

The association between mental health and obesity in postmenopausal women: A systematic review

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Postmenopausal women are at great risk of mental health deterioration, which may lead to morbidity and mortality. The decrement of mental health with aging is attributed to hormonal changes, lowered physical activity, sleep disturbances, economic factors, as well as modifiable variables such as smoking and obesity. Studies have shown controversial results on the association between obesity and mental health in postmenopausal women. This study is a systematic review of the evidence available on the association between obesity and mental health in postmenopausal women with the aim to identify the most reliable obesity measure that has been shown in association with mental health as well as the effective measures that have been practiced for improving mental health in postmenopausal obese women. CINAHL, Scopus, Science Direct and PubMed including Medline databases were searched. Out of 3,766 articles, 23 studies of average to good quality were included, out of which 17 were cross-sectional and 6 interventional. Out of the 17 studies, 12 showed a positive association between obesity and deterioration of mental health, 3 showed a negative association and two showed no association. From the interventional studies, 4 showed positive and two not significant impact of the intervention used on obesity and mental health. In conclusion, more studies showed a positive association between obesity, especially visceral obesity, and mental health issues particularly depression, anxiety, and sleep disorders. Combination of caloric restriction and exercise seems to have a better impact on the mental health of the postmenopausal in comparison with other interventions.

Key words: postmenopausal women, obesity, mental health, depression, anxiety

Women in their postmenopausal stage experience various menopausal symptoms, which may have a range of severity. These factors, which contribute to the severity may vary in relation to hormonal status, association with other diseases, treatment procedures underwent, familial characteristics, and socio-demographic factors. This transition that takes

place in women due to aging may be related to a lot of metabolic changes, obesity, mental health, and other disease conditions (Chedraui and Perez-Lopez 2013).

There are studies reporting that excessive body weight that is experienced in females in their middle age might increase the incidence of vasomotor symptoms and other diseased

conditions (Chedraui et al. 2014). Obesity could be an important component of the metabolic syndrome (METS) and directly related to other inflammatory reactions, which could increase the risk of severe life-threatening conditions (Fernandez-Alonso et al. 2010). METS has been defined to include lipid and non-lipid factors that could increase the cardiovascular risk (Fernandez-Alonso et al. 2010). There are a lot of evidences indicating that METS, of which the obesity is a dominant component, could possibly contribute to most of the postmenopausal symptoms (Lee et al. 2012). This study has concluded that obesity, as an independent factor, has been related to increased severity of menopausal symptoms. Obesity and severe menopausal symptoms have been related to increased cardiovascular risks, education and counselling should be promoted among the high-risk group of people (Fernandez-Alonso et al. 2010). This must include lifestyle habits change, weight loss program, and family education concerning the menopausal transition. The menopausal status associated with the risk that METS carries is independent of the normal aging process (Lobo 2008). There are studies indicating that an increase in the body fat and abdominal obesity among postmenopausal women might have an association with the hormonal changes that occur at that phase (Lizcano and Guzman 2014). It has also been shown that increased central obesity is associated with increased hot flushes, which is a predominant menopausal issue (Thurston et al. 2008). There are several studies reporting the relationship between METS and psychological symptoms of depression and anxiety, urogenital symptoms, and sexual dysfunction (Esposito and Giugliano 2005; Laudisio et al. 2009).

Another important component of the METS is the mental health. However, many factors are involved in determining the severity of the postmenopausal syndrome. Physical and mental health impairments have been reported in many postmenopausal women. Postmenopausal women are more likely to experience symptoms, which are closely related to the changes in their hormonal levels during this phase of their life (Carr 2003; Grundy et al. 2004). In women, lowered estrogen levels during the postmenopausal stage have been linked to depression, reduced libido, and cognitive disorders (Schmidt et al. 2015). There are evidences indicating that obesity and mental depressive states, along with other contributing factors, may play an important role in increasing the frequency and severity of the postmenopausal symptoms.

The ways, by which obesity may affect postmenopausal women's quality of life have also been identified (Jones and Sutton 2008). The menopausal transition on mood including depression, anxiety, and other psychological symptoms has been reviewed (Vesco et al. 2007). The bidirectional relationship between obesity and mental health disorders in adult men and women has been demonstrated (Mannan et al. 2016). There were few other systematic reviews on the interventional studies done in these disorders. However, we did not find any systematic reviews on the association between mental health and obesity in postmenopausal women.

In this context, the primary objectives of this systematic review were to: 1) investigate the association between the mental health and the obesity among postmenopausal women, 2) identify the common types of mental health disorders related to the postmenopausal obesity, 3) identify the obesity measures that are most likely to be associated with the mental health disorders in postmenopausal women, and 4) identify and investigate the effectiveness of the different interventional methods used in combating the postmenopausal obesity-related mental health disorders as a secondary objective.

Methodology

In conducting this systematic review, the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines were followed (Moher et al. 2009). In regard to eligibility criteria, original articles that reported the obesity and its effect on the mental health status and/or quality of the postmenopausal women's life published before 16 May 2019, were included. There was no limit placed on the language, publication year or study setting. Papers that did not report obesity, systematic review papers, technical reports, conference proceedings, papers on specific health disorders, and those that measured the outcome among the general population, were excluded from this review.

Search strategy. CINAHL, Scopus, Science Direct, and PubMed including Medline databases were searched. The keywords utilized were: mental health, quality of life, obesity, post-menopause and their synonyms, and MESH terms. Hand searching of the bibliography of included publications was utilized so that studies that might not be found during the online search could be identified.

