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Original article

Morning tiredness and insomnia symptoms are associated with increased blood pressure in midlife women

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ABSTRACT

Objectives: The objective of this study was to investigate how blood pressure, sleep architecture, sleep-disordered breathing, body habitus, and levels of serum follicle-stimulating hormone are associated with symptoms of insomnia and sleep quality during menopausal transition.
Methods: 64 healthy premenopausal women (aged 45–47 years) were recruited to the study. Data were collected at baseline and at 10-year follow-up during sleep laboratory and laboratory visits. A sleep questionnaire was used to evaluate sleep quality and insomnia symptoms. Data were analysed using multiple linear and logistic regression with a backward method.
Results: During the menopausal transition, a change in insomnia symptoms was associated with a change in morning systolic blood pressure ($\beta = 0.114$ (CI95% 0.023–0.205), $p = 0.016$). At follow-up, at the age of 56, a higher percentage of REM sleep was associated with a lower odds of restless sleep (OR = 0.842 (95 % CI 0.742–0.954), $p = 0.007$), while both higher systolic and diastolic evening blood pressure was associated with an increased odds of morning tiredness.
OR = 1.047 (95 % CI 1.003–1.092), $p = 0.034$ and OR = 1.126 (95 % CI 1.018–1.245), $p = 0.007$, respectively.
Conclusions: In healthy midlife women, a change blood pressure is related to the development of insomnia symptoms during menopausal transition. In postmenopausal women, a high evening blood pressure may be associated with morning tiredness and a reduced amount of REM sleep may be perceived as restless sleep.

1. Introduction

1.1. Menopause and sleep quality

Sleep problems are prevalent during menopausal transition and often related to climacteric symptoms [1]. Study of Women and Health Across the Nation (SWAN) showed that during the menopausal transition there is an increased risk for difficulty falling and staying asleep, but the risk for early morning awakening decreased from late perimenopause to early postmenopause [2]. Vasomotor symptoms were associated with all three insomnia symptoms but increasing serum follicle-stimulating hormone (S-FSH) levels only with trouble staying asleep [2]. While self-reported sleep quality has consistently been reported to worsen during menopausal transition the polysomnographic findings are inconsistent. Some studies report changes in sleep architecture such as an increase in slow wave sleep (SWS) [3], whereas other report no change [4]. In our dataset (Woman 46 - Study) there was a reduction in total sleep time (TST) after 6 years of follow-up [5], but no difference after 10 years of follow-up [6] when compared to premenopause. However, an increase in SWS and a reduction in stage 2 sleep was

Abbreviations: AHI, apnea-hypopnea index; BNSQ, Basic Nordic Sleep Questionnaire; BP, blood pressure; DBP, diastolic blood pressure; FSH, follicle-stimulating hormone; FEV1, forced expiratory volume; HI, hypopnea-index; IFL, inspiratory flow-limitation; MHT, menopausal hormone therapy; NREM, non-rapid eye movement; OSA, obstructive sleep apnea; ODI_3, 3 % oxyhemoglobin desaturation index; SpO_2, oxyhemoglobin saturation; PSG, polysomnography; REM, rapid eye movement; S-FSH, serum follicle-stimulating hormone; SDB, sleep-disordered breathing; SWS, slow wave sleep; SBP, systolic blood pressure; TST, total sleep time; WHR, waist-to-hip ratio.

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observed during the menopausal transition [6]. Analysis of EEG power spectra showed higher beta power in late perimenopausal and postmenopausal compared to pre- and early menopausal women, partly explained by the hot flash frequency [4].

1.2. Menopause and blood pressure

Blood pressure (BP) usually increases during menopausal transition [7]. Whether this effect is due to menopause per se or just the effect of aging is unclear. In cross-sectional analyses, postmenopausal women, compared with their pre- and perimenopausal counterparts, had a 4–5 mm Hg higher systolic BP (SBP) and 24-h BP. Furthermore, SBP rose nearly 5 mm Hg per decade more in peri- and postmenopausal women than in premenopausal participants. Longitudinal results showed no change in SBP in women who stayed premenopausal throughout follow-up but SBP increased by approximately 4 mm Hg over 5 years in postmenopausal compared with premenopausal women [8]. Also, a cross-sectional study of 18,326 women showed approximately 2 mm Hg higher SBP and diastolic BP (DBP) in postmenopausal vs. premenopausal women in the age range of 46–49 after excluding women with surgical menopause or cardiovascular disease, and controlling for confounding effects of age, body mass index (BMI), smoking, and menopausal hormone therapy (MHT) [9]. On the other hand, an Italian study including 4400 women showed that BP did not differ between fertile and postmenopausal women matched by age and BMI [10]. Normotensive pre- and post-menopausal women had high (40 %) prevalence of night non-dipping and maximum overnight diastolic BP associated with arterial stiffness. Also, poor sleep associated independently with increase in arterial stiffness, but there were no differences in vascular health measures between pre- and post-menopausal women [11]. Finally, a cross-sectional study of >60,000 women identified both age and menopausal status being independently associated with cardiovascular disease risk factors (BP, BMI, lipid metabolism) [12].

