Prague Medical Report / Vol. 108 (2007) No. 1, p. 13–26

Weight, Body Composition and Fat Distribution of Czech Women in Relation with Reproductive Phase: a Cross-sectional Study

Kosková I.[1], Petrásek R.[2], Vondra K.[3], Bláha P.[1], Skibová J.[2], Glagoličová A.[2], Karasová L.[2]
[1]Department of Anthropology of the Faculty of Science, Charles University in Prague, Czech Republic;
[2]Institute for Clinical and Experimental Medicine, Prague, Czech Republic;
[3]Institute of Endocrinology, Prague, Czech Republic

Received November 30, 2006. Accepted February 20, 2007.

Key words: Anthropometric measurement – Body composition – Fat distribution – Skinfolds

Mailing Address: Irena Kosková, MD., Jihovýchodní VII 13, 141 00 Prague 4, Czech Republic, Fax: +420 272 762 983; e-mail: irenako@quick.cz

© Charles University in Prague – The Karolinum Press, Prague 2007

Abstract: A sample of 213 healthy Czech women was classified into four groups according to their reproductive phase: fully reproductive, premenopausal, menopausal and postmenopausal women. Changes in body weight, body composition and fat distribution were studied in those four groups using the classical anthropometric method. Body weight rises till the menopause with no further increase. A decrease in relative contribution of muscle and bone mass was observed. The progressive increase in fat mass with age was clearly demonstrated, both the fat mass weight ($r=0.38$, $p<0.001$) and its percentage contribution (Matiegka $r=0.40$, $p<0.001$, Pařízková $r=0.42$, $p<0.001$). There is a stronger correlation of central fat indices as WHR ($r=0.57$, $p<0.001$), abdominal ($r=0.56$, $p<0.001$) and waist circumference ($r=0.50$, $p<0.001$) than for hip circumference ($r=0.27$, $p<0.001$) to the age. WHR and waist increase most when fully reproductive and premenopausal women were compared ($p<0.001$); less when premenopausal to menopausal women are compared (NS) and the least when menopausal to postmenopausal women were compared (NS). The mean values of 14 skinfolds thickness are shown, the skinfold at the abdomen shows the strongest correlation to the age ($r=0.49$, $p<0.001$). The results are consistent with the hypothesis of progressive fat centralisation.

Introduction

Cardiovascular diseases and other so-called diseases of civilisation have increased dramatically due to changes in the lifestyle, particularly due to the higher energy intake and lower physical activity. Sex hormones reduce the cardiovascular risk in women in their reproductive phase and after the menopause the risk increases [1, 2, 3]. Changes in the body weight, body composition, fat distribution, metabolic and endocrine parameters and the mutual relationships of these anthropometric and laboratory characteristics have been studied very intensively but usually only some parameters are studied at a time and there are not many studies in Middle-European women. It is well known that these changes are influenced by many factors like ethnic or lifestyle [4, 5, 6, 7, 8, 9].

Classical anthropometric measurement and metabolic and endocrine characteristics were assessed in a middle-sized cohort of healthy Czech women in all reproductive phases and the same examination was repeated three years later. Results of the longitudinal study and analysis of the mutual relationships of these parameters will be published in next article (in press).

In this article only baseline anthropometric data are analysed with an emphasis on the body weight and body components. Muscle, bone, and fat mass and fat distribution changes are described for different reproductive phases of women. We studied whether the body composition and fat distribution changes anticipate the weight gain and we compared our data and results with other wide-ranging studies, which were carried out in large population samples in the Czech Republic, e.g. Anthropometric studies of the Czechoslovak population from

6 to 55 years [11], MONICA [12, 13] and the study of the thyroid impairment prevalence which gave also data of menopause onset and some anthropometric parameters – BMI, WHR, 4 skinfolds [13].

