Assessment of the BMI, WHR and W/Ht in pre- and postmenopausal women

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ABSTRACT   The main goal of this study was to determine whether and how values of the BMI, WHR and W/Ht indicators change in pre- and postmenopausal women. The tested group consisted of 10,216 women aged 25-95 years. Data were collected during the national campaign „Fighting Obesity", organized by Hand-Prod Company between 2000-2002 across Poland, when adult women voluntarily filled in a questionnaire and participated in anthropometric measurements. The BMI, WHR and W/Ht values were calculated based on these measurements. The values of the BMI, WHR and W/Ht change with age. However, in each age group postmenopausal women have higher BMI, WHR and W/Ht than premenopausal women. Thus, the results obtained indicate that hormonal changes occurring in the climacterium period cause an increase in the analyzed index values. The BMI used herein is characterized by high accuracy in indicating obesity. Moreover, the WHR and W/Ht are also used as adiposity indicators, which may be useful in assessment of the risk of disease or death caused by hypertension, cardiac diseases, diabetes, or even cancers. However, they should not be used only in relation to obese women, because even a slight increase in visceral obesity, with body mass within normal limits, may contribute to unfavorable changes in the woman's metabolic profile, which in turn, may present a risk of illness.

KEY WORDS: menopausal status, overweight, obesity, Polish women

The aging process entails changes in physiological and morphological parameters. The age specific decline in physiological and morphological parameters in women reveals a similar pattern, during which the climacterium plays a large part [HARDY *et al.* 2000, JUHAERI *et al.* 2003, PROPER *et al.* 2007]. The

climacterium in women is the period when changes taking place in the body lead to the eventual cessation of the function of the reproductive organs. According to the WHO convention [WHO 1996], menopause signifies the last menstrual period in a woman's life followed by a complete cessation of menstrual flows. This moment is determined retrospectively as a 12-month long amenorrhea.

Numerous studies indicate that menopause occurs around 50 years [SZWED 2001, KACZMAREK 2007*a*]. Research and examination of the potential factors affecting the age of menopause is of particular importance for indication of risk factors of cardiovascular diseases, cancer and osteoporosis. The rapid increase in the rate of obesity in populations also constitutes a significant, global health problem. Overweight and obesity have unfavorable impact on health, increasing the risk of arterial hypertension, type 2 diabetes, cardiovascular diseases, inflammation of joints and bones and certain types of cancers [HUANG *et al.* 1998, LEITE and NICOLOSI 2006, GHAYOUR-MOBARHAN *et al.* 2007]. The researchers point to a multitude of factors contributing to the occurrence of overweight or obesity related problems, emphasizing the influence of both genetic and environmental factors [MARTI *et al.* 2004, LEITE and NICOLOSI 2006, WANG *et al.* 2006]. It is stressed that the differences in the morphological parameter values in pre- and postmenopausal women are the effect of changes in steroid hormone concentrations in blood [PHILIPS and SHERWIN 1992]. In postmenopausal women estrogen deficiency plays an important role in the change of body composition and fat tissue distribution [WEN *et al.* 2003, SKRZYPCZAK and SZWED 2005].

The main goal of this study is to determine whether and how the BMI, WHR and W/Ht indicators change in pre- and postmenopausal women.

Materials and methods

The empirical basis for this paper is the material from cross-sectional studies carried out as part of the national campaign „Fighting Obesity" organized by the Hand-Prod Company in the years 2000-2002 throughout Poland. The adult women voluntarily filled out the questionnaires and participated in anthropometric measurements. The tested group consisted of 10,216 women aged from 25 to 95. The women who participated in the studies were differentiated in terms of age, education, place of living and lifestyle. The research tool used was a questionnaire used to determine the menopausal status of the women. The menopause was assessed by a retrospective method, consisting of reference to the past and relying on the memory of the investigated women. Furthermore, anthropometric measurements of body height and weight, and waist and hip circumferences were made in the women surveyed. The anthropometric measurements of the women were carried out using GPM anthropometric instruments, according to the technique of Martin and Saller [MALINOWSKI and WOLAŃSKI 1988]. Body height was measured by a portable stadiometer in the standing up, straightened position, without shoes, with an accuracy of 0.5 cm. Body mass was measured in underwear alone, without shoes, with an accuracy of 0.1 kg. Measurements of waist and hip circum-

