Maturitas 197 (2025) 108266

Contents lists available at ScienceDirect

Maturitas

journal homepage: www.elsevier.com/locate/maturitas

Original article

State anxiety is associated with hormonal, cardiovascular, and sleep parameters in Finnish postmenopausal women

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ARTICLE INFO

Keywords:
Anxiety
Blood pressure
Depression
Hormone therapy
Menopause

ABSTRACT

Objective: To investigate how a range of variables, both physiological (sleep architecture, serum follicle-stimulating hormone (S-FSH), anthropometric and blood pressure measures) and non-physiological (stressful life events, education), are associated with symptoms of distress, anxiety, and depression from premenopause to postmenopause and at postmenopause.
Methods: We recruited 64 women (ages 45–47). Data were derived from an in-house questionnaire, the Brief Symptom Inventory, State-Trait Anxiety Inventory, Beck Depression Inventory, a sleep questionnaire, physiological measurements, and polysomnography at baseline and at ten-year follow-up.
Results: During the follow-up, an increase in weight was associated with an increase in anxiety as recorded by the Brief Symptom Inventory ($p = 0.012$, $R^2 = 0.117$). Cross-sectionally, at postmenopause, state anxiety was associated with an increase in blood pressure and S-FSH, delayed REM sleep, and the use of menopausal hormone therapy ($p_{STAI\text{-}S} < 0.001$, $R^2 = 0.343$). Distress and depressive symptoms were associated with stressful life events and a lower level of education but also with an increase in diastolic blood pressure and use of hormone therapy ($p_{BSI} < 0.001$, $R^2 = 0.328$ and $p_{BDI} < 0.001$, $R^2 = 0.312$). Sleep disruptions were associated with psychological symptoms but vasomotor symptoms were not.
Conclusions: The change in psychological symptoms during the follow-up was modest. At postmenopause, distress and depressive symptoms were associated with a range of physiological and non-physiological parameters, but state anxiety only with physiological parameters. At postmenopause, psychological symptoms were more sensitive to sleep disruptions than were vasomotor symptoms.

1. Introduction

The relationship between menopause and symptoms of depression and anxiety has been studied in numerous setups with conflicting results. Some studies report an increase in depressive [1–4] and anxiety [5,6] symptoms with menopausal transition, while other studies suggest that the symptoms are a result of declining health, life stress, or socio-economic/demographic factors [7,8]. Menopause is characterized by a number of physiological and sociological changes over time, which makes it difficult to demonstrate causality. In addition, the association of physiological parameters (other than climacteric symptoms) with psychological symptoms in this population is not thoroughly reported.

Menopausal status is independently associated with psychological, somatic and vasomotor symptoms [9]. The Study of Women's Health Across the Nation (SWAN) found that late perimenopause and postmenopause had the highest odds for increased depressive symptoms compared to premenopause, and vasomotor symptoms, very stressful life events and negative attitudes toward menopause were strong predictors of depressive symptoms [2]. A Finnish population study showed that psychological symptoms in midlife were associated with perimenopause and hysterectomy but not postmenopause [7]. Also, body mass index (BMI) >25, low physical activity, chronic disease, and low education level associated with psychological symptoms. Unadjusted symptoms of depression, nervousness and tiredness were more prevalent in postmenopause compared to premenopause [7].

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https://doi.org/10.1016/j.maturitas.2025.108266
Received 11 November 2024; Received in revised form 11 February 2025; Accepted 8 April 2025
Available online 11 April 2025

Abbreviations

BDI	Beck Depression Inventory
BMI	Body mass index
BNSQ	Basic Nordic Sleep Questionnaire
BP	Blood pressure
BSI	Brief Symptom Inventory
DBP	Diastolic blood pressure
FEV1	Forced expiratory volume in one second
IFL	Inspiratory flow limitation
MHT	Menopausal hormone therapy
PSG	Polysomnography
REM	Rapid eye movement
SDB	Sleep-disordered breathing
S-FSH	Serum follicle-stimulating hormone
STAI-S	State-Trait Anxiety Inventory - State
SWAN	Study of Women's Health Across the Nation
WHR	Waist-to-hip ratio

