

Self-Reported Sleep Quality and Fatigue Correlates With Actigraphy in Midlife Women With Fibromyalgia

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- ▶ **Background:** Limited data are available on the relationship between self-reported sleep quality, fatigue, and behavioral sleep patterns in women with fibromyalgia (FM).
- ▶ **Objectives:** To compare self-reported sleep quality, fatigue, and behavioral sleep indicators obtained by actigraphy between women with FM and sedentary women without pain, and to examine relationships among these variables.
- ▶ **Methods:** Twenty-three women with FM ($M = 47.3, \pm 6.7$ years) and 22 control women ($M = 43.5, \pm 8.2$ years) wore an actigraph on the nondominant wrist for 3 consecutive days at home. Each day women reported bedtimes, rise times, and ratings of sleep quality and fatigue in a diary. Self-reported sleep quality, fatigue, and indicators of sleep quality obtained from actigraphy (e.g., total sleep time, sleep efficiency, sleep latency, wake after sleep onset, and fragmentation index) were averaged. The Mann Whitney U test was used to assess group differences. Pearson Product Moment Correlation was used to evaluate relationships between sleep quality and fatigue, and among sleep quality, fatigue, and actigraphy sleep indicators.
- ▶ **Results:** Women with FM reported poorer sleep quality and more fatigue compared to controls (both $p < .001$). Actigraphy sleep indicators were not different between groups. In women with FM but not in controls, self-reported sleep quality was directly related to actigraphy indicators of total sleep time ($r = .635, p < .01$) and inversely related to sleep fragmentation ($r = -.46, p < .05$). Fatigue in women with FM was directly related to actigraphy indicators of wake after sleep onset ($r = .57, p < .01$), and inversely related to sleep efficiency ($r = -.545, p < .01$).
- ▶ **Discussion:** Self-reported sleep quality and fatigue are associated with behavioral indicators of sleep quality at home in women with FM. Actigraphy is a useful objective measure of improved sleep outcomes in intervention studies.
- ▶ **Key Words:** actigraphy in fibromyalgia • fatigue • sleep quality

Fibromyalgia (FM) is a common chronic pain condition, increasingly encountered in primary care settings. The prevalence of FM in the general population in the United States is estimated at 2–4% (Wolfe, Ross, Anderson, Russell, & Hebert, 1995). Fibromyalgia is nine times more common among women than men and the prevalence increases with age, affecting nearly 7% of women over 60 years of age (Wolfe et al., 1995). The case definition of FM is widespread pain in four body quadrants for at least 3 months' duration with tenderness found at 11 out of 18 discrete musculoskeletal areas with palpation (Wolfe et al., 1990). Although fatigue and disturbed sleep are not included in these standard FM criteria, over 75% of patients with FM report poor sleep quality and enduring fatigue (White, Speechley, Harth, & Ostbye, 2000; Wolfe, Hawley, & Wilson, 1996). Poor sleep quality likely contributes to greater fatigue and impaired daytime functioning in FM (Cote & Moldofsky, 1997; Jennum, Drewes, Andreasen, & Nielsen, 1993; Menefee et al., 2000). Self-reported sleep disturbance correlates with fatigue in FM (Wolfe et al., 1996) but relationships between objective measures of poor sleep quality and fatigue have not been well documented, particularly in studies conducted at home. Fatigue severely affects the

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ability of FM patients to carry out routine daily activities, to exercise, and to think clearly (Bennett, Cook, Clark, Burckhardt, & Campbell, 1997; Cote et al., 1997).

Sleep patterns obtained by polysomnography (PSG) in FM show modest increased amounts of nonrapid-eye-movement (NREM) stage 1 (transitional sleep) and wakefulness after sleep onset at night, such that sleep efficiency as an indicator of sleep quality is reduced (Drewes, Svendsen, Nielson, Taagholt, & Bjerregard 1994; Jennum et al., 1993). Women with FM symptoms also show more sleep fragmentation/hour as an indicator of sleep continuity, especially during the first half of the night (Shaver et al., 1997). Nonetheless, when women with FM who are free of current psychiatric disorders are compared to those of a similar age, their subjective perceptions of poor sleep are often out of proportion to and do not match modest changes in PSG sleep quality and continuity indicators. The polysomnogram, which is based on the simultaneous physiologic recordings of brain wave activity, eye movements, and chin muscle tone, is considered the most valid objective method for measuring sleep stages. However, recent PSG studies in healthy women have shown that indicators of reduced sleep continuity and quality were more closely related to self-reported sleep quality compared to sleep stages (Akerstedt, Hume, Minors, & Waterhouse, 1994). Controversy surrounds the clinical significance and diagnostic value of PSG in FM, in part, because of the mismatch between self-reported and PSG sleep stages and quality indicators.

