

# Passive body heating improves sleep patterns in female patients with fibromyalgia

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**OBJECTIVE:** To assess the effect of passive body heating on the sleep patterns of patients with fibromyalgia.

**METHODS:** Six menopausal women diagnosed with fibromyalgia according to the criteria determined by the American College of Rheumatology were included. All women underwent passive immersion in a warm bath at a temperature of  $36 \pm 1^\circ\text{C}$  for 15 sessions of 30 minutes each over a period of three weeks. Their sleep patterns were assessed by polysomnography at the following time-points: pre-intervention (baseline), the first day of the intervention (acute), the last day of the intervention (chronic), and three weeks after the end of the intervention (follow-up). Core body temperature was evaluated by a thermistor pill during the baseline, acute, chronic, and follow-up periods. The impact of this treatment on fibromyalgia was assessed via a specific questionnaire termed the Fibromyalgia Impact Questionnaire.

**RESULTS:** Sleep latency, rapid eye movement sleep latency and slow wave sleep were significantly reduced in the chronic and acute conditions compared with baseline. Sleep efficiency was significantly increased during the chronic condition, and the awakening index was reduced at the chronic and follow-up time points relative to the baseline values. No significant differences were observed in total sleep time, time in sleep stages 1 or 2 or rapid eye movement sleep percentage. The core body temperature and Fibromyalgia Impact Questionnaire responses did not significantly change over the course of the study.

**CONCLUSION:** Passive body heating had a positive effect on the sleep patterns of women with fibromyalgia.

**KEYWORDS:** Fibromyalgia; Balneotherapy; Sleep; Pain; Body Temperature.

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## INTRODUCTION

Fibromyalgia (FM) is a painful syndrome characterized by widespread pain persisting for more than three months, as well as pain upon palpation of at least 11 of 18 specific points (tender points) located at musculotendinous junctions (1). In addition to pain, common complaints of FM patients include generalized fatigue, headache, muscle rigidity, paresthesia, anxiety, depression and exhaustion (2,3), as well as non-restorative sleep (4-8).

Several studies investigating sleep in FM patients by polysomnography (PSG) have found an increased latency to sleep onset, an increase in the proportion of time spent in sleep stage 1, a reduction in the relative percentages of slow

wave sleep and rapid eye movement (REM) sleep, a decrease in the total sleep duration and an increased awakening frequency (9-11). All of these symptoms are associated with musculoskeletal symptoms and mood disorders. Alpha-wave intrusion occurs in approximately 60% of non-REM sleep in patients with FM; the emergence of this wave promotes superficial sleep, resulting in the feeling of alertness while sleeping (10,12). Further complaints concerning sleep include restless legs syndrome and superficial, fragmented and non-restorative sleep, followed by early awakening and morning fatigue (1,12-14).

Current treatments for patients with FM include both pharmacological and non-pharmacological therapies (7,15) and usually focus on relieving symptoms (16) such as poor sleep. Balneotherapy has been used as one type of non-pharmacological therapy in patients with FM (17).

A previous study evaluated the effects of balneotherapy in warm water ( $36^\circ\text{C}$ ) on FM patients and observed a reduction in the number of tender points and improvement in the patients' Fibromyalgia Impact Questionnaire (FIQ) scores (18). Additional studies conducted in adults have observed that passive immersion in hot baths had a positive effect on both pain and sleep quality (19-21). However, no

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studies have determined the benefits of passive body heating on the sleep patterns of FM patients using PSG.

## ■ MATERIAL AND METHODS

### Ethics

The present study was approved by the Research and Ethics Committee of the Universidade Federal de São Paulo (CEP #0866/06), and all procedures were performed in accordance with the Helsinki Declaration of 1975 and the 1983 revision. The participants received information on the procedures and objectives of the study, participated voluntarily and signed an informed consent form before the intervention has been initiated.

### Subjects

Twenty women were initially selected from the Rheumatology outpatient unit at the Universidade Federal de São Paulo. However, following clinical evaluation, only six women were eligible for inclusion in the study. The diagnosis of FM was made by a rheumatologist following criteria established by the American College of Rheumatology (1).