Material and Methods

Subjects were outpatients of gynaecological consultations in Prague 2, 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 nor other serious diseases and had given consent to participate in this study. Age intervals representing each reproductive phase of average central European women were established [14] and women were accepted to have about 50 persons in each group. Total number was 213: women in fully reproductive phase aged 20–36 (n=58, mean age 26.89, SD 4.69), premenopausal women aged 38–45 (n=48, mean age 42.54, SD 2.50), menopausal women between the ages of 48 and 54 (n=62, mean age 51.34, SD 2.51) and postmenopausal women aged between 55 and 65 (n=45, mean age 59.53, SD 2.71). Questionnaires and medical consultation were used to ascertain the health status, current medication, family and personal medical history, major weight changes through life, alimentary habits, and daily physical activity. Women taking medication, which can modify body composition were not included, however oral contraception (OC) and hormonal replacement therapy (HRT) had no influence on the choice of probands thus representing the real situation of healthy Czech women. We only had the information that the proband was taking OC/HRT at the time of examination; the length of the treatment was ignored. Out of 58 women in the fully reproductive period there were 37 (64%) on OC, out of 48 in the premenopausal period 11 (23%), out of 62 menopausal women 21 (34%) were on HRT and out of 45 women in the postmenopausal period 14 (31%). Blood was taken to assess endocrine and metabolic parameters, in women having their menstrual cycle in the early follicular phase of the cycle, between day 1 and 7 since the beginning of period. Follicle-stimulating (FSH), luteinizing hormone (LH) and estradiol as markers of reproductive phases were measured in serum samples with the RIA method (Institute of Clinical and Experimental Medicine, Prague) and they represent the only laboratory values presented in this article. Other endocrine and metabolic parameters will be published in the next article (in press) including the methods of their assessment.

Anthropometric measurement: weight with medical scales to the nearest 0.1 kg with subjects wearing underwear only, heights with anthropometer in the 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, transverse diameter of the chest, bicristal and bispinal width, sagittal diameter of the chest, width of the distal humeral and femoral epiphysis, ankle and wrist width. Circumferences with a flexible tape to

the nearest 0.1 cm: mesosternal chest circumference, abdominal circumference at the level of umbilicus, waist at the minimal point between the xiphoid process and superior iliac crest, gluteal (hip) over the widest part of the hip region, relaxed arm, contracted arm, maximum circumference of the forearm, thigh circumference under gluteal muscle and median thigh circumference and calf maximum circumference. 14 skinfolds' thickness with Best's callipers to the nearest 0.5 mm: facial, below the chin, on the chest I and II, suprailiacal, abdominal, over the patella, over the biceps, forearm I, over the triceps, subscapular, on the thigh over the quadriceps, on the calf I and II [10]. All measurements were done by the same investigator in the same room. Measured data were processed by the ANTROPO programme and the following values were used for further statistical analysis: total fat percentage by the Pařízková method, BMI: weight / (height in m)^2, WHR: waist / hip circumference, absolute (in kg) and relative (in %) weight of bone, muscle, fat and residue by Matiegka [15, 10] and these values were corrected by the difference between the real and calculated weight. Statistical analysis was carried out in the department of statistics in IKEM (Institute of Clinical and Experimental Medicine). Age group comparison was done by one-way analysis of variance (ANOVA1); groups defined by age and OC or HRT were analysed by ANOVA2. Both analyses were completed using the Bonferroni method of multiple comparisons. The correlation of the measurements to age was then calculated for the whole sample. The study protocol was reviewed and accepted by the Ethics Committee of the General Teaching Hospital in Prague.

Results

A cohort of 213 Czech women with anthropometric details and other data was established, all data available from the corresponding author. The aim was to describe body weight, body composition and fat distribution in four age-determined groups corresponding to different reproductive phases of Czech women. We have to point out that this is a cross-sectional study and the mean values of the four age groups representing the reproductive phases are compared and though some expressions used in the text are not precise, e. g. increase, decrease, lost, gain etc. and are meant as a change between the neighbouring groups and not as a change in time as it would be in a longitudinal study.

Table 1 shows the mean values of FSH, LH, estradiol, height, body weight and BMI of the individual age groups. FSH significantly increases between the fully reproductive women and postmenopause ($p<0.05$, $p<0.001$, $p<0.001$ respectively), LH follows the same trend with a significant increase in menopausal women ($p<0.001$), estradiol level decrease significantly in postmenopausal women ($p< 0.01$). In accordance with secular trend the height decreases evenly with age (difference of mean figures NS, $r=–0.21$). Body weight already increases in premenopausal women ($p<0.05$), reaches its maximum in the menopause (NS) and does not rise any more; this applies to both the body weight (height decrease must be taken into

consideration) and BMI ($p<0.01$ of fully reproductive vs. premenopausal women). The mean values of both the corrected weight values in kg and the corrected values of relative contribution of the bone, muscle and fat mass in % according to Matiegka and fat percentage according to Pařízková in each reproductive phase are shown in table 2. The total percentage is not equal to 100, the remainder being