ferences were taken directly on the body with an accuracy of 0.5 cm. The waist circumference was taken at the midpoint between the iliac crest and the lower border of the ribs after a normal expiration; the hip measurement was taken around the maximum circumference of the buttocks and the symphysis pubis. The measurements were made by experienced investigators specially trained for it, according to the presented techniques. Inter- and intra-observer variability in the measurements of waist and hip circumferences were made before investigations. The value of the inter- and intra-observer variability was less than 0.5 cm.

Based on the measurements made, the BMI (Body Mass Index, kg/m^2) was determined. The BMI values, determining the body structure, were divided into categories, according to the International Classification of adult underweight, overweight and obesity [WHO 2000]. These categories are: underweight (BMI<18.50), normal range (18.50$\leq$BMI<24.99), overweight (25.00$\leq$BMI<29.99), obesity I (30.00$\leq$BMI<34.99), obesity II (35.00$\leq$BMI <39.99), and obesity III (BMI$\geq$40.00). Based on the measurements, the WHR (Waist to Hip Ratio) and W/Ht (Waist/Height) indicators were also calculated, indicating the central distribution of the fatty tissue. The advantage of the indicators is the possibility of use in early detection of obesity related diseases, even in individuals with normal body mass. The following WHR categories were differentiated: <0.8 and $\geq$ 0.8 [WHO 2000] and for W/Ht: 0.5 and $\geq$ 0.5 [HSIEH *et al.* 2003].

All statistics were performed using the statistical software package Statistica 7.1. (StatSoft, Inc 2006 Statistica for Win-

dows). The „status quo" method was used to estimate the menopausal age in the investigated women. The mean age at menopause was calculated using probit analysis. To examine whether and how the BMI, WHR and W/Ht change with age, regression analysis was applied. For observation of the changes in the indicators under analysis in the groups of pre- and postmenopausal women, variance analysis was carried out.

