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Perceived quality of sleep across the menopausal transition: A retrospective cohort study

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Abstract

Background and Aims: To compare sleep quality among naturally and surgically post-menopausal women, and to identify lifestyle factors that predict sleep quality in pre, peri, and postmenopausal women.

Methods: This is a retrospective cohort study of data collected from 429 women who participated in Fels Longitudinal Study data. Sleep quality, based on the Pittsburgh Sleep Quality Index and the Epworth Sleepiness Scale, demographics, medical history, depression, quality of life, and physical activity levels were included in the analysis.

Results: The four study groups did not differ on overall sleep quality with either scale ($p = 0.61$). Both Post-M groups were more likely to have a major sleep problem than the Peri-M and Pre-M groups ($p < 0.001$), and to have a history of restless leg syndrome ($p = 0.016$), but the two Post-M groups did not differ on these problems. Predictors of sleep quality included depression, bodily pain, vitality, and surgical menopause ($p<0.001$).

Conclusion: Menopause is associated with sleep disrupting conditions. This study did not find any significant differences in sleep quality among the three reproductive stages or for natural versus surgical menopause. Women may benefit from addressing other lifestyle factors associated with poor sleep quality including mental health factors.

KEYWORDS

perimenopause, postmenopause, quality of life, reproductive age, sleep quality

1 | BACKGROUND AND AIMS

The transition through menopause is associated with several physical and psychological changes. Decreased sleep quality is a frequent concern of peri- and postmenopausal women, although recent research suggests that various factors likely contribute to sleep disturbances during this time period.[1,2] Factors including physiological changes associated with aging, comorbid medical conditions (including underlying mental health disorders such as anxiety and depression), and various lifestyle factors such as decreased physical activity, and tobacco or alcohol consumption have all been demonstrated to have a profound impact on sleep quality.[3–8]

Subjective sleep quality, which encompasses waking after sleep onset, number of awakenings, sleep latency, and sleep efficiency, has been reported to decline in a linear fashion with increasing age.[1,4,5,9–12] Postmenopausal women are more likely to report sleep disorders than their premenopausal counterparts and among postmenopausal women, those with surgically induced menopause have worse sleep quality than those with naturally occurring menopause.[1,4,13,14] Data on the impact of hormone therapy (HT) on sleep quality during the menopausal transition are conflicting. While some data suggest that hormone changes may impact sleep quality at any age, other data suggest that HT only seems to improve sleep in women who experience hot flashes.[15–21]

Very few studies have addressed the key mechanisms accounting for sleep and health-related quality of life changes that women report before and during the menopausal transition, that is, while premenopausal or during peri-menopause.[22–24] In one study, sleep quality was shown to be worse for women who had undergone surgical menopause versus women who had undergone natural menopause, which the study authors argue that surgical menopause may result in a more rapid decline in hormones experienced by these individuals compared to women in the natural menopause group.[13] Given the existing literature, it is difficult to distinguish which components of the patient experience are related to hormonal changes of menopause and which are attributable to the myriad of other influences that are likely to be occurring simultaneously with menopausal changes.[18,25,26]

The purpose of this study is to examine sleep quality across the lifespan by investigating differences in sleep quality assessments in (1) pre-, (2) peri-, and (3) postmenopausal women. The postmenopausal group is further divided into subgroups based on natural menopause or surgical menopause. Second, we will examine health-related quality of life among the four study groups with follow up analyses comparing the two postmenopausal groups. Third, we will compare and analyze differences in various factors that are believed to impact sleep quality such as quality of life, physical activity levels, presence of depression, and presence of medical conditions associated with poor sleep quality across the study groups.