Study identification. Totally, 3,766 articles were identified during the initial screening (Figure 1). First off, a search strategy was developed by two authors.

The keywords and their synonyms were identified. All studies from different databases were transferred into the Endnote X7 software, whereas 42 duplicate papers were removed. The remaining 3,724 articles were reviewed based on their titles and abstracts by two authors independently. In the case of disagreement between the two reviewers, the final classification was made by a consensus with the contribution of the third reviewer. Consequently, 104 articles were totally selected for the assessment of the full text. Two other authors evaluated the eligibility of the retained papers. The bibliography of the selected articles was checked for any relevant articles, which met the inclusion criteria of this systematic review and were not retrieved during the searches. As a result, one study was included. After a full review of 104 papers, 17 were selected for this review. Data extraction was finalized and all authors agreed on the eligibility of retained papers.

Quality assessment. For quantitative studies, a quality assessment of cross-sectional studies (BSA medical sociology group) was used (Blaxter 1996), which composed of seven questions. Each question responded with either a yes (1 point) or no (0 point). A score of 1–2 was considered of low, 3–5 medium, and 6–7 high quality. For interventional studies, the Oxford quality scoring system; Jadad Scale (Janad and Enkin 2007), was used, which is scored from 0 to 5. Papers with less than 3 points were considered of low and papers of 3 or more points were considered high quality. The quality assessment of included studies is illustrated in data extraction Table 1.

Data extraction. The data extracted included author, year of publication, study setting, sampling and methodology, main results, study limitation, and conclusion (Table 1).

Results

This systematic review includes 23 papers, 17 cross-sectional and 6 interventional studies. The sample size of included studies varied between 40 to 8,745 subjects with the age between 35–86 years.

Relation of psycho-social domains to obesity

Previous studies have shown that obese and overweight women had significantly higher scores in psycho-social domains. The findings showed that menopause-related psycho-social symptoms had negative impact on their quality of life (Chedraui et al. 2007; Mirhaghjou et al. 2016). In a study conducted in postmenopausal women in Ecuadorian

population, abdominal obesity increased the risk of having vasomotor, psycho-social, and physical scores above the median. Hypertension and hyperglycemia increased the risk for higher scores within the psycho-social and sexual domains, respectively. The impairment of life quality was found to be associated with age and other related conditions such as abdominal obesity, hypertension, and hyperglycemia (Chedraui et al. 2007). Besides, both psychic and somatic symptoms were significantly related to the body-shape characteristics. Nervousness, mood changes, sleeplessness, and libido loss were more commonly observed in postmenopausal women with increasing breadth and circumference and/or increasing body weight (Kirchengast 1993).

Depressive symptoms associated with obesity

In a study carried out among 117 Chinese postmenopausal women who had depressive symptoms, 44 participants had abdominal obesity. Visceral fat accumulation was an independent and positive factor significantly associated with the presence of depressive symptoms (Xiong et al. 2017). A previous study has shown an association between symptoms of depression, anxiety or distress, low levels of social support or impaired quality of life,

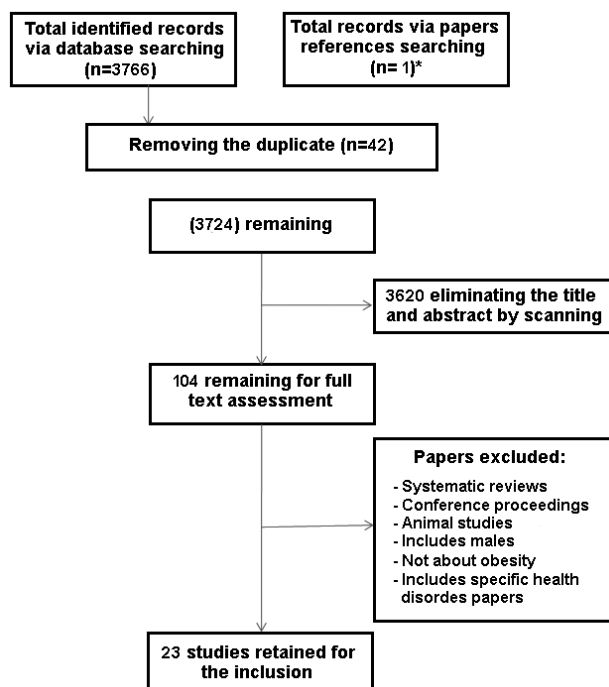


Figure 1. Scheme demonstrating the individual steps involved in the articles' selection processing.

