waist (cm)	69.2±5.0	70.7±5.5*	79.1±11.4	79.4±12.6
WHR	0.71±0.04	0.71±0.04	0.77±0.06	0.77±0.07

***P<0.001, **P<0.01, *P<0.05, FSH – follicle-stimulating hormone, LH – luteinizing hormone, BMI – body mass index, WHR – waist to hip ratio

Mean body weight increase is greatest in the menopausal group: 2.0 kg (SD=3.6, p<0.01), out of 45 women 29 gained weight (3.8±3.2 kg), the biggest individual increase in this group was 11 kg, 15 women lost weight (1.4±1.0 kg), maximum weight loss was 3.6 kg. The fully reproductive women showed a non significant weight increase of 1.5 kg (SD=4.6, NS), out of 34 women 20 gained weight (3.9±4.2 kg), there was an extreme weight increase of 15 kg in two cases, 11 women lost weight (2.6±2.2 kg) and the maximum weight loss was 6.6 kg. In the premenopausal group there was no significant change (+0.3 kg, SD=5.4, NS), out of 34 women 11 gained weight (5.0 ±4.1 kg), the maximum increase was 13 kg in one case, 17 women lost weight (2.6±4.5 kg) and there was an extreme weight loss of 19 kg due to a diet in one case. In the postmenopausal women weight increased non significantly (+0.7 kg, SD=2.6, p=0.06, NS). Out of 33 women 20 gained weight (2.2±1.7 kg) and the maximum weight gain was 5.3 kg. 12 women lost weight (1.6±2.3 kg) and the maximum loss was 8.3 kg. In each group there were a few women without weight change. BMI shows the same trends, but in

Table 2 – Mean values (mean±SD) of anthropometric parameters in the menopausal and postmenopausal groups in measured in 2000 and 2003; significance level of the difference in the mean values of two measurements of the same group is marked with *

Reproductive phase	Fully reproductive n=45		Premenopausal n=33	
Baseline age	51.56±2.61		59.55±2.82	
Year of measurement	2000	2003	2000	2003
FSH (UI/l)	38.4±27.8	58.7±35.1***	62.2±26.0	62.2±22.3
LH (UI/l)	6.3±3.6	5.7±4.1	6.6±5.0	11.8±16.1
Estradiol (pg/ml)	61.4±83.1	24.7±32.0**	22.9±20.4	12.9±16.0**
Height (cm)	164.8±6.3	164.2±6.3***	163.9±4.5	163.1±5.0*
Weight (kg)	70.3±11.9	72.3±13.0**	71.1±10.0	71.8±10.7
BMI (kg/m^2)	26.0±4.6	26.9±5.0***	26.4±3.4	27.0±3.8**
Bone mass (kg)	8.9±0.9	8.9±1.0	8.8±1.2	8.9±1.2
Muscle mass (kg)	22.1±3.6	20.9±3.7	20.0±3.0	20.2±2.6
Fat mass (kg)	25.6±7.5	28.1±10.3	28.6±7.5	28.5±7.8
Bone%	12.9±1.6	12.5±1.6***	12.5±1.4	12.4±1.4
Muscle%	31.7±5.1	29.4±5.1***	28.3±4.2	28.4±3.6
Fat% Matiegka	35.6±7.9	37.9±8.1***	39.7±6.6	39.2±6.4
Fat% Pařízková	29.4±8.2	31.1±7.4**	33.2±7.5	31.9±6.4
Abdomen (cm)	95.2±10.5	96.1±11.5	97.2±10.2	98.1±9.6
Hip (cm)	103.3±7.7	104.3±8.4*	103.7±7.8	103.4±8.0
Thigh subgluteal (cm)	62.3±6.2	65.7±5.6***	62.7±5.3	63.5±5.7
Waist (cm)	81.9±10.5	83.9±11.4**	85.0±8.9	85.7±9.6
WHR	0.79±0.06	0.80±0.07*	0.82±0.06	0.83±0.07

***P<0.001, **P<0.01, *P<0.05, FSH – follicle-stimulating hormone, LH – luteinizing hormone, BMI – body mass index, WHR – waist to hip ratio

contrast to the weight statistics the increase is significant in all groups with the exception of the premenopausal women.