2 | METHODS

This is a retrospective cohort study utilizing data collected as part of the Fels Longitudinal Study (Fels) which began in 1929 and has been the longest running study of human growth, development, and body composition over the lifespan.[27] Data for the Fels study was actively being collected at the time of data extraction for this study, therefore, data for this study were selected by identifying the most recent study visit for each participant before the planned date of database extraction. Data collected at the identified visit were used for this study. This method ensured that each participant was counted only once in the extracted data set and that the most current data were used. Among the 1260 active Fels study participants at the time of data extraction, 429 participants qualified for inclusion in this study using the following criteria: (1) Females aged 18 years or older; (2) Individuals whose records contained data needed for classification using the Stages of Reproductive Aging Workshop (STRAW) criteria for menopausal status (i.e., age, Follicle Stimulating Hormone level [FSH], Last Menstrual Period [LMP], and oophorectomy with or without hysterectomy), and (3) Individuals who had completed key assessments needed for this study (described below). Participants provided informed consent when they signed consent for the Fels study which included consent for future secondary analyses. Data for the Fels study were collected by a combination of self-administered questionnaires including menstrual cycle and reproductive history and interviews by research team members. This study was approved by the Wright State University Institutional Review Board as a new analysis of existing data.

Study measures were as follows:

Demographic information included age, highest level of education, working status, marital status and number of individuals in the household by their age.

Menopausal state was determined using the Stages of Reproductive Aging Workshop (STRAW) criteria, a standardized menopause classification tool, in which premenopausal (Pre-M) women are those under the age of 40 and still having menstrual cycles, peri-menopausal (Peri-M) women are those with abnormal FSH (>25 mIU/mL) either with cycles or a last menstrual period (LMP) within 1 year before the visit date, and postmenopausal women are those who have not had a menstrual cycle for more than 1 year before the visit date and who also had an abnormal FSH (>25 mIU/mL) level at that visit. Surgical menopause was defined as history of oophorectomy, whereas natural menopause was defined as the absence of such a surgical history.[28]

Sleep quality assessments included the Pittsburgh Sleep Quality Index (PSQI) questionnaire in which higher scores represent poorer quality of sleep and the Epworth Sleepiness Scale (ESS) in which higher scores represent greater daytime sleepiness.[29,30] The PSQI consists of a global score and 7 subscales (sleep quality, latency, duration, efficiency, disturbance, medication, and dysfunction). The ESS has one total score.

Medical history information included participants' responses to questions worded as "Has a doctor ever told you that you have/had…" to record conditions that were diagnosed by a doctor. Medical conditions of interest for this study included diagnosed sleep disorders, hypertension, thyroid disease, high cholesterol, metabolic syndrome, and history of malignancy. Body mass index (BMI, kg/cm^2) was measured by following standard protocol. Additional information was recorded on study assessments by the research team and included nighttime urinary urgency/frequency and menopausal symptoms (e.g., hot flashes, vaginal dryness), sleep problems, such as restless leg syndrome, snoring, sleep apnea, and insomnia, and social history (e.g., alcohol and tobacco use). Alcohol use was measured as number of drinks per day using standard drink amounts. Smoking status was measured as being a current smoker, previous smoker or never a smoker.

Depression was assessed from participants' responses to the Patient Health Questionnaire (PHQ-9) with high scores representing greater severity of depression.[31]

Quality of Life assessments were determined using the Medical Outcomes Study 36-item Short Form Survey (SF-36). Eight health concepts are represented and include physical functioning ([PF] how does health affect regular physical functioning), role limitations due to physical health problems ([RP] how does health affect work or regular activities), bodily pain ([BP] how much does pain affect activities), general health perceptions ([GH] how healthy one perceives), vitality ([VT] feeling energetic versus worn out), social functioning ([SF] how health affects regular social activities), role limitations due to emotional problems ([RE] how emotional problems affect work or regular activities), and mental health ([MH] feeling happy, peaceful versus down). Lower scores on the SF-36 scales represent poorer functioning.[32,33]

Physical activity levels for work, leisure, and sports participation were determined from the Baecke Habitual Physical Activity questionnaire which is based on the Compendium of Physical Activities.[34] Responses to questions about activities at work, during leisure time, and during sports participation, including amount of time engaged for each category, were used to compute the metabolic equivalents (METs) for the activities. A MET is the ratio of the caloric consumption of an individual engaging in an activity compared to being at rest. Examples of METs include 1 (watching TV or sleeping), 5 (walking briskly), 10 (playing soccer), and 16 (competitive cycling).[35–37]

2.1 | Statistical analysis

ANOVA was used to test the null hypothesis that there are no differences in quality of sleep among the study groups. Post hoc Tukey tests were performed to identify whether differences in sleep quality scores exist between the Nat Post-M and Surg Post-M groups. Similarly, the study groups were compared using ANOVA to examine differences on quality of life measures, depression, and physical activity levels with post hoc Tukey tests to identify which groups differed and to specifically look at differences between the Nat Post-M and Surg Post-M groups.