Results

BMI, WHR and W/Ht

A prevalence for underweightness was found in 1.0% women. More specifically, 38.4% of the women in the tested group were overweight, whereas 27.9% of women were found be obese (Fig. 1). The frequencies of the BMI categories by age groups (in 5 year intervals) are presented in figure 2. Only healthy women were qualified for the tests, i.e., ones in whom no chronic diseases such as diabetes, hypertension, or cardiovascular diseases were found. Normal values (below ones predisposing for obesity-related diseases) of WHR (<0.8) were found in 32% women, while those for W/Ht (<0.5) − in 22%. Positive correlations between the parameters analyzed were found: BMI-WHR R=0.29, p<0.05; BMI-W/Ht R=0.79, p<0.05; WHR-W/Ht R=0.64, p<0.05. In table 1 the frequencies of women with respect to their BMI categories are presented in the WHR and W/Ht groups. It was observed that even in women with normal body mass, almost half of them were characterized with WHR $\geq$ 0.8 and W/Ht $\geq$ 0.5, while in case in overweight and obese women, the frequency was significantly increased.
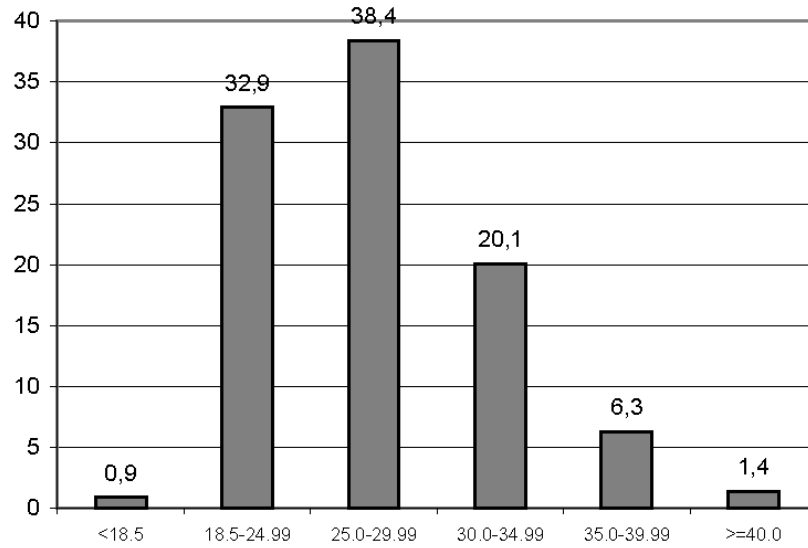
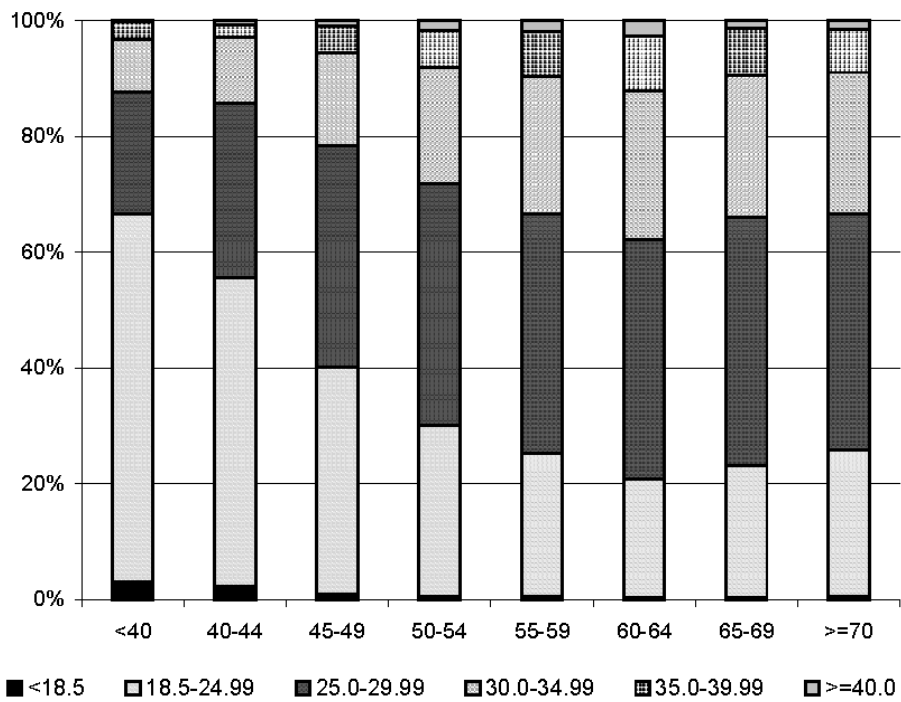Fig. 1. Frequency of women in the BMI categories.

Fig. 2. Frequency of women in the BMI categories by age groups.

Table 1. Frequencies of women, with respect to their BMI categories, in the WHR and W/Ht groups.

BMI	% WHR		% W/Ht	
	<08	≥08	<05	≥05
<18.50	56.1	43.9	93.0	7.0
18.5-24.99	52.0	48.0	57.7	42.3
25.0-29.99	28.9	71.1	12.2	87.8
30.0-34.99	19.2	80.8	1.9	98.1
35.0-39.99	15.2	84.8	0.3	99.7
≥40.00	8.8	91.2	0.0	100.0

BMI, WHR and W/Ht vs. calendar age and menopausal status

The „status quo" method was used to calculate the menopausal age, which allows for elimination of errors the retrospective method of examination is burdened with (many women may not remember the exact date of their last menstruation). The mean age at menopause was calculated using probit analysis. This analysis enabled us to determine the percentage of women in each age group, who had stopped menstruating at least 12 months prior to their participation in the study. The median of menopausal age, for women after natural menopause is 51.74 (chi^2 = 6513.59, df =1, p<0.00).