Weight and the relative proportion of bone, muscle, fat and residue were determined by the Matiegka method. The values of the residue are not shown in the tables. The fat percentage was also determined by the Parizkova method. In the fully reproductive group there was a slight decrease in lean components – bone ($p<0.001$) and muscle ($p<0.01$) and an increase in fat mass ($p<0.01$) and fat percentage both by Matiegka ($p<0.01$) and Parizkova method ($p<0.001$). The premenopausal women showed no significant change in any component, while the menopausal women showed a decrease in muscle mass of 1.2 kg and an increase in fat mass of 2.5 kg, both non significant, also the relative values show a decrease in bone and muscle percentage ($p<0.001$ for both) and an increase in fat percentage by Matiegka ($p<0.001$) and Parizkova ($p<0.01$). The postmenopausal women did not show any difference in absolute weight or relative contribution of body components over the 3-year period according to the methods used.

Regional variations were studied using circumferences, WHR and changes in the thickness of skinfolds. There is a non-significant increase in abdominal circumference in all groups except for premenopausal women (there was also no weight change). The greatest increase was in the fully reproductive group where BMI increase was also significant and the differences between the two measurements correlated most strongly with BMI differences in this group ($r=0.79$, $p<0.001$). While the BMI increase was more important in the menopausal women, menopausal and postmenopausal women had the same non-significant increase in abdominal circumference (at the level of the umbilicus). Increase in waist circumference is most evident in menopausal women who show an increase of 2.0 cm ($p<0.01$), it is smaller in fully reproductive women ($p<0.05$), and the increase in pre- and postmenopausal groups is not significant. Waist and abdominal circumferences show the same trends in all groups; however in the fully reproductive and menopausal women the waist circumference shows more important and significant increase which suggests more sensitivity to fat distribution. WHR does not change in the fully reproductive and premenopausal women, but there is an increase in the menopausal ($p<0.05$) and postmenopausal group (NS).

The hip circumference shows a small increase in the fully reproductive ($p<0.05$) and menopausal groups, but does not change in premenopausal women and also remains unchanged in the postmenopausal group, despite the weight/BMI increase. The thigh circumference below the gluteal muscle shows significant increase up to the menopausal group ($p<0.001$, $p<0.01$, $p<0.001$ respectively), and in the premenopausal group this is in spite of no change in weight; the relatively lower increase in thigh circumference in postmenopausal women is not significant.

Tables 3 and 4 show the mean values of peripheral and central skinfolds and their sums. Facial skinfold increases most in the fully reproductive group

($p<0.001$), it increases non-significantly in premenopausal women despite no weight gain, and shows the second biggest increase ($p<0.001$) in the menopausal group while it remains unchanged in the postmenopausal women. The skinfold below the chin follows the same trends, but there is no increase in the premenopausal group. Chest I and II skinfolds increase only in the fully reproductive group (chest I: $p<0.05$), and otherwise decrease non-significantly ($p<0.05$ only in chest I for postmenopausal women) except for premenopausal women where the chest I skinfold remains unchanged. It is interesting to point out that there was a non significant decrease in thoracic circumference in premenopausal women which could possibly be the result of age-related changes in the mammary area after the fully reproductive years. The abdominal and suprailiacal skinfolds do not show any significant changes over time, and only increase non-significantly in the fully reproductive and menopausal groups. In fully reproductive and premenopausal women the differences in abdominal skinfold correlated strongly with BMI changes ($r=0.63$, $p<0.001$, $r=0.54$, $p<0.01$

Table 3 – Mean values (mean±SD) of 14 skinfolds and sum of central and peripheral skinfolds in the fully reproductive and premenopausal groups measured in 2000 and 2003, significance level of the difference in the mean values of two measurements of the same group is marked with *