1.3. Sleep and blood pressure

Wisconsin Sleep cohort revealed that hypertensive participants had greater decrease in REM sleep, less decrease in SWS, and more difficulties in falling asleep over time when compared to those without hypertension [13]. Data from the Wisconsin Sleep Cohort showed that 7 h total sleep time, 1 h longer wake after sleep onset and sleep efficiency <0.8 were longitudinally associated with non-dipping of SBP [14]. Hypnolaus-study with 1172 participants found no changes in sleep architecture in relation to incident hypertension but reported changes in sleep microstructure [15]. Menopausal women with insomnia show an increase in DBP in the morning hours before wake-up, whereas in women without insomnia the DBP declines across the night [16]. Experimental data demonstrates that mild sleep restriction increases 24-h ambulatory BP in pre-menopausal women [17]. As to sleep-disordered breathing (SDB), no difference was reported in prevalence across different apnea-hypopnea index (AHI) groups when stratified according to insomnia status [14]. Still, in obstructive sleep apnea (OSA) patients, a large study observed that insomnia symptoms associated with cardiovascular comorbidities [18], and in another study with all-cause mortality [19]. In addition, inspiratory flow-limitation (IFL) is common in women [20] and we recently showed that it is associated with evening BP during menopause [21].

Therefore, we first studied how wide range of physiological parameters (BP, SDB, sleep architecture, S-FSH level, body habitus and forced expiratory volume in one second (FEV1) and menopausal symptoms) associated with the development of insomnia symptoms in healthy women during menopause. Second, we studied how the mentioned physiological parameters associated with sleep-related symptoms at post-menopause in the end of the study. It was hypothesized that insomnia symptoms and reduced perceived sleep quality would associate with the deterioration of physiological parameters.

2. Methods

Woman 46-study was conducted 2001–2017 to investigate sleep and cardiovascular risk factors in middle-aged women over menopausal transition. The study protocol was approved by the Ethics Committee of the Hospital District of Southwest Finland. Written informed consent was signed by all study participants. The current study uses part of the data gathered in the Woman 46-study, and the same population as in our previous study [21].

2.1. Participants

Premenopausal women aged 45–47 years were recruited from the community. Initially, 147 women were enrolled after excluding women with known coronary heart disease, respiratory insufficiency, sleep apnea, neurological disease, liver disease, malignancies or alcohol abuse. Participants were studied three times: at baseline, and 6 years and 10 years after the baseline study. Baseline and 10-year data was used in this study. Premenopausal state was confirmed in 116 with S-FSH $\leq$ 20 IU/L. Thirty-one women refused or missed the follow-up visit, 21 women were excluded due to missing or insufficient data, and finally 64 women were included to the study.

2.2. Measurements

Weight, height, neck/waist/hip circumferences and derived indices BMI and waist-to-hip ratio (WHR), collectively referred as body habitus, were measured at each study visit. PSG with 4 EEG channels (C3/A2, C4/A1, O1/A2, O2/A1), 2 electrooculograms and one electromyogram, nasal flow with prongs, and oxyhemoglobin saturation with finger oximeter (SpO_2) was recorded with Somnologica (Embla, MedcareFlaga hf, Reykjavik, Iceland) and scored using the common guidelines [22–24]. In addition, IFL was scored as previously described [21]. Superscripts ^{NREM} and ^{REM} (for non-rapid eye movement sleep (NREM) and REM sleep) are used with parameters when necessary. S-FSH was measured in the morning prior to PSG as described previously [6]. BP was measured in seated position (Omron M3, Japan) in the evening before PSG and in the following morning. Measurements were taken three times and average value was used in the study. Subscripts $_E$ and $_M$ for evening and morning are used with SBP and DBP when necessary. At each visit, FEV1 measurement was performed as a surrogate of lung function (One FLOW tester, STI Medical, Canada). Three measurements were taken and the average result was used in the analyses.