Table 1
Data extraction table

Author (year)	Country & Settings	Sampling	Methods	Main Results	Conclusion	Scoring
Kirchengast (1993)	Austria Vienna Universitäts-Frauenklinik	Sample: 142 females Inclusion criteria: Age: 38–60 years - Natural menopause happened at least 1 year - No major gynecological operation - Not received any hormone treatment within the last 3 years	Study design: cross sectional; Parameters: sleeplessness, nervousness; depression, and mood changes were assessed. Obesity was assessed using WC index, HC and BMI.	Both psychic and somatic symptoms are significantly related to body-shape characteristics. The anthropometric characteristics investigated, and the indices calculated mainly intensified nervousness, as well as mood changes, sleeplessness and loss of libido.	The psychic symptoms grew worse with increasing breadth and circumference measurements, and/or increasing body weight.	4/7
Mirhaghjou et al. (2016)	Iran Capital of Guilan province, Rasht city (north Iran)	Sample: 675 women Age: 40–60 years - Selected using a cluster random sampling design Inclusion criteria: - Lack of menstruation for at least one year without any interventions - No hormones were used within the last 6 months	Study design: cross-sectional Variables: husband's occupation status, educational level, marital status, menarche age, date of the last menstrual period, menopause age, BMI, physical activity and Charlson's Comorbidity Index Menopause-Specific Quality of Life (MENQOL) tool used to assess the QOL, which consists of 4 domains; vasomotor, psychosocial, physical and sexual	Obese and overweight women had significantly higher scores than underweight and normal weight women in the physical and psychosocial domains ($p < 0.05$).	Menopause-related symptoms had negative impact on QOL.	5/7
Xiong et al. (2017)	China Shanghai Community health service centers	Sample: 437 PoM women Age: 42–76 years Exclusion criteria: (BMI $< 30 \text{ kg/m}^2$), diagnosis of psychiatric disorder or depression, and current use of antipsychotics or glucocorticoids, and current smoking.	Study instrument: anthropometric and biochemical measurements	Among the participants with depressive symptoms, 44 participants had abdominal obesity. 73 participants did not. These participants with abdominal obesity also showed significantly higher levels of BMI, WC, SBP, FINS, HOMA-IR, TG, CRP ($p < 0.05$), and lower levels of HDL-C ($p < 0.05$).	VF accumulation is an independent and positive factor significantly associated with the presence of depressive symptoms.	5/7
Naufel et al. (2017)	Brazil Sao Paulo Sleep Institute	Sample size: 107 PoM women Age: 50–70 years Exclusion criteria: The use of hormone therapy ($n=8$) and missing data ($n=23$).	Study instrument: Anthropometric measurements. Polysomnography (PSG) data were collected from their medical history.	The obese group had significantly increased values of BMI, neck circumference, WC, and HC. Rapid eye movement sleep latency was positively correlated to body mass ($r = 0.4$, $p < 0.01$). The linear regression model showed that BMI and WHR were positive predictors of rapid eye-movement sleep latency.	In PoM women, high BMI and abdominal obesity are associated with sleep disturbances, decreasing deep sleep, and sleep efficiency, while increasing the risk of obstructive sleep apnea.	5/7

Table 1
Continued ...

Author (year)	Country & Settings	Sampling	Methods	Main Results	Conclusion	Scoring
Chedraui et al. (2012)	Ecuador Guayaquil Institute of Biomedicine, Medical Faculty, Universida Catolica de Santiago de Guayaquil	Sample size: 204 women Age: 40–65 years Exclusion criteria: The use of phytoestrogens or drugs intended to decrease lipid levels.	Study instrument: General questionnaire. METS, sleep difficulty, anxiety and depression were assessed.	The 50.5% of women had the METS, 57.4% hot flushes, 58.3% were abdominally obese, 51.5% had hypertension, 25.0% had hyperglycemia, 15.7% were depressed and 29.9% had anxiety. The 33.8% presented insomnia according to the AIS (scores 6 or more).	In PoM sample insomnia was not related to the METS or its components yet to other psychosomatic female and partner issues	4/7
Raikkonen et al. (1999)	USA	Sample size: 541 PoM women Age: 42–50 years Exclusion criteria: The use of insulin, thyroid, lipid-lowering, antihypertensive, or psychiatric drugs, or estrogens.	Study tool: WC, WHR, weight, and BMI were measured in a population-based sample of PoM Healthy Women Study participants. Stress and life satisfaction were measured using personality and behavior tests. With each research question, n varied from 120±345.	WC was superior over the other anthropometric measures in predicting VAT accounting for 40.1±63.5% of the variance in VAT over the study period. Increasing anger over time was associated longitudinally with increasing waist circumference ($p<0.03$).	Identification of healthy women with large waist circumferences is important for prevention and intervention of poor quality of life and chronic disease.	5/7
Schreiber et al. (2017)	United States General Clinical Research Centers in Madison, Wisconsin, Los Angeles, California, or Washington, DC.	Sample size: 815 (392 PrM women and 423 PoM women) Age: 35–86 years Completed demographic, psychological, and physical health measures.	Telephone and paper-and-pencil follow-up survey followed by in-person physical examination were body index measurements.	Depressive symptoms were not directly associated with weight ($b=-$ 0.4, 95% CI [-0.4, 0.1]). However, stress eating was a significant mediator between depressive symptoms and weight ($b=0.3$, 95% CI [0.06, 0.3]). The mediation was conditional on menopausal stage ($b=0.2$, 95% CI [0.05, 0.4]), with depressive symptoms and stress eating significantly associated in PoM, not PrM women ($b=0.3$, 95% CI [0.2, 0.5]).	Both stress eating and menopausal status significantly contributed to the depressive symptom - weight association. Psychosocial factors play an important role in the association between depressive symptoms and weight.	6/7
Naufel et al. (2018)	Brazil Brazil Main clinical laboratory, Universidade Federal de Sa Paulo	Sample size: 79 women Age: 40–65 years Exclusion criteria: The use of hormone therapy, contraceptives, antidepressants, menopausal transition, insulin.	Anxiety and depression were assessed using Beck's depression (BDI) and anxiety (BAI) scale. Anthropometric measurements and Laboratory Analysis of blood and saliva were done.	Age, percentage body fat, WHR and leptinemia were positively associated with anxiety and depression in PoM women.	PoM women showed impaired body composition and energy expenditure, insulin sensitivity, and mental symptoms, compared to women PrM.	5/7