Reproductive phase	Fully reproductive n=34		Premenopausal n=34	
Baseline age	26.96±4.47		42.23±2.78	
Year of measurement	2000	2003	2000	2003
Peripheral SF (mm)				
Facial	6.1±1.7	7.2±1.9***	7.3±1.8	7.8±1.9
Chin	6.6±3.1	8.4±4.0*	10.5±4.8	10.5±5.2
Patella	16.3±6.7	19.0±6.8*	24.0±9.8	22.2±7.6
Biceps	7.2±4.3	8.6±4.7*	11.3±4.8	11.7±6.3
Triceps	21.0±6.3	23.7±6.6*	27.8±7.2	28.0±8.9
Thigh	30.4±10.3	38.4±9.4**	22.0±8.5	22.7±8.0
Calf I	15.8±6.2	19.7±6.9**	22.0±8.5	22.7±8.0
Calf II	20.1±6.2	23.4±7.6**	27.7±8.1	28.1±7.3
Forearm	7.4±3.9	10.8±5.8*	12.4±5.6	13.9±6.6
Sum of peripheral SF	134.5±39.0	159.5±43.0***	184.5±50.5	185.0±53.0
Central SF (mm)				
Chest I	7.6±3.9	8.5±4.7	13.1±7.1	11.9±6.5
Chest II	10.1±5.3	11.9±4.8*	17.6±7.9	16.9±9.2
Suprailiacal	13.1±6.7	24.4±10.6***	18.0±9.3	26.6±13.0***
Abdomen	26.1±9.1	27.3±12.0	37.4±12.2	36.8±15.3
Subscapular	13.7±5.1	15.9±6.8	20.6±9.2	21.7±12.0
Sum of central SF	72.0±27.0	88.0±34.0***	108.5±41.5	114.0±51.0

***P<0.001, **P<0.01, *P<0.05, SF – skinfolds

respectively). The patella skinfold increases significantly in the fully reproductive women ($p<0.05$), while in the premenopausal and menopausal groups the changes are not significant, but there is a significant decrease in postmenopausal women ($p<0.05$). The biceps skinfold increases in the three younger groups, significantly in the premenopausal and menopausal women ($p<0.05$, NS, $p<0.01$ respectively). The triceps skinfold thickness increases significantly in the fully reproductive ($p<0.05$) and in the menopausal women ($p<0.001$), while it does not change in the other groups. The thigh skinfold increases in the fully reproductive ($p<0.01$) and in the menopausal women ($p<0.05$), while the premenopausal and postmenopausal women show a non-significant decrease. Calf I and II increase in the fully reproductive group (both $p<0.005$) and in the menopausal group ($p<0.05$ and $p<0.001$ respectively). The forearm skinfold increases in all the groups; the increase being significant in the fully reproductive and menopausal groups ($p<0.05$, $p<0.001$ respectively). The same is true for the subscapular skinfold, with a significant change only in the menopausal group ($p<0.001$).

Table 4 – Mean values (mean±SD) of 14 skinfolds and sum of central and peripheral skinfolds in the menopausal and postmenopausal groups measured in 2000 and 2003, significance level of the difference in the mean values of two measurements of the same group is marked with *