Abbreviations for Brief Symptom Inventory

GSI	Global Severity Index
PST	Positive Symptom Total
PSDI	Positive Symptom Distress Index
SOM	Somatization
O-C	Obsessive-compulsive
DEP	Depression
ANX	Anxiety
HOS	Hostility
PHOB	Phobic anxiety

In contrast, there are also reports that show no difference in psychological symptoms between different menopausal stages. Juang et al. found no difference in anxiety and depression scores between pre-, peri-, and postmenopausal groups, although hot flashes associated with higher anxiety and depression scores in peri- and postmenopausal women [10]. Pimenta et al. found that life events predicted depressive mood and anxiety better than menopausal status in a cross-sectional community sample [8]. Also, BMI, poor health, low education and night sweats were independently associated with depression, and trouble falling asleep, early awakening, and poor health status with anxiety, whereas progression of menopause was not [11]. While transitions to peri- or postmenopause were not associated with anxiety disorders or major depressive episodes, preceding mental health problems were related to mental health problems between ages 41 and 50 [12]. Menopausal status appears to have an independent effect on psychological symptoms, but an even stronger effect is associated with stressful life events. Poor health and low education are also often associated with psychological symptoms.

While several factors play a role in the development of psychological symptomology in midlife as recently reviewed [13], the possible association of physiological factors other than hormonal levels and hot flashes is less explored. Therefore, the purpose of our study was to determine (1) whether or how psychological symptoms (distress, anxiety, depression), measured with questionnaires, change from premenopause to postmenopause during the 10-year follow-up and (2) how the symptoms with observed changes over time associate with simultaneous changes in hormone production, anthropometrics, sleep architecture, sleep-disordered breathing (SDB), and blood pressure (BP) in each questionnaire, and, (3) which cross-sectional associations are present also or additionally at postmenopause.

2. Methods

The present study is part of the larger Woman-46 study on midlife women for investigating sleep and cardiovascular risk factors as they progress through menopause. Data collection for the study were conducted between 2001 and 2017 and the study protocol was approved by the Ethics Committee of the Hospital District of Southwest Finland.

2.1. Participants and physiological measures

Participant selection and physiological measurements (polysomnography (PSG), serum follicle-stimulating hormone (S-FSH), BP and forced expiratory volume in one second (FEV1)) have been described in detail previously [14]. Women were initially recruited from the community with newspaper announcements seeking for healthy 45–47-year-old premenopausal women. After the enrolment, 147 were included. Premenopause defined as S-FSH $\leq$ 20 IU/L was confirmed in 116 women and after detailed analysis, 64 were included to the study. Standard anthropometrics (weight, height, neck/waist/hip circumference) were measured at baseline, and at 6-year and 10-year follow-ups. FEV1 was measured 3 times with average value used in the analyses. PSG including oxyhemoglobin saturation and nasal flow was performed at each visit. Sleep stage scoring was performed using the conventional criteria [15,16]. SDB was scored according to Berry et al. [17] and additional scoring of inspiratory flow limitation (IFL) was performed as described previously [14]. S-FSH was measured in the morning prior to PSG. BP measurements were taken while seated in the evening prior to PSG as well as in the morning after PSG. None of the women were using menopausal hormone therapy (MHT) at baseline whereas 13 women were using at follow-up (one missing value).

2.2. Questionnaires

In-house multiple-choice questionnaire was used to gather information about education, chronic diseases, perceived health, significant stressful life events, coping with life events during the past year, and current smoking. English translation of the included questions and transformation to dichotomic parameters is in the Supplement. Participants' distress symptoms were measured with 37-item Brief Symptom Inventory (BSI) which is based on the longer 53-item version BSI [18] (details in the Supplement). State-Trait Anxiety Inventory -State (STAI-S) [19] was used to measure current anxiety symptoms and Beck Depression Inventory (BDI-IA) [20] to measure depression symptoms. Fourteen questions were selected from Basic Nordic Sleep Questionnaire (BNSQ) [21] and dichotomized as described previously [22] (details in the Supplement).