In order to find out whether and how the morphological parameters determined based on the indicators BMI, WHR and W/Ht change in women, along with the onset of menopause, age-related changes in these parameters were analyzed in the first instance. For this purpose regression analysis was applied, which proved that all of the indicators' values significantly increase with age. The regression analysis results are presented in tables 2 and 3. It is worth noting that the highest increase in the analyzed indicators was recorded in 50-59 year old women.

Table 2. Changes of the BMI, WHR and W/Ht with age – regression analysis results.

Index	N	R	R^2	B	SE	t	p
BMI	10216	0.24	0.06	0.096	0.01	24.61	0.000
WHR	8167	0.19	0.04	0.001	0.01	17.63	0.000
W/Ht	8173	0.31	0.097	0.002	0.01	29.65	0.000

Table 3. Mean values of the BMI, WHR and W/Ht in age categories.

Index	<40 (N=695)		40-49 (N=2704)		50-59 (N=2652)		60-69 (N=2568)		≥ 79 (N=1597)	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
BMI	24.39	4.46	26.07	4.45	28.01	4.75	28.79	4.61	28.33	4.61
WHR	0.79	0.07	0.81	0.07	0.84	0.07	0.84	0.08	0.84	0.08
W/Ht	0.49	0.08	0.53	0.08	0.56	0.08	0.58	0.08	0.59	0.08

Next, in order to observe the changes of the BMI in pre- and postmenopausal women, the analysis of variance was carried out. The results obtained indicate that the changes in the BMI in the groups of pre- and postmenopausal women show significant statistical differences. The women who still menstruate have a lower BMI than women in the postmenopausal period (F=648.62 df=1, p<0.001). Coefficient of variation (CV) values indicate considerable variability in this trait, both in the premenopausal (CV=17.62) and postmenopausal (CV=16.56) women. Table 4 presents the mean values of the BMI in pre- and postmenopausal women. Subsequently, the analysis of variance with two way interaction was carried out in order to observe changes in the BMI of pre- and postmenopausal women aged 48-52, in 1-year interval age categories. The results suggest that the BMI increases significantly after menopause (F=6.87, df=1, p<0.01) in selected categories of age. There were no interactions between age and menopausal status (F=1.41, df=4, p=0.230) (Fig. 3).

Table 4. Mean values of BMI, WHR and W/Ht in pre- and postmenopausal women.

Index	Premenopausal women				Postmenopausal women			
	N	$\bar{x}$	SD	CV	N	$\bar{x}$	SD	CV
BMI	3350	25.82	4.55	17.62	6866	28.32	4.69	16.56
WHR	2140	0.81	0.07	8.64	6027	0.84	0.07	8.33
W/Ht	2140	0.52	0.08	15.39	6033	0.58	0.08	13.79
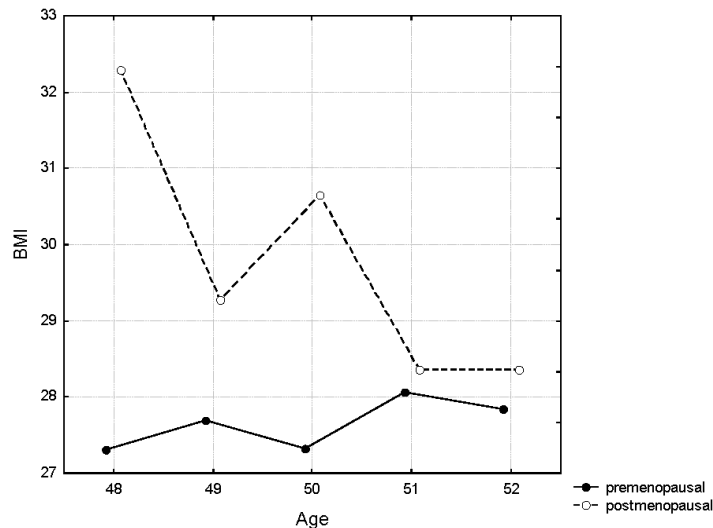
Fig. 3. The mean BMI values, depending on 1-year interval age categories in pre- and postmenopausal women; results of two-way analysis of variance.