Table 1 – Sex hormones, height, weight and BMI

	FR n=58	PreM n=48	M n=62	PostM n=45	r
Age	26.89 ±4.69	42.54 ±2.50	51.34 ±2.51	59.53 ±2.71	
FSH (IU/l)	6.7 ±2.9	10.4 ±10.5*	40.1 ±32.1***	63.1 ±25.0***	0.65***
LH (IU/l)	5.6 ±3.3	7.6 ±6.9	27.6 ±22.5***	35.0 ±14.1	0.60***
ED (pg/ml)	40.0 ±29.8**	77.7 ±78.0	58.3 ±71.8	25.3 ±35.1**	NS
Height (cm)	165.5 ±5.5	165.0 ±6.8	164.6 ±6.1	163.6 ±4.7	–0.21**
Weight (kg)	61.2 ±8.1	67.2 ±13.6*	72.0 ±14.0	71.1 ±10.9	0.33***
BMI (kg/m^2)	22.2 ±3.4	24.6 ±4.4**	26.6 ±5.1	26.5 ±3.7	0.40***

*** P<0.001; ** P<0.01; * P<0.05; FR – fully reproductive phase; PreM – premenopausal phase; M – menopausal phase; PostM – postmenopausal phase; r – correlation for the whole sample to age; FSH – follicle-stimulating hormone; LH – luteinizing hormone; ED – estradiol; BMI – body mass index.
Mean values (mean±SD) of height FSH, LH, ED, weight and BMI in the four reproductive phases. Significance level of the difference in the mean values between an x marked group and the previous – "younger" one is shown. The last line shows the correlation of each parameter to the age for the whole sample and the significance level is marked with *

Table 2 – Body components and circumferences

	FR n=58	PreM n=48	M n=62	PostM n=45	r
Age	26.89 ±4.69	42.54 ±2.50	51.34 ±2.51	59.53 ±2.71	
Bone (kg)	8.4 ±0.8	8.6 ±1.2	9.1 ±1.1	8.9 ±1.2	0.19**
%Bone	13.8 ±1.6	13.0 ±1.8	12.8 ±1.6	12.6 ±1.4	–0.30***
Muscle (kg)	21.1 ±3.2	20.8 ±3.8	22.3 ±3.8	20.0 ±2.9**	NS
%Muscle	34.7 ±5.0	31.5 ±5.2**	31.4 ±4.8	28.4 ±3.9	–0.38***
Fat Mat. (kg)	18.8 ±6.9	24.5 ±9.9**	26.9 ±10.4	28.7 ±8.2	0.38***
%Fat Mat.	30.0 ±7.5	35.1 ±8.6**	36.4 ±7.6	39.7 ±6.3	0.40***
%Fat Pař.	22.8 ±6.3	28.2 ±9.6**	30.0 ±8.2	32.6 ±7.1	0.42***
WHR	0.72 ±0.05	0.77 ±0.06***	0.80 ±0.06	0.82 ±0.06	0.57***
Waist (cm)	70.4 ±7.3	77.9 ±11.0***	83.2 ±11.5	84.9 ±9.5	0.50***
Abd. (cm)	80.4 ±8.2	88.2 ±11.8***	95.9 ±11.9**	98.1 ±10.0	0.56***
Hip (cm)	98.2 ±7.0	100.7 ±8.9	104.3 ±9.1	104.1 ±8.7	0.27***

*** P<0.001; ** P<0.01; * P<0.05; FR – fully reproductive phase; PreM – premenopausal phase; M – menopausal phase; PostM – postmenopausal phase; r – correlation for the whole sample to age; Fat Mat. – total fat weight by Matiegka method; %Fat Mat. – fat percentage by the Matiegka method; %Fat Pař. – fat percentage by the Pařízková method; WHR – waist to hip ratio; Abd. – abdominal circumference
Mean values (mean±SD) of corrected bone weight, %bone, muscle weight, %muscle, fat, and %fat – all by Matiegka method, %fat by Pařízková, WHR, waist, abdominal and hip circumference in the four reproductive phases. Significance level of the difference in the mean values between an * marked group and the previous neighbouring –"younger" one is shown. The last line shows the correlation of each parameter to age for the whole sample and the significance level is marked with *

represented by a residue, which is not shown. There is a positive correlation of fat weight ($p<0.001$) and bone weight (NS) to the age, muscle weight does not correlate with the age. A significant difference in bone weight between the neighbouring groups was not proved, muscle weight was significantly lower in the postmenopausal group ($p<0.01$) and the fat weight increased significantly in the premenopausal women ($p<0.01$). No influence
of OC or HRT was proved.