2.3. Questionnaires

Vasomotor symptoms were assessed with two questions (hot flashes and night sweats) and dichotomic variables were created with symptoms occurring once a week or more often as cut-off. Subjective sleep quality was assessed with 19 questions based on the Basic Nordic Sleep Questionnaire (BNSQ) [25]. Four questions (10, 11, 12 and 13) were used to quantify insomnia symptoms by calculating a combined score for both baseline and follow-up visits (longitudinal analyses). Score was calculated so that option a) gives one point and option b) gives two points and so forth. Question 11 had an option “cannot say”, which was omitted from calculation. Question 13 had six options, which were reduced to five by combining the last two options. These modifications give the score range of 4 to 19 with higher number indicating more symptoms. Fourteen questions in total were selected from the question battery and included in cross-sectional analysis at follow-up. Questions are categorical and the same cut-offs to create dichotomic variables were used as in a previous study [26]. In general, symptoms occurring at least on three days per week were considered significant (symptomatic). Detailed questions and cut-offs for each question are shown in the Supplement.

2.4. Statistics

Delta variables (marked with "Δ"-symbol) were calculated by subtracting the baseline value from 10-year follow-up value. Morning BP was not initially measured in baseline and therefore N = 29 for ΔSBP_M and ΔDBP_M.

2.4.1. Longitudinal analyses

Changes in participant's characteristics and questionnaire answers between the baseline and 10-year follow-up were tested with paired *t*-test or Wilcoxon signed rank test. Multiple linear regression was used to study the development of insomnia symptoms. Backward method ($p < 0.05$ for inclusion criteria and $p > 0.10$ for exclusion criteria) was used and eight explanatory parameters were initially entered from different categories: PSG (not SDB), SDB, body habitus (BMI, WHR, etc.), BP, FEV1, S-FSH, hot flashes and night sweats. When multiple parameters were available within the category, such as with PSG, the parameter with the highest correlation with dependent parameter was entered to the model.

2.4.2. Cross-sectional analyses

Mann-Whitney *U* test was used to assess the differences in physiological parameters (SDB, FEV1, S-FSH, body habitus, BP, and PSG) between symptomatic and asymptomatic women based on the sleep questionnaire. Logistic regression models were then used to analyse the role of these physiological parameters, menopausal symptoms (night sweats and hot flashes) and use of MHT with each sleep question individually. Result from the above-mentioned Mann-Whitney *U* test was used to select the physiological parameters that were entered to the logistic model if the requirement for normal distribution was satisfied. Backward method (Wald) was used to remove non-significant ($p > 0.1$) parameters from the model. The p-value <0.05 was considered statistically significant. IBM SPSS Statistics for Windows was used for statistical analyses (Version 27.0., IBM Corp., Armonk, NY).

3. Results

During the 10 years follow-up, participants gained weight and FEV1 decreased (and BP increased [21]). Change in insomnia symptom scores ranged from −13 to +7 points but did not reach significance (Table 1). Reduction in insomnia symptoms was seen in 17 women, twelve showed no change and symptoms increased in 26 women over time. Score could not be calculated for nine women due to missing values.

Parameters selected for longitudinal insomnia symptoms model were: PSG; ΔSleep latency to stage 3, SDB; $\Delta Hypopnea\text{-}Index^{NREM}$, body habitus; ΔNeck, BP; ΔSBP_M, ΔFEV1, ΔS-FSH, Δhot flashes and Δnight sweats. ΔSBP_M change, which was the only significant parameter (unadjusted $\beta = 0.114$ (CI95% 0.023–0.205), $p = 0.016$), was related to change in insomnia symptoms. Due to ΔSBP_M the final sample size was 24. Fig. 1 shows the scatter plot between the change in insomnia symptoms and ΔSBP_M during menopausal transition.

In cross-sectional analysis climacteric symptoms were associated to higher S-FSH levels and the need for naps or restless sleep to lower S-FSH levels (Table 2). Restless sleep also associated with median BP. Higher self-reported sleep latency associated with higher IFL and IFL^{NREM} Women who reported morning tiredness had higher median BP in comparison to asymptomatic women. Women with morning headaches had lower median AI compared to those without headaches, with overall indices being quite low (Table 2). AHI, Hypopnea-index (HI), or oxygen desaturations (ODI_3) were not different between symptomatic and asymptomatic participants.