Reproductive phase	Fully reproductive n=45		Premenopausal n=33	
Baseline age	51.56±2.61		59.55±2.82	
Year of measurement	2000	2003	2000	2003
Peripheral SF (mm)				
Facial	7.5±2.2	8.4±2.1***	9.1±2.3	9.2±2.5
Chin	10.5±3.9	11.4±4.1*	13.5±3.5	13.3±3.8
Patella	20.3±7.8	21.3±9.4	23.2±7.6	20.6±7.8*
Biceps	10.5±5.2	11.9±6.0**	13.3±4.8	12.9±4.8
Triceps	26.1±7.6	29.8±8.4***	27.9±6.3	28.9±7.0
Thigh	37.8±12.2	38.8±12.5*	38.7±12.5	36.9±10.3
Calf I	19.9±9.4	23.5±9.6*	24.0±9.5	22.4±7.7
Calf II	23.7±7.6	26.6±8.3***	26.9±6.4	26.5±6.5
Forearm	10.0±4.9	13.6±6.1***	12.8±4.9	14.5±4.8
Sum of peripheral SF	167.0±51.5	186.5±58.5***	189.5±44.5	185.5±43.5
Central SF (mm)				
Chest I	12.2±6.4	12.5±6.8	16.1±5.0	14.6±5.9*
Chest II	18.4±8.5	17.2±6.7	21.3±6.4	19.9±6.9
Suprailiacal	20.4±9.9	31.9±12.0***	23.4±8.4	30.7±10.1***
Abdomen	39.7±12.5	42.4±13.2	45.5±13.9	45.7±12.0
Subscapular	20.1±8.5	24.2±11.0***	20.2±7.7	23.7±8.8
Sum of central SF	110.6±40.5	128.0±44.0***	122.0±30.5	134.5±36.0*

***P<0.001, **P<0.01, *P<0.05, SF – skinfolds

If we consider the sum of the peripheral skinfolds thicknesses, it is evident that there is a significant increase in the fully reproductive and menopausal groups ($p<0.001$). The increase is greater in the fully reproductive women despite a lesser BMI increase and the same increase in total fat mass weight. Changes in the sum of peripheral skinfolds were not proven in the premenopausal and postmenopausal groups.

The sum of central skinfolds increases significantly in the fully reproductive and menopausal women ($p<0.05$), in the premenopausal group there is a non significant decrease. In the postmenopausal women there is a trend to increase and the highest sum of central skinfolds is found in this group while the sum of peripheral skinfolds shows the same values from the premenopausal to the postmenopausal women. This is consistent with the greatest central subcutaneous deposits in the postmenopausal women; however, no further increase of central skinfolds in time was proved in this group.

The individual differences in fat determined by Matiegka and the sum of 10 skinfolds correlate more strongly with BMI differences in the fully reproductive and premenopausal group than in the next two groups, the majority of correlations between individual skinfold differences and BMI differences decrease progressively from the fully reproductive to the postmenopausal group.

ANOVA 2 and Mann-Whitney rank test showed that OC in the premenopausal group was associated with significantly lower WHR ($p<0.05$) both in absolute values and the difference between the two measurements. There was no proof of any other effect of OC and no effect of HRT on the differences between the baseline and final values in this sample; however, it cannot be excluded as the power of the tests was unfortunately less than the required 80%.

Discussion

The comparison of Czech and foreign data to our original sample of 213 women, of whom 146 participated in this longitudinal study, has been published in the article containing the cross-sectional study [26]. Over the 3-year-follow-up the body weight increase was significant and greatest in menopausal women, followed by the fully reproductive and postmenopausal group. There was no weight change in the premenopausal group. Other 3-year-longitudinal studies can be used to compare the results in the group of menopausal women: an observational study of the menopausal transition called Study of Women's Health Across the Nation (SWAN) carried out on more than 3000 women aged 42–52 years showed that mean weight increased by 2.1 kg or 3% over the 3-year period [2]. Another study showed that menopausal women have an average weight gain of 0.8 kg per year, that 20% of women gained 4.5 kg or more and that only 3% lost 4.5 kg in weight or more [11]. Both the mean value and the percentage of women who gained weight are similar to our results; however, no menopausal woman lost weight more than 4.5 kg. We did not prove any weight gain in premenopausal women, on

the contrary, the majority of them lost weight, and there was one case of an extreme loss of 19 kg, but also some cases of significant weight gain. In this group, the SD shows the highest value and weight loss was noticed in half of the subjects, however, there was an upward trend to increase even in this group. As proved in other Czech studies, Prague women in general have the lowest BMI in the country and women are under the influence of western culture with its cult of a slim figure and as being overweight is viewed negatively in society, they are more likely to be under pressure to keep their achieved positions at work and in their personal life. We will not draw any conclusion from that since a progressive weight gain in this age group has been proven in large samples [1, 5, 30]; however it allows us to trace changes in body composition and fat distribution within the group which showed no change in weight. Our results suggest weight gain acceleration in the menopausal years; however, our data do not permit us to state if the weight change is menopause- or age-related.