Table 1
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Author (year)	Country & Settings	Sampling	Methods	Main Results	Conclusion	Scoring
Chedraui et al. (2006)	Ecuador Guayaquil Institute of Biomedicine, Medical Faculty, Universidad Catolica of Guayaquil	Sample size: 325 women Mean age: 55.9±8.1 years (median: 54 years) Characteristics: with >1 year of amenorrhea, non-hormone therapy users and with intact uterus were recruited and asked to participate in the program	Menopause-Specific Quality of Life Questionnaire (MENQOL) was used. No total score is available, rather a mean score within each domain is generated.	The 54.2% of women presented abdominal obesity. More than 50% of women had scores above the median for each domain of the questionnaire. Abdominal obesity increased the risk of having vasomotor, psycho-social and physical scores above the median.	Among PoM Ecuadorian population, impairment of quality of life was found to be associated to age and related conditions such as abdominal obesity, hypertension and hyperglycemia.	5/7
Chedraui et al. (2014)	Ecuador Guayaquil Institute of Biomedicine, Medical Faculty, Universidad Catolica of Guayaquil	Sample size: 204 women Median age: 56 years Exclusion criteria: The use of phytoestrogens or drugs intended to decrease lipid levels.	Subjects were requested to fill out the Menopause Rating Scale (MRS), the Hospital Anxiety and Depression Scale (HADS) and a general questionnaire containing female and partner socio-demographic data.	The 58.3% women presented with abdominal obesity. The three top prevalent menopausal symptoms were muscle and joint problems (87.2%), physical and mental exhaustion (72%) and depressive mood (64.7%). Psychological MRS scores positively correlated depressed mood and abdominal perimeter.	In this PoM sample, severity of menopausal symptoms correlated to abdominal obesity, mood and other personal aspects.	5/7
Kerwin et al. (2010)	USA Chicago IL, 40 Women's Health Initiative (WHI) clinical centers	Sample size: 8,745 women Age: 65–79 years Completed 3MSE testing during baseline screening. Eligible women were PoM, had no medical condition.	The analyses used baseline data from the WHI hormone trials cohort. Cognitive evaluation done using 3MSE. Women were classified into BMI categories that correspond to standard World Health Organization.	A large proportion of women (70.1%) were classified as overweight or obese. Overall, 3MSE scores decreased slightly with increasing BMI categories. Women with larger WHRs and older women who exercise less have a lower 3MSE score. After adjusting for other variables, BMI was inversely associated with 3 MSE score. The 3MSE scores for women with low WHRs decreased as their BMI increased, but the reverse was true for those with higher WHRs. In the highest WHR quartile, the score increased with increasing BMI.	Higher BMI was associated with poorer cognitive function in women with smaller WHR. Higher WHR, estimating central fat mass, was associated with higher cognitive function in this cross-sectional study.	4/7

Table 1
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Author (year)	Country & Settings	Sampling	Methods	Main Results	Conclusion	Scoring
Jasienska et al. (2005)	Poland Krakow Department of Epidemiology and Population Studies, Jagiellonian University Collegium Medicum	Sample size: 1156 women Mean age: 57.4 years Participants were selected from the City of Krakow Residents.	Body weight and height were measured. Depressive symptoms were assessed by the CES-D scale.	PoM women had higher scores of depressive symptoms as assessed by the CES-D scale. The score of depressive symptoms was related to the education: higher education groups had lower scores on CES-D scale then lower education groups.	Menopausal status is related to differences in the degree of occurrence of depressive symptoms. The results support the "Jolly Fat" hypothesis for PoM women with lower education, namely, a higher BMI is associated with lower score of depressive symptoms.	6/7
Fernandez-Alonso et al. (2010)	Spain Granada University of Granada San Cecilio, Clinic Hospital	Sample size: 574 women Mean age: 49.9+6.1 years Retrospective review was performed on medical records of PoM women attending the Menopause Unit for the first time	Retrieved information included age, age at menopause, time since menopause (months), parity, marital status, smoking status, type of menopause and baseline Kupperman index scores, lab results (hormonal and metabolic), weight (kg), height (m), blood pressure recordings (mmHg).	Of the 574 subjects, 66% had natural menopause and 38.9% were obese. In all, 23.1% met diagnostic criteria for METS. The mean Kupperman index score for the whole sample was 26.4+10.6, with 73.8% displaying moderate to severe scores (20 or more). Logistic regression analysis determined that obesity and marriage status were independent risk factors related to more severe menopausal symptoms (Kupperman index scores of 20 or more).	Obesity was associated with more severe menopausal symptoms among postmenopausal Spanish women.	5/7
Thilers et al. (2009)	Sweden Stockholm Adult community of Stockholm	Sample size: 193 PoM women Age: 40–65years Women who are on estrogen or birth control pills were excluded as well as women who were not menstruating due to any reason other than natural menopause such as ovariectomy.	Assessment tools for respective variables: 1. Self-administered questionnaire on social and economic issues, as well as critical life events and health. 2. Cognitive tests for assessment of cognitive functions including visuospatial abilities, semantic memory, verbal fluency, and episodic memory. 3. Blood serum analysis for estradiol values at the third wave test.	The results of data analysis from 193 PoM women showed: 1. A reliable reduction in verbal fluency, block design, and episodic memory are linked to menopause. 2. Overweight PoM women exhibited less decline in cognitive visuospatial ability and episodic memory than normal weight women. 3. A reliable positive association between estradiol and BMI ($r=0.20$; $p<0.01$).	1. BMI moderate the influence of menopause on cognitive functions. 2. The cognitive functions of PoM women with normal BMI are more likely to decline faster than overweight postmenopausal women.	6/7