There is a negative correlation of %bone, %muscle ($p<0.01$), and a positive correlation of %fat ($p<0.001$) to age (both Matiegka and Pařízková method of fat percentage determination). The difference in mean values of relative contribution of the three components between the neighbouring groups is significant only in premenopausal women vs. fully reproductive women for %fat and %muscle, and menopausal vs. postmenopausal women for %muscle. The progressive increase in fat mass with age was demonstrated, both the tissue weight and percentage contribution being determined by both methods. In the three younger groups the increase in absolute and relative fat mass accompanies the weight gain but in postmenopausal women the increase continues despite both stable BMI and weight. This reflects the progressive increase in the relative fat component at the expense of a decrease in non-fat tissues. The decrease in percentage contribution of bone and muscle components was associated with age, but the expected

Table 3 – Skinfolds

	FR n=58	PreM n=48	M n=62	PostM n=45	r
Age	26.89±4.69	42.54±2.50	51.34±2.51	59.53±2.71	
Skinfolds					
Facial	6.1±1.8	7.1±1.8*	7.5±2.3	8.5±2.5	0.37***
Chin	6.6±3.1	9.6±4.7**	10.7±3.7	13.5±4.0**	0.53***
Chest I	7.9±4.2	11.4±6.2*	12.5±6.3	15.4±5.8	0.42***
Chest II	11.1±6.1	16.0±8.0**	19.2±8.5	20.3±6.2	0.45***
Suprailiacal	14.1±7.7	17.1±9.4	20.5±9.5	22.6±8.0	0.35***
Abdominal	26.8±10.5	34.8±13.7**	39.8±12.1	45.7±13.1	0.49***
Patellar	15.7±6.7	21.5±9.5**	19.5±7.4	23.2±7.3	0.28***
Biceps	7.9±4.7	10.4±5.1	11.3±6.3	13.1±5.2	0.29***
Forearm	7.7±4.2	11.1±5.5**	10.4±4.8	12.6±5.2	0.31***
Triceps	20.9±7.0	25.3±8.1**	26.6±7.1	27.9±6.2	0.32***
Subscapular	14.7±6.6	19.1±10.5	20.4±8.9	20.5±7.7	0.26***
Calf I	16.2±7.2	19.6±8.5	20.4±8.8	22.4±9.3	0.24***
Thigh	33.7±11.5	38.9±12.0	38.5±11.6	40.1±11.8	0.18**
Calf II	21.0±8.0	24.9±8.8	24.3±7.7	26.4±7.2	0.19**

*** $P<0.001$; ** $P<0.01$; * $P<0.05$; FR – fully reproductive phase; PreM – premenopausal phase; M – menopausal phase; PostM – postmenopausal phase; r – correlation for the whole sample to age
Mean values (mean±SD) of 14 skin folds in the four different reproductive phases, significance level of the difference in the mean values between an * marked group and the previous neighbouring – "younger" one is shown. The last column shows correlation to age for the whole sample and the significance level is marked with *

decrease in the weight of bone component in postmenopausal women was not confirmed using classical anthropometric method. Muscle mass shows a significant decrease ($p<0.01$) with the smallest value in postmenopausal women but the parameter does not correlate with age.

Fat distribution was determined by WHR, waist circumference, abdominal and gluteal (hip) circumference and 14 skinfolds. Mean values of WHR and circumference measurements were determined for each group. There is a positive correlation of WHR ($r=0.57$, $p<0.001$), waist ($r=0.50$, $p<0.001$) and abdominal circumference ($r=0.56$, $p<0.001$) and a relatively weaker correlation of hip circumference ($r=0.27$, $p<0.001$) to the age of the whole cohort. The differences in mean values are significant for fully reproductive women vs. the other groups except for the hip circumference, which does not show any significant difference between the fully reproductive and premenopausal groups. WHR and waist circumference increase mostly in premenopausal women ($p<0.01$), less in menopausal women and even less (all NS) in the postmenopausal group. The abdominal and hip circumferences increase proportionally up to the menopausal group ($p<0.01$ for abdominal circumference, hip NS), hip remains stable in the postmenopausal group and abdomen continues increasing though not as steeply as in the previous groups.

Table 3 shows the mean values of 14 skinfolds in the different age groups. All of them show a positive correlation with age, $p<0.001$ for all except for the skinfolds on the leg (thigh and calf II: $p<0.01$).

As total fat increases with age, changes in the different skinfolds show different patterns. The skinfold thickness at the face, bellow the chin, chest I and II, suprailiacal, abdominal, over the triceps, over the biceps, subscapular and calf I increases proportionally in the four groups, the skinfold thickness over the patella, calf II, forearm I and thigh increases in premenopausal women, remains the same or decreases slightly in menopausal women and continues increasing in the postmenopausal women. In most cases the differences in the skinfold thickness between the groups are significant only when the fully reproductive and premenopausal groups are compared. While the thickest skinfold in fully reproductive and premenopausal women is at the thigh, in menopausal and postmenopausal women it is at the abdomen, which also shows the strongest positive correlation to the age ($r=0.49$, $p<0.001$). These results are consistent with the hypothesis of centralisation of the fat mass.