Lean body mass has been proven to decrease after the onset of the menopause; however these studies did not use classical anthropology [16, 17, 18, 31]. No decrease in the lean body mass component was proven in menopausal and postmenopausal women in this study; in addition to the limited validity and accuracy of the classical anthropometry used for body composition assessment, the 3-year-interval might have been too short to determine at least some relative changes by classical anthropometry.

The progressive increase in fat mass in the four groups was clearly demonstrated in the cross-sectional study on the sample of 213 women, though the development in the 3-year-period did not show any further increase in fat mass in the postmenopausal women, and even a non significant decrease in fat % by Parizkova in this group, which could be due to limitation in skinfold measurements in elderly subjects. Due to the fact that we only examined 146 women twice in 3 years, we obtained values for the initial fat parameters that did not completely correspond to our cross-sectional study results, however the measurements at the end of the study tend to reach the same pattern as the cross-sectional data – the fat mass parameters show the highest values in the postmenopausal women, followed by the menopausal group with equal or very close values. This implies that body fat increases only up to early postmenopause.

Regarding fat distribution determined by circumferences we did not prove any significant increase in abdominal circumference in any group, although it remains the greatest in the postmenopausal group. As there are different approaches to the place where the waist circumference is measured and this was discussed in the previous article on the cross sectional study [26], we must point out that we measured the waist circumferences as the narrowest point between the xiphoid process and the superior iliac crest, which corresponds with Fetter's definition [29]. Waist circumference increases in both fully reproductive and the menopausal women, but not in the postmenopausal women, nevertheless the mean value still

remains highest in the postmenopausal group. So does WHR, though the increase was significant only in the menopausal group. The most significant changes were in waist circumference, which is the most precise indicator of central fat if determined by classical anthropometric methods [32, 33]. We can conclude that the circumference changes show proportionate increase of circumferences in the fully reproductive group consistent with BMI increase, the premenopausal group shows only small but significant increase in thigh subgluteal circumference with no circumference changes in the central area, the menopausal group shows significant increases in waist, hip, thigh circumferences but with significant WHR increase which implies fat centralisation. The postmenopausal group shows a non-significant trend to an increase in abdominal, waist and thigh circumferences but no change in hip circumference which also implies a trend to fat centralisation in this group, though not significant. This would be in accordance with changes in lipoprotein-lipase activity in the gluteofemoral region during the reproductive phases [21].

The pattern of skinfold changes may be misleading since we have to consider that the weight gain was not linear as there was no weight gain in the premenopausal group probably due to our choice of subjects from gynaecology consultations in Prague, where women are probably more weight conscious than in other regions. We should also consider the limitation of the method in the elderly. Since we did not prove any significant increase in the abdominal skinfold in the menopausal and postmenopausal groups, a significant increase in waist circumference and WHR in menopausal women ($p<0.01$, p.0.05 respectively) and a non-significant WHR increase in the postmenopausal group implies visceral fat accumulation consistent with former findings that after the menopause the central fat is stored predominantly in the visceral area and not subcutaneously as before the onset of the menopause [34]. The baseline sum of the peripheral skinfolds was lower in menopausal than in premenopausal women, which does not accord with the pattern of our sample of 213 women, but after 3 years we can observe the same value of the sum of the peripheral skinfolds from premenopausal through to postmenopausal women. The decreasing trend of central skinfolds in the premenopausal group might be due to weight reduction of the majority of women in this group and together with stable circumferences and only subgluteal thigh increase implies no fat centralisation in this group according to the methods used in this study.

OC in the premenopausal group was associated with significantly lower WHR ($p<0.05$) both in absolute values and the difference between the two measurements. There was no proof of an effect of HRT in this sample; however there were small numbers in some groups which were further divided into women on treatment and that not on treatment and the power of the tests was lower than the required 80%. HRT prevents postmenopausal loss of bone and muscle mass [23] but studies show different results of the effect of HRT on fat centralization and fat tissue increase in the postmenopause [16, 23, 35, 36].