### Procedure

The study was conducted at the Psychobiology and Exercise Studies Center (CEPE). The patients' personal data were recorded, and the patients were subjected to a clinical evaluation to determine whether they fit the following inclusion criteria: menopausal and sedentary (minimum of three months without physical exercise), with no other chronic illnesses (e.g., rheumatoid arthritis, arthritis or any other disease that could influence the results of the survey as determined by a medical evaluation). Blood samples were collected, and electrocardiograms were conducted at rest on the six women to evaluate their health condition. Medical consent for each participant in the study was obtained from the CEPE physician. Five PSG trials were performed on each patient:

- 1<sup>st</sup> PSG - Adaptation: adaptation and familiarization with the team and equipment;
- 2<sup>nd</sup> PSG - Baseline: determination of the normal sleep pattern;
- 3<sup>rd</sup> PSG - Acute: the first day of the intervention;
- 4<sup>th</sup> PSG - Chronic: the 15<sup>th</sup> (final) day of the intervention;
- 5<sup>th</sup> PSG - Follow-up: three weeks after the end of the intervention.

The patients' core body temperatures were recorded on the days of the PSG, and they were asked to complete the FIQ at the baseline, chronic and follow-up time points. Researchers monitored the patients during all stages of the study.

### Polysomnography

All polysomnographic recordings were performed over a full night, and the recordings were made with a digital system (EMBLA\_S7000, Embla Systems Inc., Broomfield, CO, USA) available at the Sleep Institute ([www.sono.org.br](http://www.sono.org.br)). Surface electrodes were used to record the electroencephalogram, electromyogram, electrooculogram, electrocardiogram, and pneumographic impedance (for recording thoracic-abdominal movements). Patients were also equipped with thermal sensors (for recording nasal and oral airflow), body position sensors and an infrared sensor for the pulse oximeter, which was connected to the distal

phalanx (to record oxyhemoglobin saturation). A snoring sensor was also used (22). After completion of the exam, a trained sleep physician analyzed and staged the recordings.

### Core body temperature

Core body temperature was assessed using a thermistor pill (sensor), which is an electronic device 2.23 cm in length and 1.06 cm in diameter that records body temperature and transmits it to a receptor called the Core Body Temperature Monitoring System (CorTemp™), which is powered by a silver oxide battery and located at the patient's waist. The components of the sensor are encapsulated in epoxy resin and coated with silicone (HQ Inc., Florida, USA). To ensure that the sensor would be in the intestines and not the stomach, the pill was ingested at least 2 h before temperature recording began. The core body temperature was recorded every 30 minutes between 10 pm and 7 am. The time of pill elimination is variable between individuals and may be as long as 48 h.

### Fibromyalgia Impact Questionnaire (FIQ)

The FIQ is an instrument used to assess the quality of life in patients with FM. This questionnaire consists of 19 questions related to functional capacity, employment status, general well-being, psychological disorders and physical symptoms. Higher score indicate a greater the impact of FM on the individual's quality of life (23). This questionnaire was validated for Brazilian population in 2006 (24).

### Intervention Protocol

Patients attended the CEPE five times a week for three weeks between 6 pm and 8 pm for passive body-heating interventions lasting for 30 min per session. The patients were accompanied by a researcher to a therapeutic water bath (Barritz Hydrotherapy Appliance, Germany) and comfortably positioned in a supine position with their necks supported by an inflatable floating pillow to keep the body relaxed and safe during the intervention. The room temperature at the laboratory was maintained at  $23 \pm 1^\circ\text{C}$ , and the water temperature was  $36 \pm 1^\circ\text{C}$  (18,25).

### Statistical analysis

The Shapiro-Wilk test was used to assess data normality. The data obtained for repeated measures of sleep recordings (at the baseline, acute, chronic and follow-up time points) were analyzed using a two-way analysis of variance, followed by Tukey's post hoc test. The core body temperature data and FIQ scores at different points of the study were analyzed using a repeated measures analysis of variance.

The results are presented as the mean  $\pm$  standard deviation, and the level of significance was set at  $p \leq 0.05$ . The Statistics® 7.0 software was used for all analyses.

## ■ RESULTS

Twenty FM patients were initially selected for this study; however, after clinical evaluations, 14 patients were excluded for the following reasons: four patients were non-menopausal, three patients did not meet the study criteria based on the results of the electrocardiogram test, five patients were not sedentary, and two patients withdrew from the protocol due to lack of time. Thus, a total of six patients completed the entire study protocol.

**Table 1** - General characteristics of the included patients (n = 6).

Variables	
Age (years)	55.6 ± 4.3
Weight (kg)	71.8 ± 7.7
Height (m)	1.60 ± 0.10
BMI (kg/cm <sup>2</sup> )	29.4 ± 2.3

The data are presented as the mean ± SD (standard deviation); BMI: body mass index.

The characteristics of these patients are presented in Table 1.