The WHR and W/Ht changes in the women under examination show an upward trend similar to the BMI. The variance analysis results confirm that the WHR ($F=164.64$ df=1, $p<0.001$) and W/Ht ($F=743.34$ df=1, $p<0.001$) values significantly increase in women who no longer menstruate (table 4). The results of the analysis of variance with two way interaction in the WHR and W/Ht of pre- and postmenopausal women aged 48-52 suggest that the WHR ($F=16.56$, df=1, $p<0.01$) and W/Ht ($F=18.24$, df=1, $p<0.01$) increase significantly after menopause in selected categories of age. There were no interactions between age and menopausal status (WHR: $F=0.57$, df=4, $p=0.685$; W/Ht: $F=1.52$, df=4, $p=0.195$) (Figs. 4, 5).
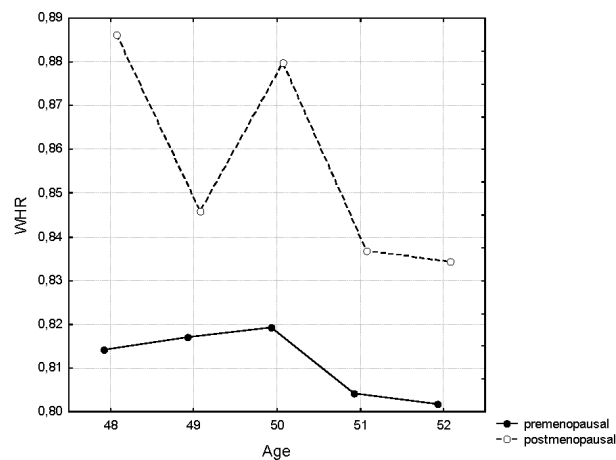

Fig. 4. The mean WHR values, depending on 1-year interval age categories in pre- and postmenopausal women; results of two-way analysis of variance.
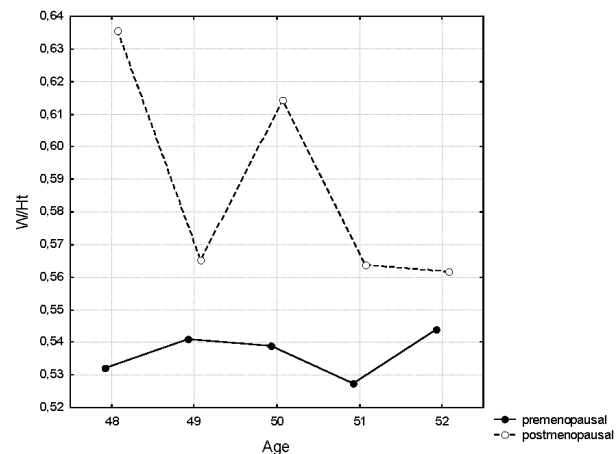

Fig. 5. The mean W/Ht values, depending on 1-year interval age categories in pre- and postmenopausal women; results of two-way analysis of variance.

Discussion

The frequencies of overweight and obesity in the tested group were found to be significantly higher than those in the population of Polish women (overweight 14% and obesity 13% – GUS Chief Statistical Office surveys of 2004). The group examined was not fully representative of all Polish women in terms of body mass. This situation occurred due to the fact that the data were collected during the national campaign „Fighting Obesity" in which the percentage of participant-women with body mass problems was by far higher. Nonetheless, only healthy women without chronic diseases were qualified for the studies.