Another aim of this study was to try to prove some changes in body composition and fat distribution before the onset of weight gain. Since BMI already increases significantly in premenopausal women as was also proved on our sample, the fully reproductive group was further divided into three subgroups according to age as shown in Table 4 which gives the mean values of BMI, %fat by Matiegka and Pařízková, WHR, waist and abdominal circumferences. BMI and %fat by both methods already increase slightly with age within the fully fully reproductive group (we have proved a positive correlation to age) but the greatest increase can be

observed in the abdominal circumference ($p<0.01$ if compared age group of 20–24 vs. 30–35) and there is an increase of WHR ($p<0.01$ for both comparison of 20–24 and 25–29 groups to the one of 30–35) as well which suggests the fat mass centralisation even when the weight and fat mass increase is still quite slow.

Table 5 shows the mean values of BMI, WHR, waist circumference, abdominal and hip circumference in OC/HRT users and non-users in each reproductive phase. Influence of OC/HRT on anthropometric parameters was not proved by ANOVA2 except for the influence of OC on WHR in premenopausal women, which was significantly lower in women on OC ($p<0.05$), however there were rather small numbers in the subdivided groups and the power of the tests was lower than 80%.

Discussion

Women generally gain weight from fully reproductive age to early postmenopause [16, 17], controversy exists regarding menopause influence on the weight gain. Some cross-sectional studies have found postmenopausal women to be heavier than premenopausal [18, 19], but most studies have not observed menopause-related differences in weight independently of age [20, 21, 22]. Longitudinal studies following initially premenopausal women did not find weight gain difference between the women who became postmenopausal and who remained premenopausal [23, 24]. A retrospective study on French women shows an even weight increase of over 10 kg in women between the ages of 20 and 56 without any acceleration in the menopause and at about the age of 50 BMI reaches 25, the borderline between the normal weight and overweight [16]. In this study, women aged between 48 and 55 had a mean BMI value of 26.6, and the mean weight increase between the fully reproductive and postmenopausal groups was 9.9 kg, which when height difference is considered (menopausal women are 2.9 cm shorter), approximates to data obtained in other studies. When comparing

Table 4 – BMI fat percentage and circumferences in the subdivided fully reproductive group

Age Group	20–24 n=26	25–29 n=16	30–35 n=16
Age	22.45±1.42	27.36±1.22	33.21±1.78
BMI (kg/m^2)	21.7±3.1	22.5±3.5	22.6±3.8
%Fat Pařízková	21.5±6.1	23.1±6.1	24.6±6.0
%Fat Matiegka	29.1±7.0	30.2±8.9	31.4±6.4
WHR	0.70±0.03	0.70±0.04	0.75±0.06
Waist (cm)	69.3±5.3	70.5±7.4	72.1±9.2
Abdomen (cm)	77.8±6.2	80.5±7.4	84.4±10.1

BMI – body mass index; WHR – waist to hip ratio

Mean values (mean±SD) of BMI, %fat by Matiegka and Pařízková, WHR, abdominal and waist circumferences in the sub-divided fully reproductive group. $P<0.01$ only for comparison of the age groups 20–24 vs. 30–35 for WHR and abdominal circumference, and 25–29 vs. 30–35 for WHR.

our anthropometric data to data obtained from measurements carried out on a large sample in the eighties as part of a nationally organised exercise – Spartakiade [11], it was shown that the women in our sample were 2 cm taller and 2–4 kg heavier except for the fully reproductive group. BMI is not available in the sample of Bláha and the weight difference is probably mainly due to the height difference. Since a BMI of less than 35 is one of the selection criteria for the sample and data in Czech studies comparing BMI in women from Prague and women from other parts of the country (e.g. district of Vsetín) shows a significantly lower BMI in Prague women aged between 18 and 35 and between 50 and 65 [25], it suggests that body weight in the whole Czech population increases even more than in some other countries as already proved by other investigators in the past [12, 13].