2.3. Statistical analysis

2.3.1. Longitudinal analyses

Changes in characteristics and physiological variables between the baseline and 10-year follow-up were tested with paired samples *t*-test or Wilcoxon signed rank test. Multiple linear regression was used to study the development of symptoms in those questionnaires that showed significant change during the follow-up. Backward method was used ($p > 0.1$ was used for exclusion) and six explanatory parameters were initially entered from six different categories. These categories were: PSG variable, SDB variable, anthropometric variable (BMI, weight, waist-to-hip ratio (WHR), neck, hip, and waist circumference), BP variable, S-FSH, and FEV1. When multiple parameters were available such as with PSG, the one with the highest correlation with dependent parameter was entered to the model.

2.3.2. Cross-sectional analyses

Multivariable linear models were used to analyse the 10-year follow-up data. Normally distributed dependent variables and logarithmic transformed dependent variables (questionnaires) were included. In addition to above mentioned physiological categories in longitudinal analyses, use of MHT and menopausal symptoms (hot flashes and night sweats separately) were included in the initial models. Only normally distributed continuous explanatory parameters and dichotomic parameters were used and therefore SDB variable was excluded. Five of the six questions from in-house questionnaire were included as the number of observations was reduced to 42 if question about coping with life event was included. To avoid data loss, the linear models were run without this parameter. Total number of parameters in each model was therefore 13. Backward method was used to reduce the parameters to the most significant ones ($p > 0.1$ was used for exclusion). Details of the parameter coding are in the supplement.

Mann-Whitney *U* test was used to assess whether vasomotor symptoms and sleep-related symptoms are associated with differences in psychological parameters (BSI-37, STAI-S, BDI) in comparison to asymptomatic women. P-value < 0.05 was considered statistically significant. IBM SPSS Statistics for Windows, Version 27.0. (IBM Corp. Armonk, NY) was used for statistical analyses.

3. Results

3.1. Baseline characteristics

Table 1 shows the demographic and questionnaire characteristics of the study population at baseline and at 10-year follow-up. Questionnaire scores in general did not change much during the 10-years of follow-up. Significant change was only observed within three BSI-37 dimensions: somatization symptoms increased whereas anxiety and hostility symptoms decreased.

3.2. Longitudinal changes in psychological symptoms during menopause

Significant multiple linear regression model was built for the change in anxiety of BSI-37 (model $p = 0.012$, $R^2 = 0.117$) and within this model, only the increase in weight parameter was significantly associated with increase in anxiety ($\beta = 0.022$ (95 % CI 0.005–0.038), $p = 0.012$).

3.3. Cross-sectional differences in psychological symptoms at postmenopause

Linear models are shown in Table 2. Diastolic BP (DBP), life events, MHT use, and delay in rapid eye movement (REM) sleep onset were the most common parameters within models. Full list of used parameters in each model is in the supplement.

3.3.1. BSI-37

Linear models were built for two global and two symptom dimension variables. Global variables shared identical explanatory parameters such as life events but also wide physiological spectrum (hormonal, cardiovascular, sleep). Somatization and obsessive-compulsive dimensions did not share parameters, but both models had hormonal and body habitus parameters. For non-physiological factors, somatization associated with three different parameters, whereas obsessive-compulsive only with smoking.

3.3.2. STAI-S

State anxiety was the only questionnaire, which had only physiological explanatory parameters in the final model. Cardio-vascular and sleep parameters were present in this model as in BSI-37 models and additionally, two hormonal parameters remained in the model.

3.3.3. BDI

Low education and stressful life events associated with depressive symptoms. The use of MHT and morning DBP were also associated with depressive symptoms.