χ^2 analyses were conducted to identify differences among the study groups on categorical variables such as having specific medical conditions (yes/no) or sleep behaviors such as going to the bathroom at night, taking sleep medications, and menopausal symptoms such as hot flashes and vaginal dryness.

Forward stepwise multiple regressions were conducted to identify predictors of sleep quality, that is, PSQI global score and Epworth sleepiness score. Menopausal state was characterized using dummy variables to denote group membership. Variables of interest for the regression analyses included menopausal group, depression, sleep disrupting conditions, quality of life scales, and physical activity levels. The Bonferroni inequality was used to reduce bias from multiple tests resulting in a $p < 0.005$ ($p < 0.05/10$ tests = $p < 0.005$) to be considered statistically significant. Tests were two sided. SPSS version 24 (IBM) was used for data analysis.

3 | RESULTS

Four hundred twenty-nine women completed a Fels study visit between 2008 and 2015 and had complete data for the variables of interest at the time of data extraction. Participants were classified into study groups based on STRAW criteria definitions, resulting in 163 premenopausal women (Pre-M), 49 perimenopausal women (Peri-M), 145 natural menopausal women (Nat Post-M), and 72 surgical menopausal women (Surg Post-M). The study groups differed on demographic variables as expected related to stage of life such as age, working status, marital status, and medical comorbidities (Table 1). However, no differences were noted on demographic variables or for medical comorbidities between the two post-menopause groups.

The study groups did not differ on sleep quality for the ESS score ($F = 0.18$; $p = 0.91$) or for the PSQI global score ($F = 0.60$; $p = 0.61$; Table 2). The Surg Post-M group had higher scores on the PSQI Sleep Medications scale (i.e., number of times taking sleep medications in a month) than the Pre-M group (0.4 ± 0.9 vs. 0.9 ± 1.3, respectively; Tukey post hoc $p = 0.006$). There were no differences among the study groups for average number of hours of sleep per night reported for the full week, including the comparison of the Nat Post-M and Surg Post-M groups.

Both Post-M groups were more likely to report having a major sleep problem (Surg Post-M = 22.2%; Nat Post-M = 16.7%) compared to the Peri-M and the Pre-M groups (Peri-M = 14.3%; Pre-M = 4.3%; $p < 0.001$), but the two Post-M groups did not differ from each other (Table 2). The Surg Post-M group was more likely to report sleep apnea than all other groups (Surg Post-M = 13.9%; Nat Post-M = 4.9%; Peri-M = 8.2%; Pre-M = 1.8% $p = 0.002$). The study groups did not differ on having a history of insomnia ($p = 0.25$) or using sleep medications three or more times a week ($p = 0.09$). Postmenopausal women were more likely to get up to use the bathroom three or more times a week than other groups (Surg Post-M = 58.3%; Nat Post-M = 55.6%; Peri-M = 32.7%; Pre-M = 17.9%; $p < 0.001$), but the two Post-M groups did not differ from each other ($p = 0.67$).

The Surg Post-M group had the lowest quality of life score for the impact of their health on physical role functioning, that is, their ability to perform physical activities related to work and daily life (RP scale, $p < 0.001$) although their scores were significantly different from only the Pre-M group (Table 3). The Surg-Post-M group also had the lowest quality of life scores for bodily pain affecting their ability to perform daily activities compared to the Pre-M group (BP scale, $p = 0.007$) although this was not considered significant due to our test criterion of $p < 0.005$. The study groups did not differ on smoking, alcohol use, or on physical activity for work, leisure, and sports participation (Table 3).

