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BODY MASS, DEPRESSIVE SYMPTOMS AND MENOPAUSAL STATUS: AN EXAMINATION OF THE "JOLLY FAT" HYPOTHESIS

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Purpose: **Estrogens are linked with depression due to their ability to alter the function of the serotonin neural systems. We hypothesize that postmenopausal women should have a higher degree of depressive symptoms than premenopausal women. Further, because estrogen levels in postmenopausal women positively correlate with body fat, we hypothesize that there is an inverse relationship between body fat and depressive symptoms among postmenopausal women.**

Methods: **We enrolled 1156 Polish urban women aged 45 to 64 in a cross-sectional study. Depressive symptoms were assessed by the Center for Epidemiologic Studies—Depression Scale (CES-D) scale. Menopausal status and education level was assessed by a standardized questionnaire.**

Main findings: **Postmenopausal women had higher mean CES-D scores of depressive symptoms than premenopausal women (14.4 versus 13.2 respectively, $p = .018$). Both among pre- and postmenopausal women, those with higher education had lower scores of depressive symptoms. In addition, in postmenopausal women with lower education an inverse relationship was observed between body mass index (BMI) and depressive symptoms: a higher BMI was associated with a lower score of depressive symptoms ($p = .009$). Such a relationship was not present among premenopausal women or women who were postmenopausal but better educated.**

Conclusions: **This study indicates that menopausal status is related to differences in the degree of occurrence of depressive symptoms. Our results support the "Jolly Fat" hypothesis for postmenopausal women with lower education, namely, a higher BMI is associated with lower score of depressive symptoms.**

Introduction

Sex steroids play an important role in female neurobiology (Genazzani, Monteleone, & Gambacciani, 2002). Estrogens and progestins have the ability to alter the function of the neurotransmitter serotonin (Bethea, Gundlah, & Streicher, 2002), which plays a major role in depression (Archer, 1999). Diminishing estrogens after the menopause have been linked to depression, reduced libido, and cognitive disturbances in women (Halbreich, 1997).

A higher prevalence of depression has been shown for women during the late premenopausal years (Weissman, Bruce, Leaf, Florio, & Holzer, 1991; Blazer, Kessler, McGonagle, & Swartz, 1994), when the production of ovarian hormones has diminished. However, there is no agreement among studies about increases in depression following the menopause when circulating levels of endogenous estrogens are generally low. Among women aged 40 to 55, those who were postmenopausal showed higher scores on

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the Beck depression scale then premenopausal women (Sagsoz, Oguzturk, Bayram, & Kamaci, 2001). However, in a prospective study, rates of depression and anxiety did not differ in the same group of women before and after menopause (Kaufert & Tate, 1992). Similarly, levels of psychological distress did not differ for groups of women who were pre-, peri-, and postmenopausal (Bush, Zonderman, & Costa, 1994).

While postmenopausal women have, on average, lower levels of circulating estrogens than premenopausal women, they still can have high levels of estrogens in specific peripheral sites, including breast, bone, and the brain (Simpson, 2002; Simpson et al., 2002). In postmenopausal women, levels of estrogens show a direct positive relationship to the amount of adipose tissue (Hankinson et al., 1995; Kirchengast, 1994; Verkasalo, Thomas, Appleby, Davey, & Key, 2001), which serves as a source of aromatase, which converts androgens to estrogens (Purohit & Reed, 2002). Therefore, it can be expected that postmenopausal women who have higher amounts of adipose tissue, and therefore higher levels of estrogen, may be less prone to depressive symptoms than postmenopausal women who have low levels of estrogens due to low levels of fat stores.