Table 1
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Author (year)	Country & Settings	Sampling	Methods	Main Results	Conclusion	Scoring
Provencher et al. (2007)	Canada Various media in the Quebec City metropolitan area	Sample size: 131 PoM women Age: 46–68 years All women included in this study were free from metabolic disorders, were not using any type of hormonal replacement therapy, were not under treatment for coronary heart disease, diabetes, dyslipidemia or endocrine disorders (except stable thyroid disease), were not involved in a weight-loss intervention and had a stable weight for at least 3 months.	Assessment tools for respective variables: 1. Psychological well-being questionnaire (PER questionnaire). 2. The Three-Factor Eating Questionnaire (TFEQ) that assesses the cognitions and behaviors associated with eating by assessing cognitive dietary restraint (control over food intake), disinhibition (overconsumption of food) and susceptibility to hunger (food intake in response to feelings and perceptions of hunger). 3. A questionnaire about dieting history (dieters: had already been on a diet; non-dieters: had never been on a diet). 4. Anthropometric measurements: Height, body weight and body mass index (BMI) were determined according to standardized procedures, as recommended.	Out of 131 PoM women only 101 completed the questionnaires and their data were analyzed and presented. 1. The range of BMI was 19.0–59.7 kg/m ² . 41 women were overweight with 25 kg/m ² < BMI < 30 kg/m ² . 22 women were obese with 30 kg/m ² ≥ BMI < 35 kg/m ² . 11 were morbid obese with BMI ≥ 35 kg/m ² . 2. A negative association between BMI and psychological well-being ($r = -0.17$; $P = 0.08$). 3. BMI was positively related to habitual susceptibility to disinhibition ($r = 0.51$; $P < 0.0001$). 4. A total of 44 PoM women showed a low score (0.69) of habitual susceptibility to disinhibition; 31 with BMI < 27.4 and 13 with BMI ≥ 27.4, respectively. 5. A total of 57 PoM women showed a high score (0.69) of habitual susceptibility to disinhibition; 19 with BMI < 27.4 and 38 with BMI ≥ 27.4, respectively. 6. Women having a higher score of habitual susceptibility to disinhibition had a lower level of psychological well-being compared to those having a lower score of habitual susceptibility to disinhibition, regardless of their weight status.	1. There is a negative association between BMI and psychological well-being of PoM women. 2. There is a positive correlation between BMI and habitual susceptibility to disinhibition in PoM women.	4/7
Seib et al. (2013)	Australia Queensland Random selection from the residents of Queensland participating in Australian Healthy Aging of Women (HOW) study in 2011	Sample size: 340 women Age: 60–70 years	A structured self-completed questionnaire including items on socio-demographics, modifiable lifestyle factors, chronic illness and health-related quality of life (using the SF-12) which included assessment of two outcome measures of mental health, the Mental Component Summary Score (MCS).	26.5% were overweight ($n = 90$), and 41.3% were obese ($n = 140$). 32% reported one or more chronic illness and 68% denied any chronic illness. 30% of the sample reported mild to major depressive symptoms and 70% reported fewer depressive symptoms. Pearson correlation showed insignificant correlation between BMI with mental health.	There is no association between mental health and obesity in postmenopausal women.	5/7

Table 1
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Author (year)	Country & Settings	Sampling	Methods	Main Results	Conclusion	Scoring
Mirzainimabadi et al. (2006)	Australia Queensland Brisbane Participants were randomly selected from residents of six selected postcodes of South-East Queensland	Sample size: 883 women which were in a menopausal state Age: 45–60 years	Population-based postal survey with a questionnaire for sociodemographic factors including BMI that was calculated from self-reported height and Weight. The Greene Climacteric Scale for assessment of Psychological (anxiety and depression) vasomotor, sexual, and somatic symptoms of menopause.	More than half (n=451) of participants had a normal BMI that is < 25, but 40.4% were obese with a BMI in the range of 25–30. A significant positive correlation between BMI with depression and anxiety was observed. (r=0.144, p of 0.013)	No relationship between BMI and psychological symptoms of depression nor anxiety in PoM women.	5/7
Chojnacki et al. (2015)	Poland Department of Clinical Nutrition and Gastroenterological Diagnostics of Medical University in Lodz	Sample size: 64 overweight PoM women aged 54–65 years with increased appetite. Exclusion criteria: severe symptoms of anxiety and depression or other mental diseases, diabetes, hypertension and other diseases requiring pharmacotherapy, the use of hormonal replacement therapy.	Women were randomly assigned in 2 groups. In group I (n=30) fluoxetine (20 mg in the morning) and placebo (in the evening) were administered for 24 weeks. Anxiety, depression and sleep quality were assessed. Laboratory tests and BMI calculation done as well.	After 24 weeks, comparable and statistically significant reduction in the level of anxiety and depression was obtained in both groups. In group I no reduction in BMI was achieved, whereas in group II this index decreased from 30.9±3.1 to 26.3±3.2 (p<0.05).	The study conclude that combined administration of fluoxetine and melatonin was useful option to treat mood, sleep and appetite disorders in overweight PoM women. There was a reduction in BMI among group II from 30.9 to 26.3 kg/m ² .	3
Gemert et al. (2014)	Netherlands Women recruited from 8 municipalities surrounding 2 research centers in the Netherlands from February 2012 to May 2013	Sample size: 243 women recruited from the general population by mass mailings and media attention. Inclusion criteria: - Age: 50–69 year - PoM more than 1 year after last menses - BMI: 25–35 kg/m ² - inactive lifestyle Exclusion criteria: - use of sex hormones - diabetes - smoking - ever diagnosed with breast cancer or other cancer types in the past 5 years.	Study design: randomized control trail Women were randomized to a diet group (n=97), an exercise group (n = 98) or control group (n = 48). Current level of physical activity was measured by the SQUASH questionnaire. Health related quality of life HRQoL was assessed by the 36-item Short-Form Health Survey (SF-36).	Diet and exercise were both associated with significant improvements in the SF-36 domain of “health change” compared with control. Both intervention groups showed a tendency towards improvements in most other domains, which were more pronounced in the exercise group but not statistically different from control or each other.	There were improvements in physical and mental HRQoL domains, but results were not statistically significant in either the diet or exercise group. However, a modest weight loss does lead to a positive change in self-perceived health status.	4