Disturbed sleep patterns have been observed with the use of actigraphy, an objective behavioral indicator of sleep, in FM and in chronic pain. Patients with FM showed increased levels of activity at night compared to healthy controls (Korszun et al., 2002). Relationships between self-report measures of sleep quality and actigraphy also have been assessed. In patients with chronic rheumatological pain, reduced sleep efficiency by actigraphy did not correlate with self-reported sleep quality (Lavie et al., 1992; Wilson, Watson, & Currie, 1998). However, other actigraphy sleep indicators (i.e., sleep latency and amount of wakefulness after sleep onset) have been correlated with diary reports of sleep quality (Wilson et al., 1998).

Increasingly in sleep research, data derived from self-report sleep diaries and from actigraphy are used to validate sleep patterns in subjects prior to sleep laboratory assessment. Compared to PSG, actigraphy is a less resource-intensive method to monitor sleep quality and continuity, especially in the home environment and over extended time periods. If relationships among actigraphy sleep indicators, self-reported sleep quality, and daytime fatigue can be shown, then actigraphy could be a useful objective measure to evaluate the extent of abnormal sleep and the effectiveness of interventions to improve sleep and daytime functioning in FM. Thus, the purpose of this study was (a) to compare indicators of sleep quality and conti-

nity obtained from actigraphy (e.g., total sleep time, sleep efficiency, wakefulness after sleep onset, and fragmentation index) at home in a group of FM patients and a sedentary group of pain-free women of similar age; and (b) to examine whether self-reported sleep quality and fatigue were related to these actigraphy indicators of sleep quality.

Actigraphy as a Measure of Sleep

The actigraph, typically worn on the nondominant wrist, is used to measure daily sleep/wake patterns based on assumptions that wakefulness is associated with arm movements and sleep is not. The validity of actigraphy as an objective measure of sleep/wake patterns has been compared to information obtained by PSG and found to distinguish sleep from wake with good agreement (Cole, Kripke, Gruen, Mullaney, & Gillin, 1992; Sadeh, Sharkey, & Carskadon, 1994; Webster, Kripke, Messin, Mullaney, & Wyborney, 1982). Notably, moderately high reliability ($r = .88$) has been reported for PSG and actigraph sleep recordings at home in women with insomnia (Shaver, Lentz & Landis, 1996). However, sleep time may be overestimated if individuals lie quietly awake with minimal arm movements (Hauri & Wisby, 1992); similarly, it may be underestimated if there are tremors or abnormal arm movements during sleep. Self-reported sleep quality has shown moderate, significant relationships with actigraphy sleep quality in women with insomnia (Shaver et al. 1996). Lastly, actigraphy is being used more frequently as a behavioral indicator of sleep quality in the evaluation of sleep problems (Sadeh, Hauri, Kripke, & Lavie, 1995).

***Fibromyalgia is nine times
more common among
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Methods

Design and Sample

In this study, self-reported sleep quality, fatigue, and actigraphy sleep indicators obtained from a convenience sample of 23 women with FM were compared with 22 women without FM; all had participated in a study of sleep and nighttime hormones in FM. Women with a diagnosis of FM based on published criteria (Wolfe et al., 1990) were identified from the database of an academic referral clinic devoted to the management of fatigue. They were contacted by telephone, and invited to participate in the study if they reported moderate to severe pain at the time of the initial screening interview. Control women from the community were recruited from advertisements placed on bulletin boards and in neighborhood newspapers. Approval for the study was obtained from the Human Subjects Review Committee of the university where the study was conducted and all women gave informed consent.

Screening Procedures

Information on age, height and weight, medical history, medication use, self-rated pain, and physical activity levels

were obtained during the initial telephone interview. Women were included in the study if they: (a) were between 25–60 years of age; (b) had a body mass index (BMI) < 40 kg/m²; (c) did not perform shift work; (d) had no history of major physical illness or sleep disorder diagnosis; (e) had no substance abuse within the past year; and (f) were able to discontinue all hypnotic, sedative, or psychotropic medications for at least 2 weeks prior to and during the sleep study at home.