3.4. Sleep and vasomotor symptoms vs. psychological symptom scores

The number and proportion of symptomatic women with perceived sleep problems has been previously published [23]. Psychological symptom parameters were not evenly distributed across all sleep problems (Table 3). Distress symptoms (BSI-37) were related to morning and daytime tiredness and nighttime awakenings. Depressive symptoms

Table 1
Sample characteristics at baseline and 10-year follow-up (N = 64).

	Baseline	Follow-up	Change	p
Age, y	46 (45.8–46.2)	56.8 (56.6–57.1)	10.8 (10.6–11.0)	**<0.001**
S-FSH, IU/L	7.4 (6.5–8.2)	66.7 (59.0–74.3)	59.3 (51.8–67.0)	**<0.001**
BMI, kg/m^2	26.4 (25.2–27.5)	28.9 (27.3–30.4)	2.49 (1.86–3.11)	**<0.001**
Neck, cm	34.0 (33.0–36.5)	35.0 (34.0–39.0)	1.0 (0.5–2.0)	**<0.001**
WHR	0.84 (0.82–0.86)	0.90 (0.88–0.91)	0.06 (0.04–0.07)	**<0.001**
FEV1, L/s *	2.78 (2.69–2.88)	2.62 (2.51–2.73)	−0.18 (−0.29–(−0.08))	**0.001**
BSI-37				
GSI	0.46 (0.27–0.80)	0.46 (0.25–0.67)	−0.05 (−0.21–0.14)	0.322
PST	13.5 (8.25–20.0)	13.5 (8.0–19.75)	−2.0 (−4,75–3.75)	0.223
PSDI	1.20 (1.09–1.45)	1.22 (1.12–1.46)	0 (−0.14–0.16)	0.600
SOM	0.43 (0.143–0.857)	0.71 (0.429–1.00)	0.14 (−0.071–0.429)	**0.006**
O-C	0.83 (0.417–1.333)	0.83 (0.333–1.167)	−0.167 (−0.50–0.167)	0.077
DEP	0.33 (0.00–0.50)	0.17 (0.00–0.50)	0.00 (−0.167–0.167)	0.344
ANX	0.33 (0.167–0.667)	0.17 (0.00–0.50)	−0.167 (−0.33–0.83)	**0.009**
HOS	0.40 (0.20–0.60)	0.20 (0.20–0.60)	0.00 (−0.40–0.20)	**0.020**
PHOB	0.00 (0.00–0.30)	0.00 (0.00–0.20)	0.00 (−0.20–0.00)	0.691
STAI-S	28.0 (24.0–33.0)	29.0 (24.0–33.0)	0.0 (−3.25–4.0)	0.627
BDI	4.0 (1.25–6.0)	5.0 (3.0–8.0)	1.0 (−2.0–3.0)	0.087

Physiological variables are presented with means and 95 % CI, except for neck circumference which is presented with median and interquartile range. These results have been reproduced from Rimpilä et al. [14] with permission, to give an outline for the population. Questionnaire results are presented with median and interquartile range. Abbreviations (top to down): S-FSH: serum follicle-stimulating hormone, BMI: body mass index, WHR: waist-to-hip ratio, FEV1: forced expiratory volume in one second, BSI: Brief Symptom Inventory, GSI: Global Severity Index, PST: Positive Symptom Total, PSDI: Positive Symptom Distress Index, SOM: Somatization, O-C: Obsessive-Compulsive, DEP: Depression, ANX: Anxiety, HOS: Hostility, PHOB: Phobic anxiety, STAI-S: State Trait Anxiety Inventory – State, BDI: Beck Depression Inventory.
Bold font shows significant p-values.

Table 2
Linear model results at 10-year follow-up (N = 60).