The "Jolly Fat" hypothesis proposes that overweight people of both genders have a lower risk of depression and show a reduction in depressive symptoms (Crisp & McGuiness, 1976) due to several possible mechanisms, including higher consumption of certain nutrients, which may reduce or prevent depressive symptoms (Crisp & McGuiness, 1976). However, studies on body weight and depression show conflicting results (Fabricatore & Wadden, 2004; McElroy et al., 2004). Obesity has been related to low levels of depression in men and low levels of anxiety in women (Crisp & McGuiness, 1976), and among the Chinese elderly, both obese men and women are less likely to exhibit depressive symptoms than do elderly people of normal weight (Bin Li et al., 2004). Another study showed an inverse relationship between body weight and depression for California men but not for women (Palinkas, Wingard, & Barrett-Connor, 1996). Several studies suggest an increased risk of depression for obese people (Hällström & Noppa, 1981; Johnston, Johnston, McLeod, & Johnston, 2004; Roberts, Strawbridge, Deleger, & Kaplan, 2002), including a prospective study showing that obesity was related to an increased risk of depression 5 years later (Roberts, Deleger, Strawbridge, & Kaplan, 2003). However, other studies either failed to show an effect of obesity on depression (Friedman & Brownell, 1995), or suggested that obesity was associated with depression only among severely obese (Dixon, Dixon, & O'Brien, 2003; Dong, Sanchez, & Price, 2004; Onyike, Crum, Lee, Lyketsos, & Eaton, 2003).

The purpose of this study was to assess if menopausal status and body composition in women show a relationship with depressive symptoms. The level of education was included as a potentially confounding variable because previous reports document a relationship between depression and education (Eisses et al., 2004; Glazer et al., 2002; Hauenstein & Boyd, 1994; Swenson, Baxter, Shetterly, Scarbro, & Hamman, 2000). In the Polish population, similar to many other countries, education was shown to be an important correlate of health status (Perova et al., 2001; Stelmach, Kaczmarczyk-Chalas, Bielecki, Stelmach, & Drygas, 2004). Education is also the most commonly used measure of socioeconomic status in epidemiologic studies (Winkleby, Jatulis, Frank, & Fortmann, 1992) and results of recently published meta-analysis suggest that socioeconomic status is an important risk factor for depression (Lorant et al., 2003).

We hypothesize that women who are postmenopausal should have greater depressive symptoms then premenopausal women. In addition, we expect an inverse relationship between body composition and depressive symptoms for postmenopausal women, assuming a protective role of estrogen on mood that is related to body fat.

Subjects and Methods

Study population

The study population consisted of 3,544 men and women from the city of Krakow in Poland. Participants were selected from the City of Krakow Residents Registry Data, randomized in strata by gender, age, and district. A sample of 900 women was randomly selected out of 63,710 registered female residents who were between 45 and 54 years of age and a sample of 888 women was randomly selected out of 40,858 registered female residents who were between 55 and 64 years of age. A letter inviting for the participation in the study was sent to all 1,788 selected women and was followed by a phone call from a study assistant. One thousand one hundred fifty-six (64.65%) women responded to solicitation and agreed to participate in the project. Participants were visited at home by a trained interviewer. A written informed consent was obtained from all study participants, and the study protocol was approved by an institutional bioethical committee.

Menopausal status was assessed based on a standardized questionnaire. Women were asked if they were still experiencing menstrual cycles, or how long ago cycles had stopped, and whether the cessation of cycles had been natural or not (due to hysterectomy). All women who reported hysterectomy or use of hormonal medication, including hormonal replacement therapies (n = 125), and women who did not complete The Center for Epidemiologic Studies—De-

Table 1. Age, BMI, and depressive symptoms in pre- and postmenopausal women with lower and higher levels of education