As to sleep architecture, hot flashes were associated with longer REM sleep, whereas daytime tiredness was associated with shorter S1 sleep (Table 3). Tendency to fall asleep was related to shortened sleep latencies and higher proportion of SWS. Restless sleep was associated with shorter REM sleep and longer S1 sleep and longer latency to S2 sleep. Snoring was associated to shorter REM sleep and longer REM sleep latency. Use of prescription hypnotics was connected to lower maximal pulse during PSG.

Logistic regression models were used to examine the associations of physiological parameters and menopausal symptoms with restless sleep and morning tiredness. Percentage of REM sleep was the only significant parameter for restless sleep. Higher percentage of REM sleep was associated with lower odds of restless sleep (OR = 0.842 (95 % CI 0.742–0.954), $p = 0.007$). With morning tiredness, logistic regression models were built for each significant BP variable. Both SBP_E and DBP_E were the only significant parameters for morning tiredness. Higher SBP_E and DBP_E values were associated with higher odds of morning tiredness (MHT adjusted OR = 1.047 (95 % CI 1.003–1.092), $p = 0.034$ for SBP_E and OR = 1.126 (95 % CI 1.018–1.245), $p = 0.021$ for DBP_E).

4. Discussion

The longitudinal aspect of this study investigated the associations between insomnia symptoms and physiological markers in a population sample of women during menopausal transition. Also, associations between sleep related symptoms and physiological markers were analysed cross-sectionally at the follow-up at the age of 56 years. The main longitudinal finding was that a change in SBP_M associated with change in insomnia symptoms during menopausal transition. Cross-sectionally, morning tiredness was associated with higher evening and morning BP, without significant differences in sleep structure, body habitus or any type of SDB, menopausal marker or pulmonary function. Restless sleep was related to differences in BP and S-FSH in bivariate analysis as well as differences in sleep architecture, but the lower percentage of REM sleep was the only significant variable in the final logistic model.

4.1. Insomnia symptoms during menopausal transition

On a group level, insomnia symptoms did not increase significantly during menopausal transition. On an individual level, changes did occur and associated with SBP_M change, but not with any other measured

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

	Baseline (95 % CI)	Follow-up (95 % CI)	Mean change (95 % CI)	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/m2	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[a]	2.78 (2.69–2.88)	2.62 (2.51–2.73)	−0.18 (−0.29 to −0.08)	0.001
Insomnia symptoms	9.0 (7.0–12.0)	9.0 (7.3–13.0)	0.00 (−1.0–2.0)	0.238

Values presented with means and 95 % CI, except for neck circumference and insomnia symptoms presented with median and interquartile range. S-FSH: serum follicle stimulating hormone, BMI: body mass index, WHR: waist-to-hip ratio, FEV1: forced expiratory volume in 1 s. Excluding insomnia and neck circumference, the results were reproduced with permission from Rimpilä et al. [21].

[a] N = 55.