Studies proved that the lean body mass decreases and fat mass increases in aging women [26], many studies proved that lean body mass does not change much in premenopausal women and decreases after the menopause [4, 5] and correlates with years since the onset of menopause [27, 28]. Even if weight is stable, people tend to become fatter with age as muscle mass diminishes and is replaced by fat [29] and the remaining muscle may be infiltrated by fat [30]. However, studies proving these data used modern sophisticated methods such as dual-energy X-ray absorptiometry (DEXA) or computed tomography for lean mass, bone and muscle

Table 5 – OC/HRT influence on WHR, waist, abdominal circumference and BMI

	FR/NHT n=21	FR/OC n=37	PreM/NHT n=37	PreM/OC n=11
Age	28.45±5.21	25.82±4.08	42.83±2.94	41.53±2.25
WHR	0.73±0.06	0.71±0.04	0.78±0.06	0.74±0.04*
Waist (cm)	71.6±8.4	69.7±6.7	78.9±11.6	74.8±8.7
Abd. (cm)	81.5±9.5	79.7±7.6	89.0±12.8	86.4±8.4
Hip (cm)	98.4±6.6	98.1±7.4	100.5±9.1	101.5±8.7
BMI (kg/m^2)	23.8±3.5	24.8±4.3	24.1±3.8	25.1±5.0
	M/NHT n=41	M/HRT n=21	PostM/NHT n=31	PostM/HRT n=14
Age	28.45±5.21	25.82±4.08	42.83±2.94	41.53±2.25
WHR	0.80±0.06	0.79±0.06	0.82±0.06	0.82±0.07
Waist (cm)	85.3±12.4	80.1±9.4	85.6±10.2	80.3±10.2
Abd. (cm)	97.6±12.8	93.7±10.3	99.1±11.0	94.4±8.0
Hip (cm)	105.9±10.2	101.5±6.7	105.2±8.8	100.9±8.3
BMI (kg/m^2)	24.5±5.0	23.8±5.4	27.2±4.7	26.0±6.0

* $P<0.05$; FR – fully reproductive; PreM – premenopausal; M – menopausal; PostM – postmenopausal; NHT – no hormonal treatment; OC – oral contraception; HRT – hormonal replacement therapy; WHR – waist to hip ratio; Abd. – abdominal circumference; BMI – body mass index; r – correlation to age for the whole sample Mean values (mean±SD) of WHR, waist, abdominal and hip circumference and BMI in the four groups subdivided into OC/HRT users and non-users (NHT) are shown. Significance level of the difference between users and non-users is marked with *. Only OC influence on WHR was significant in the premenopausal group, however, the power of the test was lower than 80% due to small numbers in the subgroups, therefore the effect of OC/HRT cannot be ruled out.

mass assessment [26, 27, 28, 31] and not the classical anthropology. Only a progressive decrease in relative contribution of bone and muscle in the four groups was proved but no decrease in bone weight in the postmenopausal group was proved in this study. The muscle weight is significantly lower in the postmenopausal women compared to the menopausal women, though it shows the highest value in the menopausal women. Anthropometric bone parameters according to Bláha [11] do not differ much; also biacromial, bicristal, bispinal and wrist widths increase slightly with age. Although the sample measured by Bláha was up to the age of 55, there was also no decrease of bone and muscle mass by that age, on the contrary there was slight increase of both components consistent with our results, which implies the possible limitation of classical anthropometric method to asses bone and muscle component. On the other hand, the increase of fat mass in the four groups was clearly shown.

Fat distribution was determined thoroughly by 14 skinfolds while most studies use 2 to 4 skinfolds. Compared to Bláha, most skinfolds are thicker in our sample, the biggest difference being represented by the abdominal skinfold and the difference between the results increases with age. As a result of this, the same applies for %fat by Pařízková. This could be due to the presence of more sportspeople in the sample measured in the national exercise. Besides the skinfolds, we have used WHR, waist and abdominal circumference as indicators of central fat accumulation. The same indicators are widely used in other studies; in some cases also W/H (waist to height index) and the index subscapular/triceps skinfold are used. Whereas WHR remains a very important central adiposity indicator [14], waist circumference or W/H index are shown to be more precise central fat indicators [32, 33] but the influence of height on waist circumference in white adults was proven to be not significant [34]. Before comparing our results to others we must point out the different methods of waist measurement and use of waist and abdominal circumference in Czech studies – in English always referred to as waist. WHO method of measuring in the middle of the line running form the last rib to the iliac crest is generally preferred, however, many studies, including this one, consider waist circumference as the narrowest point between the xiphoid process and the superior iliac crest, which corresponds with Fetter's definition [15]. Both methods of measurement correspond well according to our experience. Some use a third approach by Martin [35] who measures the horizontal circumference at the omphalos (the centre of the navel), which corresponds to our "abdominal circumference" [13, 36]. These differences in measurement could be one of the causes for higher WHR of the Czech population compared to others [36]. If we compare the results for abdominal circumference with Hajniš, there is the same trend of changes with age, but our values are lower. Hip circumference is also generally greater in the Hajniš study and it decreases in women aged 61–65, rising in the following older age group and decreasing again after the age of 70. Lower values of our abdominal and hip circumferences might