	Premenopausal Women Mean (SE)				Postmenopausal Women Mean (SE)			
	All Premenopausal	Lower Education	Higher Education	*p* Value	All Postmenopausal	Lower Education	Higher Education	*p* Value
n	402	122	280		601	216	385	
Age (y)	48.5 (0.14)	48.1 (0.23)	48.7 (0.17)	.17	57.4 (0.18)	57.3 (0.31)	57.4 (0.22)	.74
BMI (kg/m^2)	27.8 (0.27)	29.1 (0.50)	27.2 (0.31)	.001	29.1 (0.22)	29.9 (0.39)	28.7 (0.27)	.006
CES-D score	13.2 (0.47)	15.2 (0.80)	12.3 (0.57)	.008	14.4 (0.41)	15.5 (0.70)	13.8 (0.49)	.04

p Values denote the significance of difference between the lower and higher levels of education groups within either premenopausal or postmenopausal women (from planned comparisons following the analyses of variance).
Abbreviations: BMI, body mass index; CES-D, The Center for Epidemilogic Studies—Depression Scale; SE, standard error.

pression Scale (CES-D) questionnaire (n = 28) were removed from the analyses. Data on 1,003 women were used in the analyses. Body weight was measured to the nearest 0.1 kg and height to the nearest 0.5 cm. Depressive symptoms were assessed by the CES-D scale developed to detect depressive symptoms in the general population (Radloff, 1977). Scores from 0 to 60 are possible, with a score of 16 or greater indicating that a person is at elevated risk for depression. This scale has been validated for the Polish population (Dojka, Gorkiewicz, & Pajak, 2003).

Statistical analysis

Women were divided into two groups based on their level of education: the lower education group included women who attended primary schools, vocational schools, or attended but did not complete high school education. The higher education group included women who completed their high school or college education.

The depression scores were compared in a two-way analysis of covariance, with age as the covariate and menopausal status and education level as factors. Preliminary analyses revealed no significant heterogeneity of slopes among the groups and the interaction terms involving the covariate were removed from the model. Adjusted group means were compared in a priori contrasts, using the Bonferroni correction to control for significance levels. Statistical power of the tests was computed (as adjusted power estimates) according to the SAS Institute procedures (JMP Statistics and Graphics Guide, version 4, Cary, NC, 2001).

We also performed a two-way analysis of covariance, with education and menopausal status as factors and with two covariates (age and body mass index [BMI]). The relationships between BMI and depressive symptoms were evaluated using linear regression in each of the four groups (premenopausal and lower education, premenopausal and higher education, postmenopausal and lower education, and postmenopausal and higher education).

To explore further the possibility that differences in score of depressive symptoms depended on menopausal status rather than age, analysis of covariance was performed on women aged 48 to 55, including only those age categories that contained sufficient samples of both pre- and postmenopausal women (women younger than 48 and older than 55 were mostly pre- and postmenopausal, respectively). There was no heterogeneity of depression–age slopes among the pre- and postmenopausal groups and the analysis of covariance was rerun after the interaction term had been removed from the model. Another test of a possible relationship between age and depression was a two-way analysis of variance performed on the group of postmenopausal women only (ages 50 to 64), with age and education levels as factors, followed by a test of linear trend (first-degree polynomial) across 15 age groups. In all other models, age was modeled as a continuous variable.

Results

Characteristics of participants

The mean age of women was 57.4 years (range 45 to 64). Both mean and median self-reported age at natural menopause was 50.0. Thirty-one postmenopausal women did not report menopausal age. By the age of 40, only 7 women (1.2%) had reached the menopause but, by the age of 56, 95.6% of women had reached menopausal status.

Premenopausal women were younger on average than postmenopausal women (F = 1132.0, p = .0001) and had a lower mean BMI (F = 9.5, $p < .01$) (Table 1). Groups characterized by lower and higher education did not differ in mean age (54.0 years and 53.7 years, respectively; F = 1.66, p = .20). Women with a lower education had a higher mean BMI than better educated women (29.6 kg/m^2 and 28.1 kg/m^2, respectively; F = 18.1, p = .0001).