TABLE 1 Demographic and medical characteristics for four menopausal status groups.

	Pre-M (n = 163)	Peri-M (n = 49)	Nat Post-M (n = 145)	Surg Post-M (n = 72)	All groups p Value	Post-M groups p Value[a]
Age	31.3 (8.4)	50.4 (3.1)	65.7 (10.2)	66.5 (12.5)	<0.001	0.93
Highest education level completed[b]					0.34	0.71
HS/GED	24 (14.7%)	4 (8.2%)	25 (17.2%)	14 (19.7%)		
College or higher	139 (85.3%)	45 (91.8%)	120 (82.8%)	57 (80.3%)		
Currently working (full or part-time)	152 (93.3%)	40 (81.6%)	83 (57.2%)	28 (38.9%)	<0.001	0.01
Marital status (% married)	71 (43.6%)	34 (69.4%)	100 (69.4%)	44 (61.1%)	0.01	0.44
Gravida	2.1 (0.9)	3.7 (1.7)	3.2 (1.5)	3.1 (2.0)	<0.001	0.87
Parity	1.7 (0.9)	2.6 (1.1)	2.5 (1.2)	2.6 (1.6)	<0.001	0.97
# Residents >65-year-old	0.02 (0.14)	0.02 (0.14)	0.81 (0.84)	0.92 (0.88)	<0.001	0.59
Age menarche	12.5 (1.3)	13.3 (1.1)	12.7 (1.2)	12.6 (1.4)	0.008	0.91
Age first delivery	26.9 (5.5)	26.7 (5.8)	26.1 (5.8)	24.7 (4.2)	0.08	0.28
BMI (kg/m^2)	26.8 (6.4)	28.0 (8.3)	27.1 (5.6)	27.6 (4.9)	0.63	0.92
Thyroid disease	8 (4.9%)	5 (10.4%)	26 (17.9%)	17 (23.6%)	<0.001	0.37
Cancer history						
Breast cancer	1 (0.6%)	1 (2.0%)	2 (1.4%)	1 (1.4%)	0.89	>0.99
Ovarian	0	0	0	3 (4.2%)	0.002	0.04
Uterine	4 (2.5%)	0	5 (3.4%)	4 (5.6%)	0.34	0.48
Other	9 (5.5%)	3 (6.1%)	33 (22.8%)	22 (30.6%)	<0.001	0.25
CVD/stroke	2 (1.2%)	2 (4.1%)	27 (18.6%)	13 (18.1%)	<0.001	>0.99
Hypertension	17 (10.4%)	12 (24.5%)	81 (55.9%)	45 (62.5%)	<0.001	0.38
Diabetes	6 (3.7%)	3 (6.1%)	22 (15.2%)	14 (19.4%)	<0.001	0.44
High cholesterol	16 (9.8%)	9 (18.4%)	72 (49.7%)	47 (65.3%)	<0.001	0.03
Metabolic syndrome	12 (8.1%)	11 (25.6%)	27 (22.5%)	20 (31.3%)	<0.001	0.22
Menopausal symptoms						
Hot flashes	11 (7.3%)	29 (64.4%)	108 (82.4%)	51 (70.8%)	<0.001	0.07
Vaginal dryness	7 (4.7%)	16 (35.6%)	72 (55.0%)	34 (47.2%)	<0.001	0.31

Note: Data are presented as n (%) and mean (SD).

[a]Nat Post-M vs. Surg Post-M.

[b]Less than high school category is not included.