Modern methods such as DEXA and computed tomography were used in these studies. This study was not originally sampled for OC/HRT evaluation and is to be confirmed on larger samples and, as already discussed, more exact methods for assessment of lean body components are available and more precise than the classical anthropometry. These data will also serve as points of reference for metabolic and endocrine changes, details of which will be published in a later article.

Conclusion

Anthropometric examination was performed on a cohort of 146 Czech women in four reproductive phases in the year 2000 and repeated in 3 years with following results:

1. The greatest weight gain in the menopausal group (+2.0 kg, SD=3.6, $p<0.01$) suggests weight gain acceleration around the menopause.
2. Fat percentage by Matiegka and Parizkova methods increased significantly in the fully reproductive ($p<0.01$, $p<0.001$ respectively) and menopausal groups ($p<0.001$, $p<0.01$ respectively), which implies fat mass increase terminates in the early postmenopause.
3. Regional fat distribution determined by circumferences showed no fat centralisation in the fully reproductive and premenopausal women; fat centralisation was proved in the menopausal women with preserved gluteofemoral fat deposition; the postmenopausal women tend to centralise fat tissue but the measurement of skinfolds might not be the method appropriate for this age group.

References

1. MATTHEWS K. A., MEILAHN E., KULER L. H., KELSEY S. F., CAGGIULA A. W., WING R. R.: Menopause and risk factors for coronary heart disease. *N. Engl. J. Med.* 321: 641–646, 1989.
2. STERNFELD B., WANG H., QUESENBERRY C. P., ABRAMS B., EVERSON-ROSE S. A., GREENDALE G. A., MATTHEWS K. A., TORRENS J. I., SOWERS M. F.: Physical activity and changes in weight and waist circumference in midlife women: findings from the Study of Womens' Health Across the Nation. *Am. J. Epidemiol* 160: 912–922, 2004.
3. ŽIVNÝ J.: Hormonální substituční terapie. In: Stárka L. (ed): Aktuálni endokrinologie, Maxdorf, Prague, 1991, 579.
4. ČEŘOVSKÁ J., NĚMEČEK J., POBIŠOVÁ Z., ZAMRAZIL V.: Nástup menopauzy, některé somatometrické charakteristiky a indikátory osteoporózy u současných žen v devíti regionech České republiky. *Medica Revue* 1: 52–57, 2001.
5. BASDEVANT A., ELIA D., MIMOUN S., DEMYTTENAERE K., GENAZZANI A., PASINI W., STUDD J.: Evénements gynéco-endocriniens et variations pondérales: étude rétrospective chez les femmes françaises âgées de 52 à 58 ans. *Contracept. Fertil. Sex* 12: 1143–1147, 1992.
6. PASQUALI R., CASIMIRRI F., LABATE A. M., TORTELLI O., PASCAL G., ANCONETANI B., GATTO M. R., FLAMIA R., CAPELLI M., BABBARA L.: Body weight, fat distribution and the menopausal status in women. The VMH Collaborative Group. *Int. J. Obes. Relat. Metab. Disord.* 18: 614–621, 1994.