When BMI was categorized according to the World Health Organization standards (BMI 18.5 to 24.9, normal; 25.0 to 29.9, overweight; ≥30, obese), within the group of premenopausal women 31.9% were categorized as being of normal weight, 38.4% as overweight, and 29.7% as obese. Within the postmenopausal women 20.4% were categorized as normal,

40.0% as overweight, and 39.6% as obese. The frequencies in these BMI categories differed significantly between the premenopausal and postmenopausal women (G-squared = 17.47, degree of freedom [df] = 2, p = .0002). Among the premenopausal women, 32.6% had a CES-D score of 16 points or greater; in the postmenopausal group significantly more women (38.6%) had such a score (G-squared = 3.8, df = 1, p = .05).

Depressive symptoms in relation to menopausal status and education

Postmenopausal women had higher scores of depressive symptoms as assessed by the CES-D scale. After adjustment for age (F = 4.14, df = 1, 998, p = .042), postmenopausal women scored, on the average, 14.4 and the premenopausal women 13.2 (F = 5.67, df = 1, 998, p = .018). The score of depressive symptoms was related to the education: higher education groups had lower scores on CES-D scale then lower education groups. Better educated women scored 13.2, and less educated scored 15.4 (F = 11.22, df = 1, 998, p = .0008). The total effect of interaction between education and menopausal status was statistically insignificant (F = 0.66, df = 1, 998, p = .42). However, planned comparisons of means (with df = 1 and the Bonferroni critical probability level of 0.0125) showed that within the premenopausal group, the higher education group had lower scores of depressive symptoms than the lower education group (F = 6.98, p = .008, adjusted power 0.7). In postmenopausal women, the higher and lower education groups did not differ significantly in age-adjusted scores of depressive symptoms (F = 4.24, p = .04, adjusted power 0.4). In the higher education group, the postmenopausal women had higher scores of depressive symptoms than the premenopausal women (F = 7.75, p = .006, adjusted power 0.7), but in the lower education group there were no significant difference in depressive symptoms between pre- and postmenopausal groups (F = 1.82, p = .177, adjusted power 0.1).

Among women from the age range of 48 to 55 menopausal status had a significant effect on depressive symptoms (F = 5.29; df = 1, 401; p = .02), although there was no significant effect of age (F = 2.34; df = 1, 401; p = .13). Furthermore, an additional analysis showed that within the group of postmenopausal women aged 50 to 64, irrespective of education, there was no significant change of depressive symptoms score with increasing age (F = 0.90; df = 14, 541; p = .56) (Fig. 1).

Depressive symptoms in relation to BMI in pre- and postmenopausal women

A two-way (education and menopausal status) analysis of covariance with age and BMI as two concomitant variables showed that there was a marginally significant heterogeneity of BMI–depression slopes (F = 2.773, df = 3, 889, p = .04). Consequently, we explored BMI–depression relationships separately in groups defined with respect to the menopausal status, education, and four combinations of these variables. There was no relationship between the BMI and depressive symptoms either in premenopausal (r^2 = .000, p = .71) or postmenopausal women (r^2 = .005, p = .09). When splitting pre- and postmenopausal women into groups based on the level of education, in premenopausal women no relationship was present between BMI and CES-D scores either in women with lower (r^2 = .013, beta = −0.186, p = .23) or higher education (r^2 = .002, beta = 0.077, p = .54). However, among postmenopausal women with lower education, there was a significant negative relationship between BMI and depressive symptoms (r^2 = .036, beta = −0.367, p = .009). A similar relationship was not documented among postmenopausal women with higher education (r^2 = .000, beta = 0.041, p = .79) (Fig. 2).

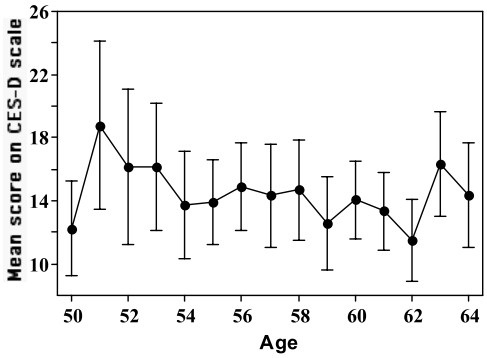

Figure 1. Relationship between mean (with 95% confidence interval) score on CES-D scale and age among postmenopausal women aged 50 to 64.