Table 1
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Author (year)	Country & Settings	Sampling	Methods	Main Results	Conclusion	Scoring
Imayama et al. (2011)	USA Seattle, WA Fred Hutchinson Cancer Research Center	Results are published in the British Journal of Sports Medicine, an open-access journal for people 50 years and older with a BMI above 25 kg/m ² and moderate or vigorous intensity physical activity (50–75 minutes per week).	Information on demographics, medication use, anthropometrics, lifestyle behaviors, psychosocial factors, and HRQOL were collected.	The diet + exercise group significantly reduced perceived stress and depression and increased social support physical functioning, role-physical, vitality and mental health scores. Increased aerobic fitness was positively associated with physical functioning scores. Weight loss was also associated with an improvement in depression scores.	Dietary weight loss and exercise combined with psychosocial factors (depression, stress, and social support) may have a larger beneficial effect on respiratory quality of life (HRQOL) than alone, according to a study published in the British Journal of Sports Medicine.	
Lemoine et al. (2007)	France Toulouse Participants recruited from the suburbs of Toulouse (in the southwest of France) were referred by their personal physician to a specialized institution located in the greater Toulouse area (Clinique du Chateau de Vernhes, Bondigoux, France)	Sample size: 57 women Exclusion criteria: Not had cardiomyopathy, diabetes mellitus, or endocrine disorders and not taking medication. Finally, PrM women using oral contraceptives and PoM women receiving hormone therapy were also excluded.	Dietary, physical activity, quality of life, and eating behaviors were assessed before and after weight reduction. Thirteen PrM and 27 PoM women received a dietary plan of 1,400 T 200 kcal/day and completed 110-minute endurance exercise 6 days per week.	Although the SF-36 mental component score increased after weight loss in both groups, the SF-36 physical component score increased in PoM women only. Restriction increased, whereas disinhibition and susceptibility to hunger decreased after weight reduction in both groups. Distance walked and SF-36 physical component score after weight loss were higher in women whose menopause ranged between 5 and 9 years and exceeded 10 years, respectively.	The study shows that a short-term weight-reducing program combining caloric restriction and physical activity has a favorable impact on women's body composition, physical condition, health-related quality of life, and eating behaviors irrespective of their menopausal status.	3
Riesco et al. (2011)	Canada Research Centre on Aging (CASS-IUGS)	Sample size: 40 PoM women Age: 50–70 years Inclusion criteria: Caucasian, absence of menses for the past 1 year; BMI: 28–40 kg/m ² or WC: 88 cm, healthy, without major physical incapacity, without hormone replacement, weight stable (2 kg) for the last 6 months, nonsmoker, moderate drinker and no influences glucose or lipid metabolism	Women randomized into 2 groups: 21 received a placebo and 19 received phytoestrogen supplements. Body weight, fat mass and lean body mass (dual-energy X-ray absorptiometry) were assessed. Quality of life was estimated by the Short Form-36 (SF-36) and Perceived Stress Scale-10 (PSS-10) questionnaires, and menopausal symptoms by the Kupperman index. All measurements were performed before and after the intervention.	Although the Kupperman index and PSS-10 remained unchanged in both groups, the SF-36 Physical Component Summary and almost all the SF-36 subscales (except for role-emotional and mental health) increased only in the exercise group taking phytoestrogens.	While phytoestrogens combined with mixed exercise were not sufficient to improve menopausal symptoms, it seemed to be a better strategy than exercise alone to improve the general quality of life in PoM women. Role-emotional and mental health remained unchanged in both groups	4

Table 1
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Author (year)	Country & Settings	Sampling	Methods	Main Results	Conclusion	Scoring
Yankura et al. (2008)	USA Pennsylvania Women were recruited by direct mailing from selected zip codes in Allegheny County, Pennsylvania, from April 2002 through October 2003. University of Pittsburgh	Postmenopausal women with a BMI: 25-39.9 kg/m ² , WC ≥ 80 cm, blood pressure < 160/95 mm Hg at initial screening, and < 140/90 mmHg at randomization. Women who self-reported diagnoses of schizophrenia, bipolar disorder, anxiety disorder, or panic disorder were excluded.	The weight regain (WR) group shows worse mental health composite values at 6 months than the weight loss (WL) group. Identical patterns were seen in the fully adjusted models. The R ² values for WR groups ranged from 0.15 to 0.28 in model.	Weight was measured at baseline, 6, and 18 months, and changes in weight over this period were analyzed.	There were no significant differences in short form-36 scales (SF-36 scales) and subscales between weight-change groups.	3