Psychiatric Interview: Following the initial screening interview, the Diagnostic Interview Schedule (DIS, C-DISR version, C-DIS group, Ottawa) (DSM-III, American Psychiatric Association, 1987) was administered to all women by two nurses trained to conduct these interviews by telephone. Control and women with FM were excluded if they had a psychiatric diagnosis of panic, generalized anxiety, posttraumatic stress, mania or bipolar disorder, alcohol or drug abuse or dependence. The sections of the DIS on depression (major depression, dysthymia, melancholia) were administered 1 week prior to the sleep study. Because sleep disturbances are common in depression (Brunello et al., 2000) and have been documented by actigraphy (Lemke, Puhl, & Borderick, 1999), women with a diagnosis of current depression and FM ($n = 4$) by the DIS were excluded from this study.

Pain: In this study, our goal was to select women with FM and pain and control women with minimal or no pain. Self-rated pain scores (1 = no muscle aches and pain to 10 = worst muscle aches and pain you can imagine) were obtained at the initial telephone screening interview and later verified in daily symptom diary reports. On the basis of the initial phone screen, women with FM were excluded for current pain rated < 4 and control women were excluded for current pain rated > 3. In this study prospective ratings in a daily diary were used to select women with FM who had at least moderate-to-intense pain and control women with minimal pain. Women who met initial study criteria completed a daily diary (Mitchell, Woods, & Lentz, 1991) of symptoms for 4 weeks prior to the sleep study. Symptoms were rated (0 = not present to 4 = extreme). Seven items from the diary related to pain (i.e., right and left arm and right and left leg muscle pain, upper and lower back pain, joint pain) were used to further screen the women. The number of days that any of these seven pain items were rated as a 3 or a 4 was counted for each woman as an indicator of moderate to high intensity pain. Women with FM were included in the study if the total number of days that pain items were rated 3 or 4 was > 6, indicating that they had at least one episode of moderate to high intensity pain for at least 1 week during the 4-week assessment period. In addition, the number of days that any of the seven pain items were rated between 2 and 4 was counted for the control women. Control women were included in

this study if the total number of days pain items were rated 3 or 4 was < 3, OR if the total number of days pain items were rated between 2 and 4 was < 6, indicating that they had pain of any intensity for less than a week.

Physical Activity: Since women with FM report low levels of physical activity (Bennett et al., 1989), control women with relatively low levels of physical activity were selected. Physical activity was measured using the Paffenbarger Physical Activity Questionnaire (Paffenbarger, Wing, & Hyde, 1978), which was administered during the initial telephone interview.

This questionnaire measures leisure time physical activity (e.g., the number of stairs climbed, blocks walked, and time spent in vigorous activities in the previous week). Test-retest reliability of this questionnaire has been assessed previously in studies of postmenopausal women (Cauley, Sandler, Schramm, Kriska, & LaPorte, 1987; LaPorte et al., 1983). A locally developed computer program calculated energy expenditure based on responses to the physical activity items from the questionnaire and published estimates of kilocalories/activity (Paffenbarger et al., 1978). Control women with a calculated energy expenditure of ≥ 1500 kcal/week were excluded from the study. This energy expenditure level was based on findings

of an average score of 1,408 kcal/week derived from the Paffenbarger Physical Activity Questionnaire reported in a sample of 541 women of similar age as the women in this study (Owens, Matthews, Wing, & Kuller, 1990).

Medications: Control women were eligible for the study if they were willing to discontinue taking medications or herbal supplements for a minimum of 2 weeks prior to and during the sleep study. Women with FM were weaned from antidepressant, hypnotic, or psychotropic medications and were drug free for at least 2 weeks prior to and during the sleep study (as monitored by daily diary entries). For medications such as nonsteroidal anti-inflammatory drugs and antihistamines, women were permitted to take these medications until five halflives prior to the first night of the study. Women were permitted to remain on birth control pills or hormone replacement therapy during the study.