Dependent variable	Parameter(s)	β	β (stand.)	95 % CI	p	Model		
						p	R^2	adj. R^2
GSI_{LOG}	DBP_M (mmHg)	0.003	0.261	0.000–0.006	**0.033**	<0.001	0.328	0.273
	REM L.Ons (min)	0.001	0.284	0.000–0.001	**0.021**			
	Life events (n)	0.021	0.366	0.007–0.035	**0.003**			
	MHT (yes/no)	0.083	0.259	0.006–0.160	**0.034**			
PST	DBP_M (mmHg)	0.152	0.210	−0.029–0.333	0.099	0.004	0.264	0.203
	REM L.Ons (min)	0.025	0.232	−0.002–0.053	0.069			
	Life events (n)	1.204	0.363	0.375–2.034	**0.005**			
	MHT (yes/no)	4.092	0.225	−0.474–8.658	0.078			
SOM_{LOG}	DBP_M (mmHg)	0.004	0.239	0.000–0.008	0.059	<0.001	0.384	0.306
	Education (L/H)	0.091	0.231	−0.005–0.186	0.062			
	Per.Health (P/G)	0.173	0.303	0.035–0.311	**0.015**			
	S-FSH (IU/L)	0.002	0.275	0.000–0.003	**0.038**			
	Life events (n)	0.018	0.241	0.000–0.036	**0.046**			
	Waist (cm)	0.004	0.349	0.001–0.007	**0.010**			
$O\text{-}C_{LOG}$	MHT (yes/no)	0.127	0.267	0.002–0.252	**0.046**	0.017	0.182	0.133
	Smoking (yes/no)	0.219	0.240	−0.017–0.456	0.069			
	WHR	1.124	0.327	0.226–2.021	**0.015**			
$STAI\text{-}S_{LOG}$	DBP_M (mmHg)	0.003	0.340	0.001–0.006	**0.006**	<0.001	0.343	0.290
	S-FSH (IU/L)	0.001	0.213	0.000–0.002	0.095			
	REM L.Ons (min)	0.001	0.450	0.000–0.001	**<0.001**			
	MHT (yes/no)	0.074	0.301	0.015–0.132	**0.015**			
BDI_{LOG}	DBP_M (mmHg)	0.009	0.267	0.001–0.016	**0.030**	<0.001	0.312	0.256
	Education (low/high)	0.277	0.361	0.093–0.461	**0.004**			
	Life events (n)	0.043	0.295	0.008–0.079	**0.018**			
	MHT (yes/no)	0.172	0.213	−0.023–0.366	0.082			

For dichotomic parameters (MHT, Education, Per.Health and Smoking) the first one in the parentheses was coded as 1. See supplement for details. Abbreviations: GSI: Global Severity Index, $_{LOG}$: logarithmic conversion, PST: Positive Symptom Total, SOM: Somatization, O-C: Obsessive-Compulsive, STAI-S: State Trait Anxiety Inventory – State, BDI: Beck Depression Inventory, DBP_M: diastolic morning blood pressure, REM L.Ons.: Latency of REM sleep from the sleep onset, MHT: menopausal hormone therapy, Per.Health: perceived health, S-FSH: serum follicle-stimulating hormone, WHR: waist-to-hip ratio. Bold font shows significant p-values.

(BDI) were only related to use of prescription hypnotics. Higher scores on six items that measured sleep problems were positively associated with anxiety levels (STAI-S). Psychological symptoms did not associate with vasomotor symptoms.

4. Discussion

We explored how psychological symptoms developed from premenopause to postmenopause in an initially healthy population recruited from the community. Longitudinally, the increase in anxiety (BSI-37) was related to increase in weight. Models for somatization and hostility were not significant. Cross-sectionally, at postmenopause, distress (BSI-37) and depressive symptoms (BDI) had both physiological and non-physiological explanatory parameters. State anxiety (STAI-S) was associated only with physiological parameters. In addition, state anxiety was most often associated with sleep complaints in comparison to distress and depressive symptoms.

4.1. Distress (BSI-37)

Longitudinal models did not reveal physiological factors for increased somatization, but instead weight increase was associated with increased anxiety score. There was an overall decrease in anxiety score over time, which is in line with a previous study [24], but seems contradictory to linear model. However, post hoc analysis of weight change vs. anxiety change scatter plot showed that while most of the anxiety changes over time were negative, a positive slope was observed, which explains these results.