### Sleep pattern

The statistical analysis of the polysomnographic records is shown in Table 2. The patients presented a significant decrease in sleep latency [ $F_{(3,18)} = 11.12$ ,  $p < 0.0002$ ] at the chronic and follow-up time points compared with baseline values. A significant and progressive decrease in REM sleep latency [ $F_{(3,18)} = 15.47$ ,  $p < 0.0001$ ] occurred at all evaluated conditions relative to the baseline evaluation.

A decrease in alertness time [ $F_{(3,18)} = 6.19$ ,  $p < 0.01$ ] was accompanied by a significant increase in sleep efficiency [ $F_{(3,18)} = 3.94$ ,  $p < 0.02$ ] at the chronic and follow-up time points compared with baseline.

During non-REM sleep, an increase in the time spent in slow wave sleep [ $F_{(3,18)} = 6.27$ ,  $p < 0.004$ ] was observed at the acute and chronic points of the intervention compared with the baseline evaluation.

The sleep fragmentation presented by these patients was significantly reduced over the course of this study [ $F_{(3,18)} = 6.5340$ ,  $p < 0.003$ ]. The awakening index was significantly decreased compared with baseline at the end of the treatment and at the follow-up time point.

No statistically significant differences were observed in total sleep time (TST) ( $p = 0.08$ ), sleep stages 1 or 2 or REM sleep.

### Core body temperature and Fibromyalgia Impact Questionnaire

No significant differences in these two variables were found over the course of the study.

## DISCUSSION

The results of the present study demonstrated that passive body heating decreased sleep onset time, REM sleep latency

and the number of awakenings in patients with FM. Sleep efficiency and slow wave sleep were also improved.

Immersion in warm water promotes muscle relaxation, resulting in improvements in mood and muscle tension, which can apparently have an anxiolytic effect in patients with FM (27). Passive body heating is used as a non-pharmacological intervention by 75% of FM patients in an attempt to relieve symptoms (26,27). However, no study has evaluated the effects of passive body heating on the sleep patterns of patients with FM using PSG, a gold standard for sleep studies.

Sleep complaints are common in patients with FM (29,30), and deviations from a normal sleep pattern were observed during the baseline evaluations of the FM patients included in the present study. Warm water may enhance blood flow, which may in turn dissipate algogenic chemicals and facilitate muscle relaxation. Apart from these mechanical and thermal mechanisms, the psychological mechanisms of the spa environment should not be undervalued. Mental relaxation might also play a role in pain relief (31) and provide an explanation for the decrease in sleep latency (11.1 min) observed after 15 sessions of balneotherapy. In addition to muscle relaxation and pain relief, the patients reported mental relaxation, which promotes sleep onset and consequently contributed to the improved sleep efficiency of these patients.

All patients had low sleep efficiency at baseline ( $71.6 \pm 7.0\%$ ) because only values above 85% are considered normal (32). These findings are consistent with previous studies reporting sleep pattern alterations and decreased sleep efficiency in individuals with FM (8,12). Interestingly, a significant increase in sleep efficiency was observed at the chronic ( $86.4 \pm 4.3\%$ ) and follow-up ( $84.6 \pm 8.9$ ) time points, suggesting a clear trend towards improved sleep patterns.

Most adults do not feel fully satisfied with less than 7 h of sleep per day, although sociocultural demands commonly force them to sleep less than their endogenous requirement. Daily sleep requirements generally vary between 5 and 8 h (33). The TST measured by PSG at the baseline evaluation was approximately 5 h ( $325.4 \pm 28$  min), which could be considered insufficient and non-restorative for these patients. A similar TST (4.8 h) was previously reported in another group of FM patients (13). These authors subjected patients with FM to hydrotherapy and determined that TST was significantly increased (to 7.2 h) after three weeks of treatment according to a questionnaire evaluation. No statistically significant differences in TST were observed in the present study after 15 sessions of warm water treatment,

**Table 2** - Sleep parameters obtained by polysomnography.

	Baseline	Acute	Chronic	Follow-up
Awake (min)	96.8 ± 20.3	65.0 ± 23.1	50.6 ± 21.6*	59.9 ± 22.6*
Sleep latency (min)	26.8 ± 6.1	21.3 ± 5.4	15.7 ± 4.2*	15.3 ± 7.2*
REM sleep latency (min)	126.9 ± 16.0	94.9 ± 19.9*	75.8 ± 13.6*	70.6 ± 12.5*
TST (min)	325.4 ± 28.0	329.4 ± 66.2	373.3 ± 21.9	380.8 ± 40.1
Sleep efficiency (%)	71.6 ± 7.0	79.4 ± 13.4	86.4 ± 4.3*	84.6 ± 8.9*
Stage 1 (%)	2.3 ± 1.2	2.9 ± 1.3	2.9 ± 1.8	2.0 ± 1.0
Stage 2 (%)	52.0 ± 6.2	51.2 ± 4.8	50.4 ± 9.4	51.4 ± 3.2
SWS (%)	19.3 ± 5.7	28.4 ± 7.6*	32.8 ± 6.5*	26.4 ± 3.9
REM sleep (%)	21.2 ± 3.0	21.8 ± 4.9	26.1 ± 2.7	27.1 ± 12.5
Awakening index/h	23.5 ± 4.2	19.3 ± 5.4	13.6 ± 3.4*	14.7 ± 5.8*