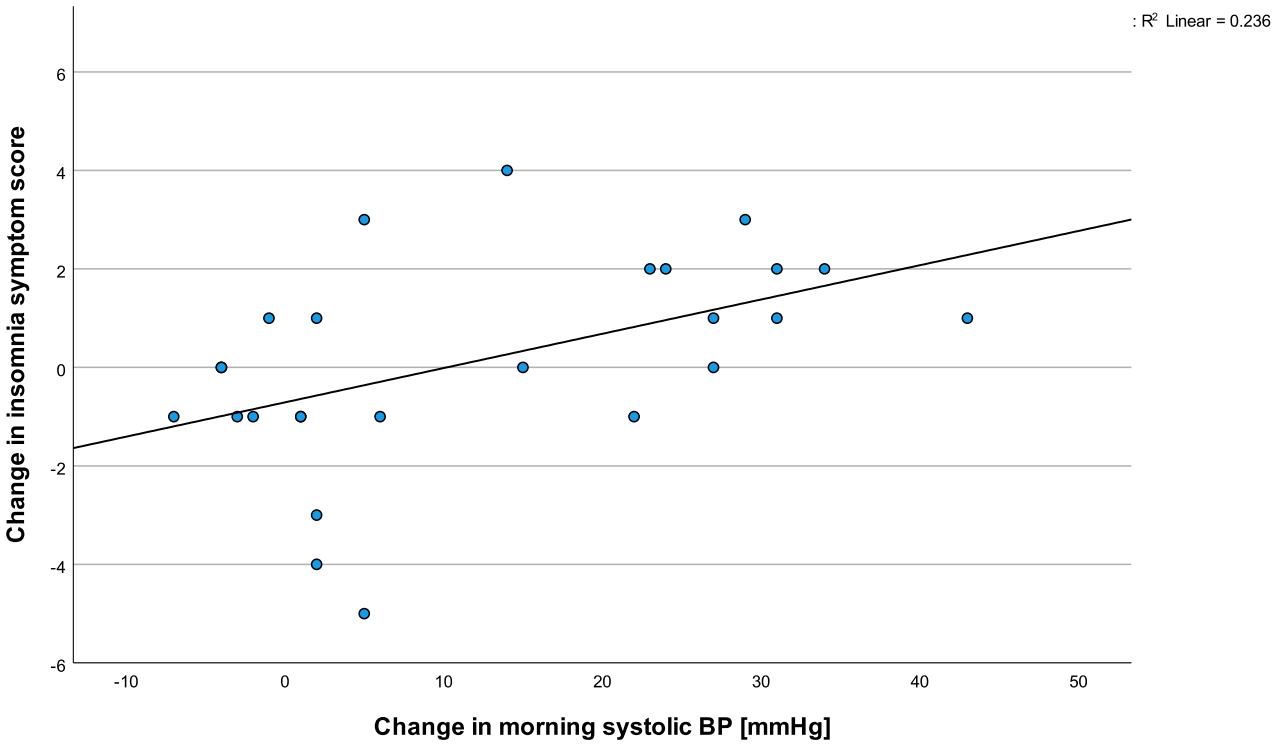

Fig. 1. Scatter plot between the change in insomnia symptom score and change in SBP_M. Association between insomnia symptoms and SBPM was observed during the menopause. Notice how reductions in BP associated with reductions in insomnia symptoms.

physiological factors. According to the regression model, 10 mm Hg change in SBP_M would lead to 1.1 unit change in insomnia symptom score on average. This change corresponds to situation where one of the four questions asked within the insomnia symptoms variable gets worse (or better) by one unit during the follow-up. Changes in vasomotor symptoms or S-FSH level did not associate with insomnia symptoms, which is in contrast with previous studies where both vasomotor symptoms and increased FSH were related to insomnia symptoms [2,27,28]. It should be noted though that less than third of the women in our study reported vasomotor symptoms once a week or more often. The clinical significance of our finding is that even small systematic changes in insomnia symptoms during menopause should be taken seriously. Insomnia has been linked to increased morning BP [16], non-dipping BP [29] as well as increased risk of developing or dying from cardiovascular disease [30]. Since both reciprocal increase and decrease of insomnia and BP were observed, we speculate that this is not purely an age effect associated with BP increase.

4.2. *Perceived morning tiredness and sleep latency at follow-up*

Perceived morning tiredness for more than two times a week could be considered a clinically significant threshold. Our statement is based on the findings that most asymptomatic women reported morning tiredness 1 to 2 times a week or more rarely. Further, 7 of the 8 symptomatic women reported morning tiredness 3 to 5 times a week. Since there were no polysomnographic or any other differences between groups besides the 10 mm Hg higher median BP on both evening and morning measurements, we speculate that morning tiredness in our population could be a marker for impaired cardiovascular health. Interestingly, those who reported generally poor sleep quality, awakenings, or daytime tiredness showed no difference in BP between groups. Our results support the view that just the experience of poor sleep does not relate to BP increase in initially healthy midlife women. Instead, being disturbingly tired on three or more mornings per week is a prerequisite for the effects seen on BP.

Our previous study in this same population showed that increase in systolic and diastolic evening BP was associated with IFL [21]. However, association between morning tiredness and IFL was not observed cross-sectionally in this study. Thus, even though morning tiredness and IFL can be linked to evening BP, it appears that they are not linked to each other in this population. Instead, increased subjective sleep latency associated with IFL whereas PSG defined sleep latency did not. This finding is in line with a previous study showing declining sleep perception from healthy to SDB patients and to insomniacs [31]. Potentially, IFL may affect sleep perception by increasing the sympathetic drive and altering the EEG spectra towards wakefulness since conventional PSG did not detect differences in sleep structure. However, we were unable to make a valid logistic regression model for sleep latency, thus the association between subjective sleep latency and IFL remains speculative in this population. It has also been shown that there was no difference in severe snoring in OSA population stratified according to sleep perception [32].