3.1 | Predicting sleep quality

Predictors of sleep quality (PSQI global score) included PHQ9 depression score ($\beta = 0.53$; $p < 0.001$), SF-36 bodily pain (BP) score ($\beta = -0.17$; $p < 0.001$), SF-36 vitality (VT) score ($\beta = -0.14$; $p = 0.004$), and being Surg Post-M ($\beta = 0.08$; $p = 0.03$) (Model $R = 0.73$; $R^2 = 0.53$; $p < 0.001$). When medical history, activity levels, and current health were allowed to enter the equation, variables in the regression model included depression score ($\beta = 0.46$; $p < 0.001$), history of insomnia ($\beta = 0.19$; $p < 0.001$), bodily pain (BP) score ($\beta = -0.14$; $p = 0.001$), vitality (VT) score ($\beta = -0.16$; $p = 0.001$), getting up to go to the bathroom ($\beta = 0.07$; $p = 0.05$), work activity index ($\beta = 0.09$; $p = 0.01$), and current hypertension ($\beta = 0.09$; $p = 0.01$) predicted PSQI sleep quality (Model $R = 0.76$; $R^2 = 0.58$; $p < 0.001$). So, having higher depression, having a history of insomnia, having poorer quality of life from bodily pain, getting up to go to the bathroom, greater work activity, and having current hypertension were related to worse quality of sleep.

Predictors of daytime sleepiness (Epworth score) included only the SF-36 vitality (VT) score ($\beta = -0.41$; $p < 0.001$) (Model $R = 0.41$; $R^2 = 0.17$; $p < 0.001$), that is, having low energy or feeling tired because of one's health, was associated with increased daytime sleepiness.

TABLE 2 Sleep quality, average hours of sleep, and sleep disrupting conditions among four menopausal status groups.

	Pre-M (*n* = 163)	Peri-M (*n* = 49)	Nat Post-M (*n* = 145)	Surg Post-M (*n* = 72)	All groups *p* Value	Post-M groups *p* Value[a]
Epworth Sleepiness Scale[b]	6.4 (3.9)	6.7 (4.9)	6.6 (3.8)	6.7 (4.0)	0.91	0.99
PSQI Global Score[c]	4.5 (3.0)	4.8 (3.1)	4.5 (3.0)	5.0 (2.9)	0.61	0.69
PSQI sleep quality	1.0 (0.7)	1.1 (0.8)	0.8 (0.8)	1.0 (0.7)	0.05	0.55
PSQI sleep latency	1.1 (1.0)	0.9 (1.0)	0.9 (0.9)	1.0 (1.0)	0.37	0.77
PSQI sleep duration	0.1 (0.5)	0.1 (0.5)	0.1 (0.4)	0.1 (0.4)	0.99	>0.99
PSQI sleep efficiency	0.02 (0.23)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.65	>0.99
PSQI sleep disturbance	1.2 (0.5)	1.3 (0.5)	1.3 (0.6)	1.3 (0.5)	0.52	0.92
PSQI sleep medication	0.4 (0.9)	0.5 (1.0)	0.6 (1.1)	0.9 (1.3)	0.01	0.28
PSQI day dysfunction	0.7 (0.8)	0.9 (0.8)	0.6 (0.7)	0.8 (0.7)	0.29	0.59
Average # sleep hours/night	8.4 (1.3)	8.1 (1.0)	8.1 (1.1)	8.4 (1.4)	0.09	0.21
Took sleep medications >3 times per week	14 (8.6%)	6 (12.2%)	23 (16%)	14 (19.4%)	0.09	0.57
Got up for bathroom ≥3 times per week	29 (17.9%)	16 (32.7%)	80 (55.6%)	42 (58.3%)	<0.001	0.67
Any major sleep problem	7 (4.3%)	7 (14.3%)	24 (16.7%)	16 (22.2%)	<0.001	0.35
Untreated sleep problem	13 (8%)	4 (8.2%)	18 (12.4%)	4 (5.6%)	0.35	0.15
History of sleep apnea	3 (1.8%)	4 (8.2%)	7 (4.9%)	10 (13.9%)	0.002	0.03

Note: Data are presented as *n* (%) and mean (SD).

[a]Nat Post-M vs. Surg Post-M.

[b]Higher scores represent greater daytime sleepiness (scores range from 0–24).

[c]Higher scores represent worse sleep (scale scores range from 0–3; global score ranges from 0–21).