Data are presented as the mean ± SD. REM: rapid eye movement; TST: total sleep time; h: hour; SWS: slow wave sleep. \* $p < 0.05$  compared with baseline (ANOVA, followed by Tukey's test).



although improvements in the awakening frequency, latency to sleep onset and sleep efficiency were detected.

Moldofsky et al. (5) were pioneers in the study of sleep and FM in the 1970s. These authors reported decreased sleep efficiency and decreased TST in FM patients, similar to the present study. The poor sleep patterns might be related to a feeling of alertness during sleep, daytime sleepiness or the subjective feeling of non-restorative sleep by subjects with FM (34).

These conclusions are consistent with the results obtained at baseline in the present study (Table 2). However, after 15 treatment sessions, alertness during sleep, sleep latency and REM sleep latency were significantly decreased. These improvements persisted to at least the follow-up evaluation performed three weeks after the end of the treatment. The continuity of the therapeutic benefits might reflect the incorporation of the intervention into the patient's daily routine, as the practice of a heated bath lasting 30 minutes at the end of the day affected these results. The use of balneotherapy therefore promoted lifestyle changes, which are paramount for improving the quality of life of FM patients.

Reductions in slow wave sleep and increased sleep fragmentation caused by awakenings (5,12) are among the sleep pattern alterations reported by more than 90% of patients with FM (35). Promisingly, an increase in slow wave sleep after treatment with peripheral passive body heating was observed in the present study. Slow wave sleep is considered a facilitator of muscle recovery and a great peripheral restorer, given that growth hormone is primarily released during this sleep stage. This result, combined with the significant reduction in the number of awakenings, suggests that sleep patterns were significantly improved in FM patients following passive body heating therapy. Indeed, less fragmented sleep leads to a more consolidated sleep pattern.

Passive body heating appears to promote muscle relaxation, reduce anxiety and increase physical comfort, all of which result in a feeling of well-being, reduced level of pain and consequently, improved sleep pattern. While the patients' responses to the FIQ were not significantly altered over the course of the intervention, a trend towards improvement in quality of life was observed after the treatment period.

Body temperature is known to affect sleep. The patients' core body temperatures remained within the physiological levels established in the literature (36). Therefore, passive body heating seems to act via peripheral responses, promoting muscle relaxation, reducing pain and improving the sleep pattern of FM patients without changing the core temperature. The propensity to sleep coincides with a progressive decrease in core body temperature (37). We noted that the passive body heating performed between 6 and 8 pm did not impair this thermoregulatory mechanism.

The lack of a control group should be considered when interpreting the results of the present study. However, this deficiency does not invalidate the progress or conclusions of this study. The results support the use of balneotherapy for overcoming the negative effects of FM on sleep and/or for resuming physical, personal and professional activities. We propose the extrapolation and application of these results in clinical practice.

In conclusion, passive body heating therapy positively affected the sleep pattern of FM patients and may be

broadly used as a non-pharmacological, affordable therapy for patients with this syndrome.

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## ■ AUTHOR CONTRIBUTIONS

Silva A wrote the project, directly and actively supervised all phases of the research and completed the manuscript together with Queiroz SS who was responsible for recruiting volunteers and data collection/plotting and also helped drafting the manuscript, particularly the discussion and literature review, then the first two authors had the same contribution to this study. Andersen ML assisted with all phases of the research, helped with the data analyses and read and corrected the manuscript. Mônico-Neto M was responsible for recruiting volunteers and data collection/plotting and also helped drafting the manuscript, particularly the discussion and literature review. Campos RMS was responsible for recruiting volunteers and data collection/plotting and also helped drafting the manuscript, particularly the discussion and literature review. S Roizenblatt, the team physician, was responsible for the diagnosis of fibromyalgia, assisted the volunteers and read and significantly contributed to the drafting and correcting of the manuscript. Tufik S directly contributed to the data analysis, interpretation of the results and elaboration of the discussion. Mello MT, together with Silva A wrote the project, assisted with all phases of the research, corrected the manuscript and updated the discussion.

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