be due to the use of a BMI lower than 35 and Prague region as selection criteria for the sample in our study. These changes of gynoid (pear shape) to android (apple shape) fat distribution accompanied by and increase in WHR with negative metabolic consequences are explained by changes in lipoprotein lipase activity under the influence of sex hormones, particularly oestrogen. Oestrogen stimulates the activity of this enzyme in the gluteofemoral area and thus increases lipid deposition in this area [37]. However, in all the studies, there is no agreement on whether these changes are due to onset of the menopause or to aging itself or other factors, although most of them tend to show a proven correlation of fat free body mass lost [28] and fat mass increase and fat centralisation to menopause or years after menopause [5, 27, 38, 20, 39], some have proven age related fat mass increase and fat centralisation [18, 28]. Many studies also point out the determining influence of physical activity, which decreases significantly with age and onset of the menopause and this plays a role in the change from gynoid to android shape [5, 8, 40]. Professional sportswomen with a high level of training show neither these changes nor the decrease in lean body mass [6].

Even if the influence of OC/HRT on body weight and body composition was not the purpose of this study, we did a comparison of anthropometric parameters between OC/HRT users and non-users as these medications may have influence on body composition and fat distribution. A review of randomized placebo-controlled trials found no evidence of large effect of OC on weight gain [41], studies are also quite consistent in proofs of no HRT effect on body weight [43, 44, 45]. Some short-term studies have proven HRT influence on fat centralisation [26, 42, 43], on the other hand, a recent randomized, double-blind and placebo-controlled 2-year-trial on 51 postmenopausal American women showed no difference in weight, intraabdominal fat, subcutaneous abdominal fat, total fat, fat percentage and fat-free mass assessed by DEXA [44]. Another randomized placebo-controlled study on 835 American postmenopausal women showed that after 3-year-follow-up HRT significantly reduced the loss of lean soft tissue mass and the ratio of trunk to leg fat mass, however there was no significant difference in the most important central fat anthropometric indicators such as WHR and waist circumference between HRT and placebo group [45]. We have not found any significant difference between OC/HRT users and non-users with the exception of lower WHR in OC users in the premenopausal group ($p<0.05$). We have to point out that the OC/HRT influence cannot be ruled out as test power is less than 80% due to small numbers of women sampled in the subgroups, however, this study was not scheduled to prove the effect of OC/HRT.

More investigation is needed to understand changes through the reproductive phases and aging in women, although it is clear that the menopausal and postmenopausal women should be subjects for preventive programmes to reduce cardiovascular risk by the change of lifestyle, mainly with regard to physical activity and a balanced diet.

Conclusion

Changes in body composition through the four reproductive phases of women's life assessed by age were studied in a cross-sectional study using the classical anthropometric method. Analyses of the cohort of Czech women showed: 1) Total body weight increases up to the menopause, fat mass absolute weight and fat relative proportion increase progressively up to the postmenopause. 2) Relative contribution of muscle and bone mass decreases with age. 3) Centralisation of fat mass with age, our results suggesting fat centralisation even before the onset of menopause.

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. HJORTLAND M. C., MCNAMARA P. M., KANNEL W. B.: Some atherogenic concomitants of menopause: The Framingham Study. *Am. J. Epidemiol*. 103: 304–311, 1976.
3. GORDON T., KANNEL W. B., HJORTLAND M. C., MCNAMARRA P. M.: Menopause and coronary heart disease. The Framingham Study. *Ann. Intern. Med.* 89: 157–161, 1978.
4. POEHLMAN E. T., GORAN M. I., GARDNER A. W., ADES P. A., ARCIERO P. J., KATZMAN-ROOKS S. M., MONTGOMERY S. M., TOTH M. J., SUTHERLAND P. T.: Determinants of decline in resting metabolic rate in aging females. *Am. J. Physiol.* 264: 450–455, 1993.
5. POEHLMAN E. T., TOTH M. J., GARDNER A. W.: Changes in energy balance and body composition at menopause: a controlled longitudinal study. *Ann. Intern. Med.* 123: 673–675, 1995.
6. DAVY K. P., EVANS S. L., STEVENSON E. T., SEALS D. R.: Adiposity and regional body fat distribution in physically active young and middle-aged women. *Int. J. Obes. Relat. Metab. Disord.* 20: 777–783, 1996.
7. 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.
8. GILLIAT-WIMBERLY M., MANORE M. M. WOOLF K., SWAN P. D., CARROLL S. S: Effects of habitual physical activity on the resting metabolic rates and body compositions of women aged 35 to 50 years. *J. Am. Diet. Assoc.* 101: 1181–1188, 2001.
9. HU G., TUOMILEHTO J., SILVENTOINEN K., BARENGO N., JOUSILAHTI P.: Joint effect of physical activity, body mass index, waist circumference and waist-to-hip ratio with the risk of cardiovascular disease among middle-aged Finnish men and women. *European Heart Journal* 25: 2212–2219, 2004.
10. 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.
11. 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.
12. ŠKODOVÁ Z., PÍŠA Z., BERKA L., CÍCHA Z., EMROVÁ R., PIKHARTOVÁ J., VORLÍČEK J., WIESNER E., VOJTÍŠEK P., PETRŽILKOVÁ Z., ČEŘOVSKÁ J., VALENTA Z.: Vývoj tělesné hmotnosti v populaci České republiky. *Čas. Lék. čes.* 33: 1033–1036, 1990.