4.3. *Hormonal and vasomotor effects*

Women who expressed the need for naps at 10-year follow-up or reported restless sleep had lower levels of S-FSH. This seems contradictory to the view that progression of menopause in general is characterized with reduced sleep quality [1]. For example, FSH associated positively with wake after sleep onset, arousals, and awakenings in perimenopausal women [33]. However, according to a detailed report from the SWAN study, there is a greater risk for nocturnal awakenings and early morning wake up in perimenopause compared to postmenopause [2]. This could be one explanation for our seemingly contradictory finding; perimenopausal women need more sleep, which leads to napping. Another interesting result was that REM sleep duration was longer in women who had hot flashes. Several studies have confirmed that vasomotor symptoms associate with decreased subjective sleep quality [1,34,35].

Table 2
Relationship between climacteric/subjective sleep symptoms and physiological variables at 10-year follow-up.

Question	N (%)	Variable(s)	Asymp.	Symp.	p
Night sweats	19 (31.1)	S-FSH (IU/L)	55.5	84.0	0.006
Hot flashes	15 (25.0)	S-FSH (IU/L)	56.0	85.0	0.006
Poor sleep quality	18 (28.1)	–	–	–	–
Witnessed apnea[a]	2 (3.4)	–	–	–	–
Naps	16 (25.8)	S-FSH (IU/L)	67.5	48.5	0.043
Daytime tiredness	14 (21.9)	–	–	–	–
Unintentional falling asleep[a]	1 (1.6)	–	–	–	–
Falling asleep when passive	8 (12.7)	–	–	–	–
Long sleep latency (>30 min)	8 (12.5)	IFL (%)	15.9	25.5	0.025
		IFL^{NREM} (%)	19.2	29.3	0.040
Restless sleep	22 (36.7)	DBP_M (mm Hg)	78.0	87.0	0.008
		S-FSH (IU/L)	67.0	47.0	0.031
Awakenings during the night	17 (27.0)	–	–	–	–
Trouble falling asleep[a]	3 (4.7)	–	–	–	–
Morning tiredness	8 (14.5)	**SBP_E (mm Hg)**	**128.0**	**142.5**	**0.014**
		DBP_E (mm Hg)	**85.0**	**97.0**	**0.004**
		DBP_M (mm Hg)	80.0	90.0	0.026
Witnessed snoring	14 (24.1)	AI (#/h)	1.3	4.7	0.040
		AI^{NREM} (#/h)	0.5	1.6	0.040
Use of prescription hypnotics	10 (16.1)	–	–	–	–
Morning headaches	13 (20.6)	AI (#/h)	2.2	0.4	0.029
		AI^{NREM} (#/h)	1.1	0.3	0.027
		AI^{REM} (#/h)	6.4	1.2	0.046

Values are presented with median in asymptomatic (Asymp.) and symptomatic (Symp.) groups. N = number of symptomatic individuals. p = p- value for Mann-Whitney U test, AI: apnea-index, IFL: inspiratory flow-limitation, S-FSH: serum-follicle stimulating hormone, SBP: systolic blood pressure, DBP: diastolic blood pressure, $_E$: evening, $_M$: morning. Significant variables in logistic regression models are marked with bold.
[a] Not tested due to small number of subjects in the symptomatic group.

4.4. Polysomnography and sleep questionnaire

Polysomnographic findings other than sleep latency were well in line with the reported symptoms. Self-assessed falling asleep when passive may suggest sleep deprivation since there was an increase in SWS and a decrease in sleep latencies at follow-up. Restless sleep was also well in line with the observations of reduced amount of REM sleep, increased amount of S1 sleep, and increased latency to S2 sleep. These findings indicate reduced sleep quality. Witnessed snoring associated with increased REM sleep latency and reduced percentage of REM sleep, a finding explained by the sleep disruption caused by snoring.

4.5. Strengths and limitations

The population in our study is rather small, and therefore the statistical power may be reduced. However, the benefit of a small population is that we can control confounding effects with a wide range of measurements. Since we used fixed age range, chronological aging is

Table 3
Relationship between climacteric/subjective sleep symptoms and sleep architecture variables at 10-year follow-up.