Abbreviation: AIS – Athens Insomnia Scale; BMI – body mass index; HC – hip circumference; HDL-C – high-density lipoprotein cholesterol; HOMA-IR – Homeostatic Model Assessment of Insulin Resistance; METS – metabolic syndrome; 3MSE – Modified Mini-Mental State Examination; PoM – postmenopausal; PrM – premenopausal SBP – systolic blood pressure; TG – triglycerides; VF – visceral fat; WC – waist circumference; WHR – waist to hip ratio.

which were cross-sectional with waist circumference (Raikonen et al. 1999). Besides, increasing anger over time was longitudinally associated with an increasing waist circumference (Raikonen et al. 1999). The body fat percentage, waist/hip ratio, and leptinemia were positively correlated with anxiety and depression scores in postmenopausal women. In all the overweight midlife women, these symptoms were more strongly associated with age and leptin levels than reproductive aging itself. The data indicate that in overweight middle-aged women with abdominal obesity, the aging process and the development of leptin resistance are associated with impairment of mental health (Naufel et al. 2018, 2019). The mental exhaustion and depressive mood were highly prevalent in postmenopausal sample, whereby the severity of menopausal symptoms correlated with abdominal obesity (Fernandez-Alonso et al. 2010; Chedraui et al. 2013). Besides, higher body mass index (BMI) in postmenopausal women with smaller waist-hip-ratio was associated with poorer cognitive function. Higher waist-hip-ratio estimating central fat mass was associated with higher cognitive function (Kerwin et al. 2010). On the other hand, insomnia in overweight postmenopausal women also plays a crucial role in the impairment of the mental health (Chedraui et al. 2013).

Negative association/no relationship between BMI and psychological well-being

A few previous studies have shown a negative association between BMI and the psychological well-being. BMI was positively related to the habitual susceptibility to disinhibition in 131 postmenopausal women. Women with a higher score of habitual susceptibility to disinhibition had a lower level of psychological well-being compared to those having a lower score of habitual susceptibility to disinhibition, regardless of their weight status (Provencher et al. 2007). In another study, 30% of the sample have reported mild to major depressive symptoms and 70% fewer depressive symptoms. Pearson correlation showed an insignificant correlation between BMI with mental health in postmenopausal women (Seib et al. 2013). Another study highlighted a decline in the cognitive functions in postmenopausal women with normal BMI as compared to overweight ones. Overweight postmenopausal women exhibited less decline in cognitive visuospatial ability and episodic memory than normal-weight women (Thilers et al. 2010). Similarly, no relationship between BMI and psychological symptoms of depression nor anxiety in postmenopausal women has also been reported (Mirzaiinjmaadi et al. 2006).

Treatment and prevention of depressive symptoms associated with obesity

Various treatment and prevention methods have been used to combat depressive symptoms associated with obesity. The combined administration of fluoxetine and melatonin was used as a useful option to treat mood, sleep, and appetite disorders in overweight postmenopausal women. A statistically significant reduction in anxiety and depression levels was observed after 24 weeks. This reduction was observed in women with unchanged BMI and also reduced BMI (Chojnacki et al. 2015). Exercise, which resulted in a weight loss also brought an improvement in the mental and physical health, but the results were not significant (Van Gemert et al. 2015). However, a significant reduction in perceived stress and depression via proper diet and exercise has been reported (Lemoine et al. 2007; De Tapsoba et al. 2016). These findings indicate that the combination of dietary weight loss and exercise may have a larger beneficial effect on HRQOL compared with dietary weight loss or exercise itself (De Tapsoba et al. 2016). Besides, exercise combined with phytoestrogens improves the quality of life in the postmenopausal women rather than the exercise alone (Riesco et al. 2011).

Indirect association between depressive symptoms and weight

In a few studies, the presence of indirect association between depressive symptoms and weight has been shown. Stress eating has been shown to be a significant mediator between depressive symptoms and weight significantly associated in postmenopausal women (Schreiber and Dautovich 2017). Besides, the level of education in postmenopausal women has also been reported to have a significant role in depressive symptoms. For postmenopausal women with lower education, a higher BMI is associated with lower score of depressive symptoms (Jasienska et al. 2005). It was also reported that weight loss correlated with a small to moderate improvement in perceived general health and energy. However, it was reversed by weight gain in postmenopausal women (Yankura et al. 2008).

Discussion

The escalating prevalence of obesity represents a global burden affecting different age groups including postmenopausal women (Flegal et al.

2010; Teede et al. 2010; Xi et al. 2012; Bagnoli et al. 2014; da Costa Pimenta et al. 2020). Studies have reported an association of many co-morbidities with obesity such as insulin resistance (Kahn and Flier 2000), malignancy (Berger 2014), and mental health disorders including insomnia, depression, anxiety, etc. (Van Vuuren et al. 2019). Anxiety and depression have also found to be common in postmenopausal women due to hormonal changes during menopause, lifestyle changes, social factors, ethnicity, and body image (Kim et al. 2018; Simbar et al. 2020). Controversial findings have been reported regarding the association between obesity and mental health deterioration in postmenopausal women, where positive or negative association (Kirchengast 1993; Provencher et al. 2007; Fernandez-Alonso et al. 2010) as well as negative or no association (Mirzaiinj Mabadi et al. 2006; Kerwin et al. 2010; Thilers et al. 2010; Seib et al. 2013) have been reported in some studies.