Cross-sectional linear models at postmenopause showed the combined effect of physiological and non-physiological parameters on distress. It is noteworthy that the spectra of parameters were quite wide. Somatization dimension captures not only the effect of life events and education but also the effect of physiologic parameters: increased waist girth, higher blood pressure and higher S-FSH levels. In addition, the global parameters were sensitive to REM sleep latency. This association suggests a presence of sleep disruption as REM sleep is commonly postponed to the latter part of the night when sleep disruptions are present. Also, MHT is unlikely the source of distress, but rather the menopausal symptoms that it is used for.

4.2. State anxiety (STAI-S)

State anxiety did not show any systematic decrease or increase from premenopause to postmenopause. In this respect, our study differs from some of the previous studies. For example, a greater risk for anxiety symptoms in postmenopause in comparison to premenopause has been shown but this could be explained by much larger population (N = 711) and a different questionnaire [6]. In a longitudinal study, anxiety as a risk factor for menopausal hot flashes has been reported [25] but we were unable to replicate this result, possibly due to low levels of anxiety in our population.

At postmenopause, our study is not in full agreement with previous studies since our model has two menopause-related parameters, S-FSH and use of MHT, but no life events while Pimenta et al. showed that life events are more important for anxiety than menopausal status [8]. Association to REM sleep latency is partially in line with findings of Tang et al. [11], who showed that anxiety associated with trouble falling asleep and early awakening. We were unable to replicate the association between hot flashes and anxiety which has also been reported cross-sectionally [10,26]. This may be due to low levels of anxiety in our cohort.

4.3. Depressive symptoms (BDI)

The BDI scores for depressive symptoms were well within normal limits and development of depressive symptoms over the course of study was negligible. An early study from US using a population sample showed that menopausal status had a significant role for depressive symptoms and general well-being but the effect size was only 1–2 % [27].

Table 3
Relationship between vasomotor/subjective sleep symptoms and psychological questionnaire variables at 10-year follow-up.

Question	N (%)	Variable(s)	Asymp. (IQR)	Symp. (IQR)	p
Night sweats	20 (31.7)	–	–	–	–
Hot flashes	16 (25.8)	–	–	–	–
Poor sleep quality	18 (28.1)	STAI-S	28.0 (22.5–31.5)	32.5 (26.0–35.5)	0.017
Witnessed apnea[a]	2 (3.4)	–	–	–	–
Naps	18 (28.1)	–	–	–	–
Daytime tiredness	14 (21.9)	GSI	0.41 (0.23–0.58)	0.62 (0.42–0.82)	0.041
		PSDI	1.21 (1.09–1.41)	1.46 (1.20–1.69)	0.009
		SOM	0.71 (0.36–1.00)	1.07 (0.68–1.39)	0.010
		STAI-S	28.0 (24.0–31.5)	34.0 (27.0–31.5)	0.036
Unintentional falling asleep[a]	1 (1.6)	–	–	–	–
Falling asleep when passive	8 (12.5)	–	–	–	–
Long sleep latency (>30 min)	8 (12.5)	GSI	0.43 (0.22–0.59)	0.70 (0.41–0.98)	0.046
		HOS	0.20 (0.20–0.60)	0.60 (0.40–0.75)	0.028
		STAI-S	28.0 (24.0–32.0)	31.5 (26.0–37.8)	0.048
Restless sleep	22 (36.7)	STAI-S	28.0 (23.5–32.0)	31.5 (26.0–37.8)	0.044
Awakenings during the night	18 (28.1)	PSDI	1.20 (1.07–1.44)	1.43 (1.20–1.69)	0.014
		STAI-S	27.0 (22.5–31.0)	33.5 (28.0–37.8)	<0.001
Trouble falling asleep[a]	3 (4.7)	–	–	–	–
Morning tiredness	9 (14.1)	PSDI	1.22 (1.10–1.45)	1.46 (1.18–1.75)	0.036
Witnessed snoring	14 (24.1)	–	–	–	–
Use of prescription hypnotics	10 (15.9)	STAI-S	28.0 (24.0–32.0)	34.5 (29.5–38.5)	0.008
		BDI	4.0 (2.0–7.0)	7.0 (4.8–14.5)	0.015
Morning headaches	13 (20.6)	–	–	–	–