The results of this paper confirms the fact of a significant increase in the BMI, WHR and W/Ht with age of the women participating in the survey, as previously presented by HSIEH *et al.* [2003], MATAIX *et al.* [2005], WILSGAARD *et al.* [2005] and KACZMAREK [2007*b*]. The most probable cause of the phenomenon was suggested to be in the demand for energy decreasing with calendar age caused equally by the decrease of basic metabolism and decrease of physical activity. Physical activity, promoted in numerous countries as a significant factor contributing to positive aging, plays a particularly important role in health maintenance and proper morphological parameters, in particular body mass [REN *et al.* 1995, STATHI *et al.* 2003, MATAIX *et al.* 2005].

The results obtained also indicate that hormonal changes occurring during the climacterium period cause the changes in the morphological parameters. The postmenopausal women have statisti-cally significant higher values of the BMI, WHR and W/Ht than those who still menstruate (table 4). Similar results were obtained by KIRCHENGAST *et al.* [1998], IJUIN *et al.* [1999], and SKRZYPCZAK and SZWED [2005]. PRADO *et al.* [2003] suggest the absence of significant changes of the BMI after menopause. These researchers suggest changes of this indicator only along with the age of the examined subject. However, the results of this paper expressly show that for each age group postmenopausal women have higher BMI, WHR and W/Ht than premenopausal women (Figs. 3-5).

The increase of the indicators analyzed after menopause is related to the lack of ovarian hormones, particularly estrogens, that used to play a significant role in body composition regulation and fat tissue distribution in pre- and postmenopausal women [JUHAERI *et al.* 2003, WEN *et al.* 2003].

In premenopausal women the main hormone is estradiol, while the main postmenopausal estrogen is estrone. Following the cessation of hormonal production in the ovaries, they are produced exclusively from suprarenal androstenedione and aromatized to estrone in the process of peripheral extraglandular conversion [KULIKOWSKI and TOMASZEWSKA 1995, WARENIK-SZY-MANKIEWICZ 1996]. This transformation takes place mainly within fatty tissue, which explains the greater adiposity in postmenopausal women.

On the other hand, however, researchers indicate the subsequent protective role of adiposity during the climacterium period, which manifests in later menopause in women having a higher BMI [AKAHOSI *et al.* 2002]. As under-

lined by KIRCHENGAST [1993], more corpulent women having higher circumference and breadth measurements produce more oestrogen during the climacterium than very slender women. Therefore, the intensity of climacteric symptoms in these women is significantly lower than in slim women of the same age. At the same time, one should remember that the fat mass increase has a greater impact on the metabolic process in aging women than the mass *per se*. Fatty tissue growth leading to visceral obesity increases the risk of the occurrence of metabolic disorders of fat and carbohydrate management and the cause of such diseases such as arterial hypertension, sclerosis or type II diabetes [VAN PELT *et al.* 2001].

Conclusions

Based on the results obtained, we can state that the hormonal changes occurring during the climacterium cause increase of the BMI, WHR and W/Ht values. Regardless of calendar age, the menopause contributes to changes in fatty tissue distribution in women. The BMI used herein has high accuracy in indicating obesity. Moreover, the WHR and W/Ht, which are also used as adiposity indicators, may be useful in assessment of the risk of disease or death caused by hypertension, cardiac diseases, diabetes, or even cancers. However, they should not be used only in relation to obese women, because even a slight increase of visceral obesity within normal body mass limits may contribute to unfavorable changes of the woman's metabolic profile, which in turn, may represent a risk of sickness to occur.

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Streszczenie

Głównym celem niniejszej pracy było określenie czy i w jaki sposób zmieniają się wartości wskaźników BMI, WHR oraz W/Ht u kobiet przed menopauzą i po menopauzie. Badaną grupę stanowiło 10.216 kobiet w wieku 25-95 lat. Dane zebrano podczas ogólnopolskiej akcji „Walczymy z Otyłością", organizowanej przez Firmę Hand-Prod w latach 2000-2002 na terenie całej Polski, podczas której zgłaszające się dorosłe kobiety dobrowolnie wypełniały ankietę, i którym wykonano pomiary wysokości, masy ciała, obwodu pasa oraz bioder. Na podstawie wykonanych pomiarów określono wskaźnik BMI, WHR oraz W/Ht.