Study Protocol

Women came to the sleep laboratory for a procedural orientation session several days before they were scheduled to wear an actigraph for 3 days at home. At the orientation session, they completed a consent form, a demographic profile, and height and weight were verified for the calculation of BMI (kg/m²). The women were given a diary for recording symptoms each day of the sleep study and an actigraph along with written instructions for use of the actigraph at home. Women recorded daily activities, bedtimes, and rise times in the diary. They were instructed to press the event marker on the actigraph at bedtime, at rise time, and if they removed it for any reason. Throughout

**Women with FM symptoms
also show more sleep
fragmentation/hour**

the study, women were asked to carry out their regular daytime activities and usual sleep/wake schedules, they were requested not to take naps. They were allowed to consume food and beverages containing caffeine in usual amounts, but were requested to abstain from consuming them during the afternoon and evening hours. Women with menstrual cycles were scheduled during postmenses days 2 to 7 for study.

Measures

Self-Reported Sleep Quality and Fatigue:

Items from the Washington Women's Health Diary (WWHD) (Mitchell et al., 1991) were used to assess self-reported sleep quality and fatigue. Women rated sleep quality on a scale from 1 = very poor to 6 = excellent and the intensity of fatigue on a scale from 0 = not present to 4 = extreme. Mean scores for sleep quality and fatigue were calculated from the symptom reports for the 3 days of actigraphy recordings. In this study, the test-retest reliability coefficient for sleep quality was $r = 1.04$ and for fatigue was $r = .76$ based on the method developed by Heise (1969). This method controls for the inherent variation of symptoms over time and reliability is not attenuated in size because of changes during the testing interval. This method has been used in assessing reliability of diary data obtained from the WWHD over 3 years (Mitchell & Woods, 1996) and was adapted for use with the 3-day time interval used in this study. With this method reliability coefficients are not restricted to positive or negative scores with a maximum value of 1.0.

Actigraphy Recordings: The Mini-logger™, a motion sensor actigraph (Mini-Mitter, Sun River, OR) was used to measure physical activity. Movement is sensed by an "omni-directional" mercury switch that is "open" when there is no movement and is "closed" when movement is detected. Each time the switch closes an individual count is registered. Movement counts were collected and stored in 15-second epochs. Each Mini-logger™ used in this study was placed on a shaker table in the laboratory and its output assessed to ensure that the mercury switch sensor was able to detect motion. At the end of the 3-day home recordings, the activity data were downloaded to a computer and subsequently processed. Frequency histograms of movements were plotted for each day and the total movement time of activity was calculated.

Sleep/Wake Scoring of Activity Data: To score activity data as sleep/wake patterns, a computer-based automatic sleep-scoring algorithm was used (based on the amplitude and frequency of detected movements scored in 30-second epochs), which was developed and previously validated by Webster and colleagues (1982). This algorithm was adjusted with a scaling factor developed in our laboratory

to maximize agreement between activity data and scored PSG sleep data (Splus 2000 professional release 2, Math Soft Inc.). The PSG sleep efficiency scores (range 79–89.7%) from eight women were randomly selected and used to optimize and increase the validity of activity scored sleep data as an objective indicator of sleep quality for each woman for each day.

Bedtime and rise time reported in the diary were matched with the marker file from the actigraph and used to determine time in bed. Sleep onset latency was calculated from reported bedtime until 2 minutes of inactivity, indicating sleep, was evident on the actigraph recording. Total sleep time in minutes was defined from actigraphic sleep onset until reported rise time (sleep offset). Sleep efficiency was calculated by dividing the amount of total sleep time by time in bed. Wake after sleep onset was based on the total minutes of activity scored as wake between sleep onset and sleep offset. The fragmentation index (expressed as wake counts/hour) was derived from the number of times a change from sleep to wake state occurred. These sleep variables were averaged over at least two nights of actigraphy recordings. The correlation of sleep efficiency between the mean of

two nights with the third night ($r = .60$ for the total sample) was a measure of actigraphy recording stability.

Statistical Analysis

Measures of central tendency and dispersion were examined for all variables. Statistical tests were selected based on variable type, the distribution of the data/variable, and the observation of unequal variance between groups. Descriptive statistics were used to summarize the ethnicity of the sample/group. The Mann Whitney U test was used for between group comparisons on (a) BMI, (b) calculated energy expenditure as a measure of physical activity, (c) actigraphy sleep indicators, (d) self-reported sleep quality, and (e) fatigue. Pearson Product Moment test was used to describe relationships among actigraphy sleep indicators, self-reported sleep quality, and fatigue. Because of the number of comparison tests and the sample size, significance levels were set at $p < .01$. Significance levels $< .05$ were considered as trends.