Values are presented with median (IQR). N: number of symptomatic individuals, p = p-value for Mann-Whitney U Test, Asymp.: asymptomatic, Symp., symptomatic, STAI-S: State Trait Anxiety Inventory – State, GSI: Global severity index, PSDI: Positive Symptom Distress Index, SOM: somatization, HOS: Hostility, BDI: Beck Depression Inventory.

[a] Not tested due to small number of symptomatic women.

At postmenopause, the effect of low education and life events on depressive symptoms are somewhat expected and not surprising. It is also speculated that the effect of menopausal symptoms on depressive symptoms is shown via the use of MHT; severe menopause symptoms are likely to affect mood negatively, leading to depressive symptoms and the use of MHT. A study on depressive symptoms in midlife showed that while reproductive status did not affect the prevalence of major depression, menopausal transition and postmenopause associated with higher scores in depression questionnaire [28]. A longitudinal study showed that negative mood and depressive symptoms were highest during menopausal transition and lowest in late postmenopause, but after controlling for age the difference was no longer observed [29]. Similarly, the effect of menopause disappeared in a population sample when prior depressive status was controlled [27]. Based on these results we conclude that the effect of menopause on depressive symptoms is relatively modest. Increase in DBP is in line with previous studies as depression has been associated with increased cardiovascular risk [30].

4.4. Sleep quality, vasomotor symptoms and psychological symptoms

We found that although almost one third of our population had vasomotor symptoms, these symptoms were not directly associated with any of the psychological parameters. Our cohort was relatively small but within this same population the various sleep-related problems had a clear effect on psychological parameters, even when the prevalence of sleep problems was lower. Therefore, it seems plausible that sleep problems are more significant in the development of psychological symptoms in comparison to vasomotor symptoms in postmenopausal population.

Poor sleep quality has a profound effect on wellbeing and psychological symptoms. When different aspects of distress symptoms (BSI-37) were considered, the global indices, Global Severity Index (GSI) and Positive Symptom Distress Index (PSDI), were found to be higher in association with long sleep latency and nighttime awakenings which are purely sleep-related, and with morning and daytime tiredness, which are more or less the result of poor sleep. What was not seen is also interesting; positive symptom total (PST) score was not significantly different in any of the sleep questionnaire items, suggesting that sleep problems do not introduce new symptoms of distress but rather amplify the existing ones. Somatization score was higher for daytime tiredness, which is not surprising given the range of parameters in Table 2. Long sleep latency associated with hostility dimension, which is understandable with this insomnia symptom.

Connection between worse sleep quality and state anxiety (STAI-S) was evident. Six of the sixteen sleep questions showed a higher anxiety score when sleep quality was worse. This is more than with other questionnaires. Anxiety scores were higher in women with insomnia type symptoms: long sleep latency, restless sleep, and awakenings during the night. As a probable result of lower sleep quality, higher anxiety scores were observed in women who reported daytime tiredness and the use of prescription hypnotics. Those with overall poor sleep quality had also higher state anxiety scores. On average, reduced sleep quality associated with five-point increase in state anxiety. Anxiety dimension of BSI-37 was not significantly different in any of the sleep questions but the questionnaires do not measure the same construct, which presumably explains the different results. For example, BSI-37 addresses feelings during the past 7 days and three of the six anxiety statements are related to fear whereas STAI-S addresses feelings of nervousness, tension, and restlessness in the current moment. Depressive symptoms (BDI) were not associated with any specific sleep symptom, which was unexpected since associations between depression and sleep disorders are common [31]. Instead, BDI scores were found to be higher in those who reported the use of prescription hypnotics, indicating the presence of sleep disorder.