4 | DISCUSSION

The four study groups did not differ on the primary sleep quality outcome measures. The women, regardless of menopausal status, reported similar average number of hours of sleep as well as similar physical activity levels for sports, work, and leisure in our study. Medical conditions differed as expected with increasing age, and the two Post-M groups did not differ from each other on demographic variables or medical conditions. Quality of life was worse for both the Nat Post-M and Surg Post-M women for health affecting daily physical functioning, and for only Surg Post-M women for health affecting work or role related activities. While the Surg Post-M group had lower health related quality of life for most scales, including bodily pain affecting daily activities, the Surg Post-M and Nat Post-M groups did not differ from each other. Regarding the predictors of poor sleep quality, our finding that depression score was the predominant predictor for poor (higher) sleep scale scores is consistent with some of the literature reporting lower mental health scores being associated with poor sleep quality in the general population.[38,39] We did not find higher depression scores in the Post-M groups as others have reported.[40]

Quality of life scales for bodily pain (BP) and vitality (VT) also entered the prediction equation, indicating that poorer function due to BP affecting regular activities was related to poorer sleep quality and that lower scores on VT, that is, feeling tired or worn out, were also associated with poor sleep quality. Bodily pain has been reported in the literature to affect sleep quality however, low vitality may be the result of poor sleep quality.[39,41–43] The literature on physical activity is mixed in that some studies have shown that high levels of physical activity may be related to poor sleep, for example, athletes with high levels of physical activity and fatigue had poorer sleep quality, while other studies suggest physical exercise, including meditative movements and yoga, decreased depression scores and improved sleep quality and quality of life.[41,44–47] One strength of this study is the well-characterized data set from the Fels study that included multiple validated and reliable assessments for the outcomes of interest. This study adds to the literature by extending our understanding of sleep and sleep related problems across three stages of reproductive life and between different groups of postmenopausal women. We did not find differences in sleep quality across the three reproductive stages, nor did we show differences between natural versus surgical menopausal women. We did not find a difference in history of insomnia between naturally menopausal women and surgically menopausal women that has previously been reported in the literature.[13] This study adds quality of life and physical activity, assessed with validated methods, to the conversation about factors affecting sleep, which provides an analysis of novel factors, not previously described in the same study.[38,39,41–45,48,49]

TABLE 3 Quality of life and lifestyle factors among four menopausal status groups.

	Pre-M (n = 163)	Peri-M (n = 49)	Nat Post-M (n = 145)	Surg Post-M (n = 72)	All groups p Value	Post-M groups p Value[a]
SF-36: Rated health as excellent	21 (12.9%)	13 (26.5%)	23 (16.1%)	8 (11.1%)	0.12	0.25
SF-36: Physical functioning	91.9 (14.4)	84.3 (20.8)	73.8 (26.0)	70.6 (25.8)	<0.001	0.73
SF-36: Role physical	89.9 (25.4)	88.8 (26.0)	75.8 (36.9)	63.5 (40.0)	<0.001	0.04
SF-36: Bodily pain	73.9 (21.9)	72.2 (21.3)	68.2 (21.6)	63.8 (23.7)	0.007	0.52
SF-36: General health	73.2 (17.5)	73.3 (20.4)	70.9 (18.1)	68.4 (19.0)	0.24	0.77
SF-36: Vitality	55.7 (19.1)	56.8 (20.6)	58.8 (20.9)	56.0 (21.9)	0.58	0.78
SF-36: Social function	84.1 (21.1)	82.7 (22.6)	83.9 (24.0)	83.2 (22.0)	0.07	>0.99
SF-36: Role emotional	84.0 (28.7)	85.0 (23.6)	81.5 (32.4)	84.0 (29.2)	0.29	0.93
SF-36: Mental health	74.3 (15.9)	76.2 (13.4)	78.8 (16.6)	79.8 (15.8)	0.05	0.91
PHQ9 (depression)	3.97 (4.5)	3.07 (3.8)	2.96 (4.3)	2.75 (3.1)	0.09	0.98
Current smoker	29 (17.8%)	11 (22.4%)	16 (11.0%)	10 (13.9%)	0.18	0.66
Average # drinks/day	0.4 (0.7)	0.5 (1.0)	0.5 (0.8)	0.3 (0.5)	0.20	0.25
Physical activity level						
Sports	2.2 (0.7)	2.2 (0.7)	2.1 (0.6)	2.1 (0.7)	0.24	>0.99
Work	2.7 (0.7)	2.7 (0.5)	2.7 (0.5)	2.7 (0.5)	0.80	>0.99
Leisure	2.6 (0.6)	2.6 (0.7)	2.4 (0.6)	2.4 (0.6)	0.09	0.98