To further examine the relationship between BMI and depressive symptoms, we performed a three-way ANOVA, comparing the three categories of BMI (normal, overweight, and obese), while taking into account the education and menopausal status. Planned-comparison tests showed that in the group of postmenopausal, lower education women, those who were obese had significantly lower CES-D scores than the normal BMI women (13.7 and 18.5, respectively, p = .01). Postmenopausal, lower education women categorized as overweight had CES-D score of 15.2, but this score was not significantly different from those in either normal or obese women (p = .10 and p = .33, respectively). In the all other examined groups, postmenopausal higher education, premenopausal lower education, and premenopausal higher educations, the differences in CES-D score among the three categories of BMI were not statistically significant.

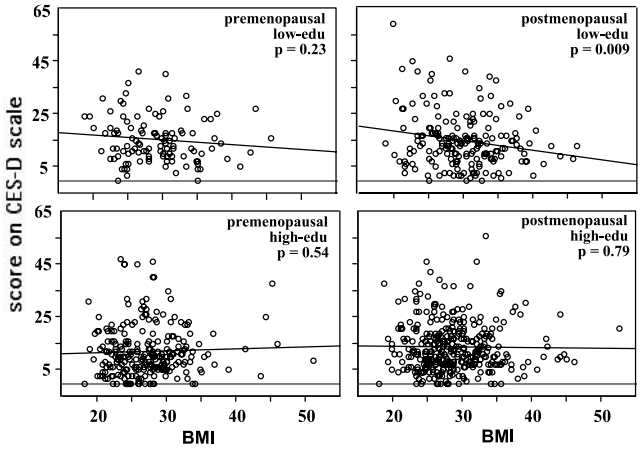

Figure 2. Relationships between BMI and CES-D score in four groups of women. In the postmenopausal lower education group the relationship remained significant when the point with the highest score on CES-D scale (59) was removed from the analysis (r^2 = .024, p = .034). In other groups, no significant relationships between BMI and CES−D score were observed.

Discussion

Our study shows an inverse relationship between BMI and depressive symptoms as assessed by the CES-D scale in a group of postmenopausal women with lower education. Such a relationship was not present among premenopausal women or in women who were postmenopausal but better educated. We also show that postmenopausal women had higher scores of depressive symptoms than premenopausal women. In addition, both among pre- and postmenopausal women, groups with a higher education had lower scores of depressive symptoms.

There are biological mechanisms linking postmenopausal status with depression via levels of sex steroids and serotonin (Joffe & Cohen, 1998). Estrogens and progestins can affect serotonin function system (Bethea et al., 2002), which is thought to play a major role in the etiology of depression (Archer, 1999). Therefore, it can be expected that postmenopausal women who have very low levels of circulating sex steroids should show an increased risk of depression.

Given a suggested physiologic background of depression in women, data on women should be analyzed with regard to menopausal status. Whereas in postmenopausal women the amount of adipose tissue correlates with estrogen levels, such a relationship has not been described for premenopausal women. In fact, during the reproductive years, obese women often have lower levels of estrogens than women with body weights in the "normal" range (Potischman, Swanson, Siiteri, & Hoover, 1996; Zumoff, 1982). Therefore, although there is a biological basis for expecting an inverse relationship between body weight and risk of depression in postmenopausal women, such a relationship should not be postulated for women before the menopause, where there is no direct relationship between body weight and estrogen levels.

In our study, as is the case in any cross-sectional study, the causal connection between body fat and depressive symptoms cannot be proved, especially because we did not measure estrogen levels in our subjects. It is theoretically possible that women with higher scores of depressive symptoms had appetite problems and, therefore, it is the depression that leads to lower body weight rather than the reverse. However, if this were the case, it would be hard to explain why this relationship should only be apparent among postmenopausal, better educated women and not other groups.