4.5. Strengths and weaknesses

Our study has several strengths but also some drawbacks that should be addressed. First, the study population was recruited from the community, thus the results are applicable to a general population in this age range. However, the potential risk with community studies is always the uncontrollable selection bias. Longitudinal setup enabled us to investigate the progression in various parameters but unfortunately in this case the final population was smaller than expected, which reduces statistical power. We did not address the specific phase of menopause due to fixed end-point, but the S-FSH levels and records for last menstruation support

the view that women were postmenopausal at 10-year follow-up. Further, the median age of menopause in Finland is 51 years [32].

We used fixed ages for the study and the advantage of this approach was that the effect of age and time span were controlled by design, which made it easier to detect the effects of other parameters. Global distress scores in our study were close to those listed by Derogatis for non-patient population with BSI-53 [18], GSI and PST being slightly higher and PSDI slightly lower in our study. It should be acknowledged, though, that three dimensions are omitted in BSI-37, and this might distort the values. However, symptom dimensions in our population did not fully correspond to non-patient data [18]. Obsessive-compulsion dimension score was double the reference level (0.43 vs. 0.83) in our population and consistent over the follow-up period. One explanation for this finding could be the memory difficulties that are often reported in menopausal populations [33]. Of note, the original results by Derogatis [18] are based on the dataset with an equal ratio of men and women but the scores are not stratified according to gender.

5. Conclusions

Changes in physiological parameters from premenopause to postmenopause had a minor role for changes in psychological symptoms and changes in psychological symptoms were smaller than expected. Only the increase in weight associated with increased anxiety. At postmenopause, 13 different parameters were studied and distress and depressive symptoms associated with a range of both physiological and non-physiological parameters. Increase in state anxiety was associated with physiological parameters only. Increase in morning DBP, delay in REM sleep onset, use of MHT, and increase in the number of stressful life events were commonly observed parameters. Finally, the results show how psychological symptoms are affected by different types of sleep disturbances, which could be beneficial for future studies. The effect of vasomotor symptoms on psychological symptoms was not directly observed, whereas the effect of sleep disturbances was evident in this cohort. To conclude, over the ten years of follow up, healthy women show little change in psychological symptoms; at postmenopause, a number of physiological parameters had an effect on psychological symptoms, and psychological symptoms were more sensitive to sleep disruption than vasomotor symptoms in this cohort.

Contributors

Ville Rimpilä contributed to study concept and design, data analysis and drafting and editing of the paper.

Tero Vahlberg contributed to study concept and design, and participated in data analysis and drafting and editing of the paper.

Katja Valli contributed to study concept and design, and participated in data analysis and drafting and editing of the paper.

Tarja Saaresranta contributed to study concept and design, and participated in data collection, data analysis and drafting and editing of the paper.

All authors saw and approved the final version and no other person made a substantial contribution to the paper.

Ethical approval

The work described in this article was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Written informed consent was signed by all study participants.

The study protocol (update) for the main study (Woman-46) was approved by the Ethics Committee of the Hospital District of Southwest Finland (ETMK: 124/180/2011) on November 22nd in 2011.

Provenance and peer review

This article was not commissioned and was externally peer reviewed.

Funding

This study was supported by grants from Finnish Research Foundation of Pulmonary Disease, Foundation of the Finnish Anti-Tuberculosis Association and Governmental Grant for the Turku University Hospital (no: 13542). Funding sources had no role for the conduct of the research.

Data sharing and collaboration

There are no linked research data sets for this paper. The collected data is confidential and is therefore not publicly available.

Declaration of competing interest

The authors declare that they have no competing interest.

Acknowledgements

MD.PhD Olli Polo is acknowledged for initiating the Woman-46 Study. PhD Erkki Kronholm is acknowledged for his help with questionnaires and Ms. Marjo Sunnari is acknowledged for her efforts in data management. We also want to express our gratitude to all the women who participated the study.

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