Niedowagę stwierdzono u 1,0% kobiet. Częstość występowania nadwagi w badanej grupie wynosiła 38,4%, natomiast otyłości 27,9% (ryc. 1 i 2). Prawidłowe wartości (poniżej predysponujących do wystąpienia chorób powiązanych z otyłością) dla WHR stwierdzono u 32% kobiet, zaś dla W/Ht u 22%. Stwierdzono pozytywne korelacje pomiędzy analizowanymi parametrami (BMI-WHR R=0,29, p<0,05; BMI-W/Ht R=0,79, p<0,05; WHR-W/Ht R=0,64, p<0,05). Zaobserwowano, że nawet wśród kobiet o prawidłowej masie ciała niemal połowa charakteryzowała się WHR≥0,8 oraz W/Ht≥05, zaś wśród kobiet z nadwagą oraz otyłych częstości te istotnie rosły (tab.1).

Do obliczenia wieku menopauzy wykorzystano metodę „status quo", która umożliwia wy- eliminowanie błędu, jakim obarczone jest badanie retrospektywne. Wykorzystując analizę probitową, określono procent kobiet w każdej grupie wiekowej, które przestały miesiączko- wać, co najmniej 12 miesięcy przed poddaniem się badaniu. Średnia probitowa wieku post- menopauzalnego dla kobiet po menopauzie naturalnej wynosi 51,74 lata (chi^2 = 6513,59, df =1, p<0,00).

Chcąc zbadać, czy i w jaki sposób wraz z menopauzą zmieniają się u kobiet wartości pa- rametrów morfologicznych określonych na podstawie wskaźników: BMI, WHR oraz W/Ht, w pierwszej kolejności przeanalizowano zmiany tych parametrów z wiekiem. W tym celu zastosowano analizę regresji, która wykazała, że wartości wszystkich wskaźników istotnie rosną z wiekiem (tab. 2 i 3). Następnie w celu zaobserwowania zmian wskaźnika BMI w grupach kobiet przed menopauzą i po menopauzie, przeprowadzono analizę wariancji. Uzyskane wyniki wskazują, iż zmiany wartości wskaźnika BMI, WHR oraz W/Ht, w gru- pach kobiet przed menopauzą i po menopauzie, istotnie się różnią (tab. 4). Kobiety, które nadal miesiączkują mają wskaźniki BMI (wartość testu F=648,62 df=1, p<0,001), WHR (F=164.64 df=1, p<0.001) oraz W/Ht (F=18.24, df=1, p<0.01) niższe niż kobiety, znajdujące się w okresie pomenopauzalnym. Wartości współczynników zmienności wskazują na znaczną zmienność tej cechy, zarówno w grupie kobiet przed menopauzą, jak i po menopau- zie. Jednakże w każdej grupie wiekowej kobiety po menopauzie mają wskaźniki BMI, WHR oraz W/Ht wyższe niż kobiety przed menopauzą (ryc. 3-5).

Zmiany hormonalne zachodzące w okresie klimakterium powodują wzrost wartości wskaźników BMI, WHR oraz W/Ht. Niezależnie od wieku kalendarzowego menopauza przyczynia się do zmian w rozkładzie tkanki tłuszczowej u kobiet. Wykorzystany w niniej- szej pracy wskaźnik BMI charakteryzuje się wysoką dokładnością w predykowaniu otyłości. Wskaźniki WHR oraz W/Ht, jako indykatory otłuszczenia, mogą być użyteczne do oceny ryzyka zachorowania lub śmierci z powodu nadciśnienia, chorób serca, cukrzycy a nawet nowotworów. Wskaźniki te powinny być wykorzystywane nie tylko w odniesieniu do kobiet otyłych, ponieważ nawet niewielki wzrost otyłości wisceralnej, przy masie ciała pozostającej w normie, może przyczyniać się do niesprzyjających zmian profilu metabolicznego kobiety, a tym samym stanowić ryzyko wystąpienia chorób.