Results

Demographic Clinical and Sleep Characteristics

Demographic and clinical characteristics for 23 women with FM ($M = 47.3$ years of age) and 22 control women ($M = 43.5$ years of age) (Table 1) show that the sample was comprised of mainly White women. There were no statistically significant differences in age, ethnicity, BMI, and calculated physical activity energy expenditure between groups. Mean self-reported sleep quality was lower and mean fatigue was higher in women with FM compared to control women (both $p < .001$) (Table 1).

The actigraph is used to measure daily sleep/wake patterns

TABLE 1. Demographic and Clinical Characteristics of Women With Fibromyalgia and Control Women

	Fibromyalgia (n = 23)		Controls (n = 22)	
	M (SD)		M (SD)	
Mean age (years)	47.3 (6.7)		43.5 (8.2)	
BMI (kg/m ²)	27.2 (4.5)		25.1 (3.6)	
Energy expenditure (calculated kcal/week)	647.8 (715.4)		767.9 (437.2)	
Fatigue ^{a,b}	3.1 (0.7)		0.9 (0.8)	
Sleep quality ^b	2.6 (1.1)		4.5 (1.05)	
	<i>n</i>		<i>n</i>	
Ethnicity				
White	21		20	
Hispanic	1		0	
Asian or Pacific Islander	0		2	
American Indian or Alaskan Native	1		0	

Note. Data are mean \pm standard deviation or number of the group sample. BMI = body mass index.

^aMean \pm standard deviation based on three days of diary entries at home.

^bMann Whitney U, $p < .01$.

There were no differences in the actigraphy sleep indicators between the women with and without FM (Table 2).

Correlation of Self-Reported Sleep Quality and Fatigue With Actigraphy Sleep Indicators

For women with FM self-reported sleep quality was inversely correlated with fatigue ($p < .01$) but, for control women, this relationship was not as strong ($p < .05$) (Table 3). Moderately strong, statistically significant relationships among self-reported sleep quality, fatigue, and actigraphic indicators of sleep quality were observed only in the group of women with FM. In the women with FM, self-reported sleep quality showed a strong direct relationship with total sleep time ($p < .001$) and a weak inverse relationship with fragmentation index ($p < .04$); fatigue was inversely corre-

lated with sleep efficiency and directly correlated with the amount of wake after sleep onset (both $p < .01$).

Discussion

The results of this study showed that self-reported sleep quality and fatigue are related to objective, behavioral measures of sleep quality and continuity in women with FM. Longer sleep times were associated with better sleep quality; reduced sleep efficiency and longer intervals of wakefulness at night were associated with greater fatigue. Potential confounders to relationships among self-reported sleep quality, fatigue, and actigraph indicators of sleep quality in this study were controlled. Women with FM had at least moderate levels of pain, had no evidence of current

TABLE 2. Mean and Standard Deviations of Sleep Actigraph Measures

Measure	Fibromyalgia n = 23				Control n = 22			
	Mean ^a	Night 1	Night 2	Night 3 ^b	Mean ^a	Night 1	Night 2	Night 3 ^b
Time in bed (min)	492 \pm 82	483 \pm 111	497 \pm 113	493 \pm 95	451 \pm 77	458 \pm 91	436 \pm 99	458 \pm 74
Total sleep time (min)	401 \pm 72.5	399 \pm 114	406 \pm 95.5	395 \pm 68	364 \pm 73	381 \pm 72.5	342 \pm 101	368 \pm 83.5
Sleep efficiency (%)	81.7 \pm 8.1	82 \pm 11.8	81.8 \pm 7.2	81 \pm 9.4	81.2 \pm 10.4	83.7 \pm 8	79.2 \pm 15.4	80.9 \pm 15.2
Sleep latency (min)	12.4 \pm 12.2	12.4 \pm 23.8	14.7 \pm 12.1	10.3 \pm 21	10.5 \pm 9.3	8.5 \pm 5.5	13.8 \pm 22.5	10.1 \pm 9.8
Wake after sleep onset (min)	74.3 \pm 40	67.5 \pm 49	73.9 \pm 42	82.7 \pm 57	66.7 \pm 36.5	66.1 \pm 49	61.9 \pm 35	68.2 \pm 50
Fragmentation index ^a	3.2 \pm 0.8	3.2 \pm 1.0	3.2 \pm 0.8	3.3 \pm 1.1	3.2 \pm 0.7	3.3 \pm 0.8	3.2 \pm 1.0	3.0 \pm 0.8

^aMean \pm standard deviations of at least two nights of actigraph data.