Question	N (%)	Variable(s)	Asymp.	Symp.	p
Night sweats	19 (31.1)	–	–	–	–
Hot flashes	15 (25.0)	REM (min.)	61.0	80.5	0.047
Poor sleep quality	18 (28.1)	–	–	–	–
Witnessed apnea[a]	2 (3.4)	–	–	–	–
Naps	18 (28.1)	–	–	–	–
Daytime tiredness	14 (21.9)	S1 (min.)	33.5	26.0	0.038
Unintentional falling asleep[a]	1 (1.6)	–	–	–	–
Falling asleep when passive	8 (12.7)	SL60 (min.)	18.5	10.5	0.043
		SWS (%)	25.8	30.7	0.038
		SLS2 (min.)	21.5	12.0	0.030
		Max. pulse (bpm)	85.0	80.0	0.048
Long sleep latency (>30 min)	8 (12.5)	–	–	–	–
Restless sleep	22 (36.7)	REM (min.)	74.3	56.8	0.012
		REM (%)	**19.7**	**14.7**	**0.008**
		S1 (min.)	30.3	38.5	0.014
		S1 (%)	8.2	10.6	0.008
		L. Ons S2 (min.)	0.8	3.0	0.042
Awakenings during the night	17 (27.0)	Awake Index (#/h)	2.2	2.5	0.047
Trouble falling asleep[a]	3 (4.7)	–	–	–	–
Morning tiredness	8 (14.5)	–	–	–	–
Witnessed snoring	14 (24.1)	REM (%),	19.4	15.3	0.043
		L. Ons REM (min.)	100.5	156.3	0.043
Use of prescription hypnotics	10 (16.1)	Max. pulse (bpm)	86.5	78.5	0.047
Morning headaches	13 (20.6)	–	–	–	–

Values are presented with median in asymptomatic (Asymp.) and symptomatic (Symp.) groups. N = number of symptomatic individuals. p = p-value for Mann-Whitney U test. REM: rapid eye movement sleep, S1: stage 1 sleep, SL60: sleep latency to continuous sleep (60 s), SWS: slow-wave sleep, SLS2: sleep latency to stage 2 sleep, L. Ons: latency from sleep onset. Awake Index: number of awakenings/h. Significant variable in logistic regression model is marked with bold.
[a] Not tested due to small number of subjects in the symptomatic group.

controlled by design, but women might be in different phases of menopause at the age of 56. We did not classify women to different groups according to menopausal phase at the end of the follow-up. Different phases may translate to contradictory findings such as the need for naps and poor sleep quality with lower S-FSH levels. However, all women had been without menstruation for several years, and therefore, we considered all to be postmenopausal at follow-up. SDB was carefully examined in our previous study [21] and since we are using the exactly same population in this analysis it is safe to assume that the differences observed on BP are not due to masked effect of SDB. Women with morning tiredness had the median BP >10 mm Hg higher but the symptomatic population was small, only 8 women. Therefore, this finding needs to be confirmed in a larger population.

5. Conclusions

Contrary to expectations, insomnia symptoms did not increase in our population during menopausal transition. Despite this unexpected finding, an association between insomnia symptoms and BP was nevertheless observed, which supports the previously reported strong association between insomnia and BP. Having disturbing morning tiredness 3 or more times per week at follow-up was associated with ≥10 mm Hg higher BP compared to those who reported morning tiredness less frequently, and was not explained by any other physiological measurement. Given such dramatic difference in BP, it is suggested that in this age group, morning tiredness should be regularly inquired and investigated. Progression of menopause was followed with S-FSH levels. Associations were observed with individual sleep questionnaire items but regression models showed no effect. It is concluded that in this context the effect of sleep and the effect of BP exceeded that of S-FSH.

Contributors

Ville Rimpilä contributed to study concept and design, and participated in data collection, 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.

Tero Vahlberg 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 approved the final version and no other person made a substantial contribution to the paper.

Ethical approval

This study was approved by the Ethics Committee of the Hospital District of Southwest Finland (ETMK: 124/180/2011). Written informed consent was obtained from all participants.

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This article was not commissioned and was externally peer reviewed.

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

Tarja Saaresranta is a member of the Finnish Task Force for Adult Sleep Apnoea.

All the other authors have no competing interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.maturitas.2024.108131.

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