7. DENTONKELAAR I., SEIDELL J. C., VAN NOORD P. A., BAANDERS-VAN HALEWIJN E. A., OUWEHAND I. J.: Fat distribution in relation to age, degree of obesity, smoking habits, parity and estrogen use: a cross-sectional study in 11,825 Dutch women participating in the DOM-project. *Int. J. Obes.* 14: 753–761, 1990.
8. TREMOLLIERES F. A., POUILLES J. M., RIBOT C. A.: Relative influence of age and menopause on total and regional body composition changes in postmenopausal women. *Am. J. Obstet. Gynecol.* 175: 1594–1600, 1996.
9. PANOTOPOULOS G., RUIZ J. C., RAISON J., GUY-GRAND B., BASDEVANT A.: Menopause, fat and lean distribution in obese women. *Maturitas* 25: 11–19, 1996.
10. BJORKELUND C., LISSNER L., ANDERSSON S., LAPIDUS L., BENGTSSON C.: Reproductive history in relation to relative weight and fat distribution. *Int. J. Obes. Relat. Metab. Disord.* 20: 213–219, 1996.
11. WING R. R., MATTHEWS K. A., KULLER L. H., MEIHLAHN E. N., PLANTINGA P. L.: Weight gain at the time of menopause. *Arch. Intern. Med.* 151: 97–102, 1991.
12. MACDONALD H. M., NEW S. A., CAMPBELL M. K., REID D. M.: Longitudinal changes in weight in perimenopausal and early postmenopausal women: effects of dietary energy intake, energy expenditure, dietary calcium intake and hormone replacement therapy. *Int. J. Obes. Relat. Metab. Disord.* 27: 669–676, 2003.
13. ŠKODOVÁ Z., PÍŠA Z., ČEŘOVSKÁ J., GRAFNETTER D., WIESNER E., CÍCHA Z., PIKHARTOVÁ J., BERKA L., VORLÍČEK J., EMROVÁ R.: 1992: The effect of body fat distribution on cardiovascular risk factors in the population of the Czech Republic. *Cor Vasa*: 34: 189–98.
14. BLÁHA P., ŠEDIVÝ V., ČECHOVSKÝ K., KOSOVÁ A.: Antropometrie československé populace od 6 do 55 let, Československá spartakiáda 1985, vol. 1, part 2, Ústřední štáb československé spartakiády, Prague, 1986, 139–262.
15. POBIŠOVÁ Z., ZAMRAZIL V., ŠIMEČKOVÁ A., ČEŘOVSKÁ J., HNÍKOVÁ O., NOVÁK Z., VLČEK P., VOBORSKÁ M., VRBÍKOVÁ J.: Porovnání základních somatometrických charakteristik u náhodně vybraných osob pražské a vsetínské oblasti. *Vnitř. Lék.* 40: 26–31, 1994.
16. GENAZZANI A. R., GAMBACCIANI M.: Effects of climacteric transition and hormone replacement therapy on body weight and body fat distribution. *Gynecol. Endocrinol.* 22: 145–150, 2006.
17. POEHLMAN E. T., TOTH M. J., BUNYARD L. B., GARDNER A. W., DONALDSON K. E., COLMAN E., FONONG T., ADES P. A.: Physiological predictors of increasing total and central adiposity in aging men and women. *Arch. Intern. Med.* 155: 2443–2448, 1995.
18. SVENDSEN O. L., HASSAGER C., CHRISTIANSEN C.: Age- and menopause-associated variations in body composition and fat distribution in healthy women as measured by dual-energy X-ray absorptiometry. *Metabolism* 44: 369–373, 1995.
19. TOTH M. J., TCHERNOF A., SITES C. K., POEHLMAN E. T.: Effect of menopausal status on body composition and abdominal fat distribution. *Int. J. Obes. Relat. Metab. Disord.* 24: 226–231, 2000.
20. PASCOT A., LEMIEUX S., LEMIEUX I., PRUD'HOMME D., TREMBLAY A., BOUCHARD C., NADEAU A., COUILLARD C., TCHERNOF A., BERGERON J., DESPRES J. P.: Age-related increase in visceral adipose tissue and body fat and the metabolic risk profile of premenopausal women. *Diabetes Care* 22: 1471–1478, 1999.
21. REBUFFE-SCRIVE M., ELDH J., HAFSTROM L. O., BJORNTORP P.: Metabolism of mammary, abdominal, and femoral adipocytes in women before and after menopause. *Metabolism* 35: 792–797, 1986.
22. PARK Y. W., ZHU S., PALANIAPPAN L., HESHKA S., CARNETHON M. R., HEYMSFIELD S. B.: The metabolic syndrome: prevalence and associated risk factor findings in the US population from the

Third National Health and Nutrition Examination Survey, 1988–1994. *Arch. Intern. Med.* 163: 427–436, 2003.