Depression is a disorder caused by multiple factors. Although rich or poor estrogen environments may contribute to the development of depression, the importance of social factors should be emphasized. Our results confirm previous reports from the literature showing a relationship between depression and education (Glazer et al., 2002; Hauenstein & Boyd, 1994; Swenson et al., 2000). Women with a lower education level had higher scores of depression than better educated women. Interestingly, among postmenopausal women it is only in those with a lower education that an inverse relationship between BMI and depressive symptoms has been observed. Lack of a relationship between BMI and depressive symptoms in postmenopausal women who are better educated may have several explanations. Because better educated women had a significantly lower BMI, it is likely that variation in the levels of estrogens was not high enough to show a relationship with depressive symptoms.

On the other hand, it is likely that in industrial societies more stigma is attached to being overweight in higher rather than in less educated layers of the society (Fabricatore & Wadden, 2004). Well-educated people are more likely to diet to lose weight than the poorly educated (Ross, 1994); among U.S. adults aged 18 to 90 of both genders being overweight had no effect on depression except among the well educated people (Ross, 1994). In addition, poorly educated women, lacking the resources or knowledge to cope with stress, may be more likely than better educated women to use food to self-medicate their depressive symptoms. This could potentially (assuming the efficacy of food as an antidepressant) produce a negative correlation between depressive symptoms and body weight. However, a relationship between body weight and depression could be confounded by cultural differences in attitude toward obesity, thus contributing to the existence of conflicting results of numerous studies. In a recent study of elderly men and women in Hong Kong, those who were obese were about 20% less likely to suffer from depressive symptoms than people of normal weight (Bin Li et al., 2004).

In our study, we did not control for potential confounders, such as marital status and income (see, for example, Chen, Subramanian, Acevedo-Garcia, & Kawachi, 2005). We did, however, control for other variables, by directly measuring (rather than using self-reported values) body height and body mass of our subjects. Johnston et al. (2004) suggested that the fact that many studies relied on the self-reported values of body height and body mass might be one of the reasons behind conflicting results of studies on body composition and depression. Another reason that may account for the disparate results among studies is the number of BMI categories and their cut-off points used in statistical analyses (Johnston et al., 2004).

The higher incidence of depressive symptoms observed in postmenopausal women in our study may have a hormonal background or may result from other, nonendocrine risk factors, for example, age-related health problems (Huerta, Mena, Malacara, & de Leon, 1995a, 1995b), which might be more common in postmenopausal years. The relationship between BMI and depressive symptoms in postmenopausal, less educated women may result from a biological link between body fat and estrogens. It is likely that women with higher levels of adipose tissue have concentrations of estrogens that offer some protection against the development of depressive symptoms.

In our study, differences in BMI explained only about 4% of variation in the occurrence of depressive symptoms in Polish women. However, it is remarkable that in the case of such a multicausal disorder as depression a statistically significant relationship with a single factor can be detected at all. It should be stressed that even though the relationship between BMI and depressive symptoms may be too weak to have a clinical significance in the Polish population, such a relationship may be more pronounced in other groups, especially in populations characterized by a wider range of BMI values than those encountered in the Polish population. Further, women from various populations differ in average levels of sex hormones (Ellison et al., 1993). For example, it has been observed that U.S. women have higher levels of progesterone than women from Poland (Jasienska & Ellison, 1998, 2004; Jasienska & Thune, 2001), therefore, it is more likely that in the U.S. population the postulated body fat–estrogens–depression link may have a stronger causal effect. Therefore, variation among populations in body composition and hormone levels merits further studies to clarify the relationship between body mass and depression in women.

The results of our study clearly suggest that for a comprehensive exploration of the factors associated with the occurrence of depressive symptoms, women should not be treated as a homogeneous group. Different patterns of depression may be expected in women who vary in menopausal status, education level, and body mass.

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