13. ŠKODOVÁ Z., PÍŠA Z., ČEŘOVSKÁ J., GRAFNETTER D., WIESNER E., CÍCHA Z., PIKHARTOVÁ J., BERKA J., VORLÍČEK J., EMROVÁ R., VOJTÍŠEK P., VALENTA Z., PACLT M.: Body fat distribution and cardiovascular risk. *Cor et Vasa* 34: 189–198, 1992.
14. 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.
15. FETTER V., PROKOPEC M., SUCHÝ J., TITLBACHOVÁ S.: Antropologie, Academia, Prague, 1967, 49–50.
16. 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.
17. HAAPANEN N., MIILUNPALO S., PASANEN M., OJA P., VUORI I.: Association between leisure time physical activity and 10-year body mass change among working-aged men and women. *Int. J. Obes. Relat. Metab. Disord.* 21: 288–296, 1997.
18. PASQUALI R., CASIMIRRI F., LABATE A. M., TORTELLI O., PASCAL G., ANCONETANI B., GATTO M. R., FLAMIA R., CAPELLI M., BARBARA 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.
19. 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.
20. 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.
21. 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.
22. 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.
23. 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.
24. 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.
25. 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.
26. GENAZZINI 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.
27. 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.
28. 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.

29. GALLAGHER D., RUTS E., VISSER M., HESHKA S., BAUMGARTNER R. N., WANG J., PIERSON R. N., PI-SUNYER F. X., HEYMSFIELD S. B.: Weight stability masks sarcopenia in elderly men and women. *Am. J. Physiol. Endocrinol. Metab.* 279: 366–375, 2000.
30. GOODPASTER B. H., KELLEY D. E., THAETE F. L., HE J., ROSS R.: Skeletal muscle attenuation determined by computed tomography is associated with skeletal muscle lipid content. *J. Appl. Physiol.* 89: 104–110, 2000.
31. 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.
32. ASHWELL M., COLE T., DIXON A.: Ratio of waist circumference to height is strong predictor of intraabdominal fat. *BMJ* 313: 559–560, 1996.
33. 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.
34. HAN T. S., SEIDEL J. C., CURRALL J. E. P., MORISSON C. E., DEURENBERG P., LEAN M. E.: The influence of height and age on waist circumference as an index of adiposity in adults. *Int. J. Obesity* 21: 83–89, 1997.
35. MARTIN R., SALLER K.: Lehrbuch der Anthropologie, G. Fischer, Stuttgart, 1957, p 661.
36. HAJNIŠ K., KUNEŠOVÁ M.: Vývoj obvodu břicha a gluteu (pasu a boků) v dospělosti. *Čas. Lék. čes.* 17: 537–543, 2000.
37. REBUFF-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.
38. POEHLMAN E. T., TCHERNOF A.: Traversing the menopause: changes in energy expenditure and body composition. *Coron. Artery Dis.* 9: 799–803, 1998.
39. 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.
40. STERNFELD B., NGO L., SATARIANO W. A., TAGER I. B.: Associations of body composition with physical performance and self-reported functional limitation in elderly men and women. *Am. J. Epidemiol.* 156: 110–121, 2002.
41. GALLO M. F., GRIMES D. A., SCHULZ K. F., HELMERHORST F. M.: Combination estrogen-progestin contraceptives and body weight: systematic review of randomised controlled trials. *Obstet. Gynecol.* 103: 359–373, 2004.
42. 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.
43. REUBINOFF B. E., WURTMAN J., ROJANSKY N., ADLER D., STEIN P., SCHENKER J. G., BRZEZINSKI A.: Effect of hormone replacement therapy on weight, body composition, fat distribution, and food intake in early postmenopausal women: a prospective study. *Fertil. Steril.* 64: 963–968, 1995.
44. 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.
45. 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.