Note: Data are presented as n (%) and mean (SD). On SF-36, lower scores represent poor function/greater disability; (weighted) scores range from 0–100. On PHQ9, higher scores represent greater severity of depression; depression severity is minimal for scores 0–4, mild for scores 5–9, moderate for scores 10–14, moderately severe for scores 15–19, and severe for scores 20–27. A MET is the ratio of the caloric consumption of an individual engaging in an activity compared to being at rest. Examples of METs include 1 (watching TV or sleeping), 5 (walking briskly), 10 (playing soccer), and 16 (competitive cycling).

[a]Nat Post-M vs. Surg Post-M.

Additionally, our use of the STRAW criteria to categorize women into menopausal groups ensured that hormonal changes, such as changes in FSH and removal of ovaries, regardless of age, were considered. In addition, the data used in this secondary data analysis were gathered in a large longitudinal study minimizing the impact of participant response bias for sleep related assessments.

The limitations of our study include an acknowledgment that given this was a cross-sectional study of sleep quality, health status, quality of life and physical activity levels, we are only able to assess for association not causation. We acknowledge the potential for a circular relationship between quality of life, mental health, and physical activity with sleep quality, each having the potential to affect sleep quality and be affected by it. This study is further limited to the population of participants of a large longitudinal study who have participated over their lifetime. This population is predominantly Caucasian, living in the Midwest, and may not be representative of other population segments. However, the sleep quality scores and quality of life scores in the Pre-M group are consistent with scores reported by van Dammen et al.[22] and Celikhisar et al.[50] for reproductive aged women suggesting that our results may be applicable to other populations.

Additional research is needed to understand the multifactorial influences of reproductive stage, lifestyle, activity level and physical health, including quality of life, on sleep quality. Our study noted little difference across the different stages of reproductive life suggesting that the impact of hormones on sleep quality is minimal. The variations among studies on how variables are defined results in challenges in synthesizing this literature.

5 | CONCLUSIONS

Stage of reproductive life was not associated with sleep quality for women across the lifespan. Postmenopausal groups, that is, natural and surgical onset of menopause, had lower quality of life for general physical functioning and physical function for their role, but the two post-menopausal groups did not differ from each other. Poor sleep quality was associated with having depression, lower quality of life due to bodily pain, lower quality of life due to decreased vitality, and a surgical onset for menopause.

AUTHOR CONTRIBUTIONS

Rose A. Maxwell: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; software; supervision; validation; writing—original draft; writing—review & editing.

Keith M. Reisinger-Kindle: Conceptualization; validation; writing—original draft; writing—review & editing. **Traci M. Rackett**: Conceptualization; project administration; resources; writing—review & editing. **Jerome L. Yaklic**: Conceptualization; investigation; methodology; project administration; writing—original draft; writing—review & editing. **Stefan A. Czerwinski**: Conceptualization; Data curation; formal analysis; investigation; methodology; writing—original draft; writing—review & editing. **Miryoung Lee**: Conceptualization; formal analysis; investigation; methodology; validation; writing—original draft; writing—review & editing.

CONFLICT OF INTEREST STATEMENT

Keith M. Reisinger-Kindle is an Editorial Board member of Health Science Reports and a co-author of this article. To minimize bias, they were excluded from all editorial decision-making related to the acceptance of this article for publication. The remaining authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data will be available upon request.

TRANSPARENCY STATEMENT

The lead author Rose A. Maxwell affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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