^b $n = 22$ for FM and 15 for controls.

TABLE 3. Correlations of Self-Reported Fatigue and Sleep Quality With Sleep Actigraphy Measures

	Fatigue		Sleep Quality	
	Fibromyalgia <i>n</i> = 22	Control <i>n</i> = 21	Fibromyalgia <i>n</i> = 22	Control <i>n</i> = 21
Diary sleep quality	-.58*	-.46**	—	.10
Sleep efficiency	-.545*	.095	.40	.12
Total sleep time	-.25	-.07	.635*	.09
Wake after sleep onset	.57*	-.14	-.35	.07
Fragmentation index	.41	-.16	-.46**	

p* < .01. Two-tailed tests *p* < .05.

psychiatric disorders, and were not taking hypnotic, antidepressant or other psychotropic medications at the time of the study. Actigraphy sleep indicators showed moderately high stability from night to night. These results support the idea that actigraphy along with sleep logs and symptom diaries would be useful to monitor sleep in intervention studies designed to improve sleep and outcomes in FM at home.

Overall, self-reported (Schaefer, 1995; Jennum et al., 1993) and actigraphy-derived sleep quality (Hyyppa & Kroholm, 1995; Korszum et al., 2002) observed in this study were similar to previous findings in FM. Although it was unexpected, no differences in actigraphic sleep efficiency or continuity (e.g., wake after sleep onset or fragmentation) were observed between women with and without FM. On average, women with FM spent 8 hours in bed and slept slightly less than 7 hours; control women spent 7.5 hours in bed and slept 6 hours, yet both groups had similar sleep efficiency. This observation is similar to findings reported from two studies that used body movements as a behavioral measure of sleep in FM (Hyyppa & Kroholm, 1995; Korszum et al., 2002). Hyyppa & Kroholm (1995) reported no group differences in sleep efficiency as registered by a static charge bed sensitive to respiratory and body movements in groups of patients with musculoskeletal disorders with and without FM. In a more recent study, Korszum and colleagues (2002) found higher levels of overall nighttime activity with the use of actigraphy in FM patients both with and without concurrent depression as compared to healthy controls. However, sleep efficiency, which was measured as the percentage of time during periods of inactivity, was actually similar between women with FM without depression and healthy controls. Relationships between self-reported and objective indicators of sleep quality, and between objective indicators of sleep quality and subsequent daytime fatigue were not evaluated in these studies.

The finding that the groups did not differ in actigraphy measures of sleep quality was unexpected. Women in the control group rated themselves as good sleepers, reported good sleep, and reported low levels of fatigue despite having overall actigraphy sleep quality similar to the women with FM. Thus, the lack of relationships among self-reported sleep quality, fatigue, and actigraphy sleep indicators in con-

trol women are not surprising. It is usually assumed that in normal, healthy adults sleep recorded at home will be of better quality than that recorded in a laboratory. Recent findings from a comparison study of PSG at home vs. the laboratory in middle-aged adults with insomnia vs. normal sleepers challenges this assumption (Edinger et al., 2001). Adults with insomnia showed similar sleep quality at home compared to the laboratory, but normal sleepers had significantly less consolidated sleep at home and better sleep quality in the laboratory. A study comparing PSG and actigraphy at home and in the laboratory, and including relationships to self-reported sleep quality, would help clarify the influence of environment on objective sleep in women with FM compared to normal women.