23. CHEN Z., BASSFORD T., GREEN S. B., CAULEY J. A., JACKSON R. D., LACROIX A. Z., LEBOFF M., STEFANICK M. L., MARGOLIS K.: Postmenopausal hormone therapy and body composition – a substudy of the estrogen plus progestin trial of the Womens´Health Initiative. *Am. J. Clin. Nutr.* 82: 651–656, 2005.
24. SITES C. K., L'HOMMEDIEU G. D., TOTH M. J., BROCHU M., COOPER B. C., FAIRHURST P. A.: The effect of hormone replacement therapy on body composition, body fat distribution, and insulin sensitivity in menopausal women: a randomized, double-blind, placebo controlled trial. *J. Clin. Endocrinol. Metab.* 90: 2701–2707, 2005.
25. GAMBACCIANI M., CIAPONI M., CAPPAGLI B., PIAGGESI L., DE SIMONE L., ORLANDI R., GENAZZANI A. R.: Body weight, body fat distribution, and hormonal replacement therapy in early postmenopausal women. *J. Clin. Endocrinol. Metab.* 82: 414–417, 1997.
26. KOSKOVÁ I., PETRÁSEK R., VONDRA K., BLÁHA P., SKIBOVÁ J., GLAGOLIČOVÁ A., KARASOVÁ L.: Weight, body composition and fat distribution of Czech women in relation with reproductive phase: a cross-sectional study. *Prague Med. Rep.* 108: 13–26, 2007.
27. BLÁHA P., ŠEDIVÝ V., ČECHOVSKÝ K., KOSOVÁ A.: Antropometrie československé populace od 6 do 55 let, Československá spartakiáda 1985, vol. 1, part 1, Ústřední štáb československé spartakiády, Prague, 1986, 36–46.
28. PAŘÍZKOVÁ J.: Body Fat and Physical Fitness. Martinus Nijhoff, The Hague, 1977.
29. FETTER V., PROKOPEC M., SUCHÝ J., TITLBACHOVÁ S.: Antropologie, Academia, Prague, 1967, 49–50.
30. LEWIS C. E., JACOBS D. R., MCCREATH H., KIEFE C. I., SCHREINER P. J., SMITH D. E., WILLIAMS O. D.: Weight gain continues in the 1990s: 10 year trends in weight and overweight from the CARDIA Study. *Am. J. Epidemiol.* 151: 1172–1181, 2000.
31. WANG Q., HASSAGER C., RAVN P., WANG S., CHRISTIANSEN C.: Total and regional body composition changes in early postmenopausal women: age-related or menopause-related. *Am. J. Clin. Nutr.* 60: 843–848, 1994.
32. HAN T. S., MCNEILL G., BARAS P.: Waist circumference relates to intra-abdominal fat mass better than waist: hip ratio. *Proc. Nutr. Soc.* 54: 182, 1995.
33. ASHWELL M., COLE T., DIXON A.: Ratio of waist circumference to height is strong predictor of intraabdominal fat. *BMJ* 313: 559–560, 1996.
34. ZAMBONI M., ARMELLINI F., MILANI M. P., DE MARCHI M., TODESCO T., ROBBI R., BERGAMO-ANDREIS I. A., BOSELLO O.: Body fat distribution in pre- and post-menopausal women: metabolic and anthropometric variables and their inter-relationships. *Int. J. Obes. Relat. Metab. Disord.* 16: 495–504, 1992.
35. HAARBO J., MARSLEW U., GOTFRENDSEN A., CHRISTIANSEN C.: Postmenopausal hormone replacement therapy prevents central distribution of body fat after menopause. *Metabolism* 40: 1323–1326, 1991.
36. KRISTENSEN K., PEDERSEN S. B., VESTERGAARD P., MOSEKILDE L., RICHELSEN B.: Hormone replacement therapy affects body composition and leptin differently in obese and non-obese postmenopausal women. *J. Endocrinol.* 163: 55–62, 1999.