This systematic review aimed to: 1) review the pieces of evidence available on the type of association between obesity and mental health in postmenopausal women, 2) identify, which from the obesity measures is most likely to be associated with the mental health, and 3) review the evidence available on the effectiveness of various interventional methods used to combat obesity and its related mental health disorders in postmenopausal women. From 17 cross-sectional studies relevant to this topic, 12 studies have been reported in positive association with obesity and mental health deterioration in postmenopausal women, especially depression, anxiety, and sleep disorders (Kirchengast 1993; Raikonen et al. 1999; Katz et al. 2000; Chedraui et al. 2007, 2014; Provencher et al. 2007; Fernandez-Alonso et al. 2010; Mirhaghjou et al. 2016; Xiong et al. 2017; Naufel et al. 2018, 2019). Body mass index (BMI), visceral fat (VF), waist circumference (WC), waist-to-hip ratio (WHR) were used as measures of obesity. From the anthropometric measures, VF (visceral fat) and WC; the best predictor for VF (Raikonen et al. 1999) showed a negative impact on the psychological well-being of the postmenopausal women (Kerwin et al. 2010; Xiong et al. 2017). Decreased estrogen level during menopause, the lack of physical activity, and consumption of unhealthy food contribute to the accumulation of the abdominal fat (Vanis et al. 2018), which subsequently negatively impact the women's perception of their body image (Simbar et al. 2020).

An excessive accumulation of body fat, especially the abdominal one has also been hypothesized to

be involved in development and progression of depression (Baudrand and Vaidya 2015) via the activated hypothalamic-pituitary-adrenal (HPA) axis (Pasquali et al. 2008), which has been found to be overactivated in 75% of patients with major depression. HPA overactivation may result from glucocorticoids hypersecretion and a subsequent higher accumulation of the visceral fat (Valtonen et al. 2012), where adipocytes are rich in glucocorticoid receptors (Pasquali et al. 2008). In addition, visceral obesity plays a crucial role in the development of insulin resistance and type 2 diabetes mellitus, which are likely to contribute to mood disorders via the alteration of cerebral vessels and brain metabolites (Ajilore et al. 2007). Increased resistance to leptin in obese individuals may also contribute to the increased incidence of depressive mood and anxiety due to the potential protective role of leptin as an antidepressant (Lu et al. 2006; Lu 2007). In addition to these biological mechanisms, the perceptions of postmenopausal women regarding overweight and obesity may cause psychological distress, dissatisfaction with body image, loss of self-esteem, loss of attractiveness, and sexual dysfunction (Thomas et al. 2019), which may impact their mental health (Atlantis and Ball 2008). These evidences emphasize the importance of mental health monitoring when treating obesity and the need to control the weight gain when treating mood and anxiety disorders, especially in aging females.

On the other hand, a negative association between BMI and depression has been reported by Jasienska et al. (2005) in postmenopausal women with lower but not higher education level, reinforcing the role of education level as a contributor to the depression (Ahlawat et al. 2019). This negative association can be explained by the possibility of depression causing eating disorders that resulted in low BMI. Another study conducted in Stockholm has reported that the cognitive functions of postmenopausal women with normal BMI are more likely to decline faster than overweight postmenopausal women (Thilers et al. 2010). They have suggested that the higher level of estrogen in overweight postmenopausal women may have a protective effect on the cognitive performance. The main source of estrogen in postmenopause is it being produced in adipose tissue resulting in higher levels of both estradiol and estrone in overweight women (Rannevik et al. 2008). This was supported by a reliable positive association between BMI and estradiol level in their study (Thilers et al. 2010). This is also evidenced by the better effect of combining phytoestrogen with

mixed exercise than exercise alone in improving the mental health and quality of life in postmenopausal women (Riesco et al. 2011). The third study has reported that higher BMI was associated with poorer cognitive function in women with smaller WHR. Higher WHR, estimating central fat mass, was associated with higher cognitive function in this cross-sectional study (Kerwin et al. 2010), which was also associated with higher estrogen level enforcing the importance of identifying the cut-off point of the serum estrogen level that can protect the postmenopausal women from the deterioration in her cognitive function. An absence of association between mental health and obesity has been reported in two studies conducted in postmenopausal women in Queensland (Mirzaiinjmabadi et al. 2006; Seib et al. 2013). This can be due to a higher level of estrogen secretion in obese postmenopausal women as compared to the lean postmenopausal ones, and the possibility of an indirect relation between BMI and mental health by affecting the sleep of the participants. The association between obesity and the mental health of postmenopausal women has been also evidenced by the effectiveness of weight reduction interventions, such as diet, exercise or combination of both in improving the mental health-related quality of life as well as reducing the severity of menopausal symptoms as it has been shown in the data extracted (Lemoine et al. 2007; Imayama et al. 2011; Van Gemert et al. 2015). Combined administration of fluoxetine and melatonin has been reported as a useful option in treating mood, sleep, and appetite disorders in overweight postmenopausal women (Chojnacki et al. 2015).

Conclusion

Many studies have reported a negative impact of obesity, particularly visceral obesity, on the mental health of postmenopausal women through the link with depression, anxiety, and sleep disorders. The best obesity measure that can predict a mental health decline in postmenopausal women is the visceral fat and/or waist circumference. The combination of increased physical activity with caloric restriction seems to be the most effective intervention to improve the mental health and the quality of life in postmenopausal women.

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