The association between self-reported poor sleep quality and behavioral measures of sleep suggests that disturbed sleep patterns contribute to fatigue in FM. This fatigue may be mediated by disturbed sleep along with abnormal sleep-related neuroendocrine hormone secretion. Compared to control women, it has been reported that the plasma concentration of growth hormone is reduced during sleep and unrelated to age in FM (Landis et al., 2001). Other research has shown low plasma concentrations of growth hormone and insulin-like-growth factor-I in FM (Bagge, Bengtsson, Carlsson, & Carlsson, 1998; Bennett et al., 1997; Leal-Cerro et al., 1999). Moreover, various clinical features of FM (e.g., muscle weakness, decreased exercise capacity, cold intolerance, fatigue) are similar to signs and symptoms of adult growth hormone deficiency, even though most patients with FM are not considered to have a true deficiency (Dinser, Halama, & Hoffman, 2000). Among FM patients with low pretreatment levels of insulin-like-growth factor-1, GH therapy increased insulin-like-growth factor-1 levels, reduced pain, and improved overall symptoms (Bennett, Clark, & Walczyk, 1998). Intervention strategies that have the potential to enhance functioning of the hypothalamic-somatotrophic axis may improve sleep quality and physical activity tolerance in FM.

This study has several limitations. The women with FM were highly selected since they were drawn from an academic referral clinic and willing to discontinue their medications. Blood or urine toxicology tests were not conducted; it is not certain that the women were completely medication-free. As well, we cannot be certain that some of

the women in both groups did not have sleep disorder, since a thorough screening for sleep apnea and periodic limb movements requires PSG. In addition, the study was restricted in terms of age, sex, and size. As such, these patients do not represent the larger population of community-dwelling individuals of all ages who suffer from FM. Nonetheless, the findings from this study are important because they show a relationship between poor sleep quality, using an objective behavioral measure of sleep, and subsequent daytime fatigue in FM. Interventions designed to improve sleep quality have the potential to improve sleep-related fatigue in FM. Actigraphy along with daily sleep logs are useful measures of sleep quality in intervention studies. ▣

Accepted for publication February 2, 2003.

The authors thank Ms. Stacy Riffle and Ms. Darla Chapman for subject recruitment and Ms. Diana Gates and Ms. Sophia Shiau for assistance with data collection; Mr. Josh McMillion, Dr. Diana McMillian, and Ms. Sandra Johnston for technical and statistical assistance in data processing and analysis.

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Erratum

An error occurred in the article entitled "Testing a Theoretical Model of Exercise Behavior for Older Adults" by Barbara Resnick and Claudio Nigg, pages 80-88, published in the March/April 2003 issue of *Nursing Research* (Volume 52, Number 2). The images published for Figure 1 and Figure 2 were identical. The correct Figure 2 is published below. The publisher regrets the error and any inconvenience caused.

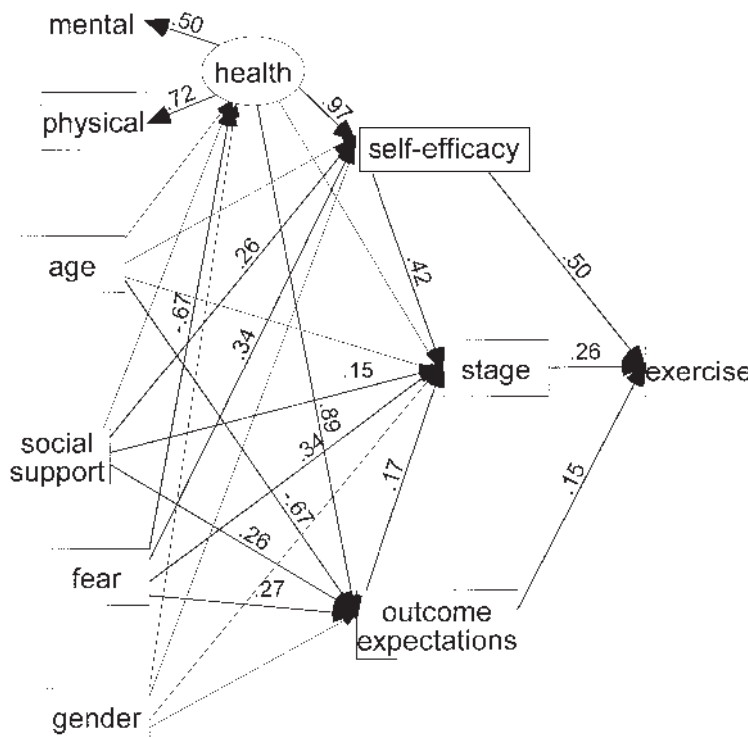


FIGURE 2. Modified Model. Significant Paths Labeled.