Pilot Study of the Effect of Ultraviolet Light on Pain and Mood in Fibromyalgia Syndrome

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Abstract

Background: There is a lack of effective systemic or adequate symptomatic treatment for pain associated with fibromyalgia syndrome (FMS). Anecdotes suggest ultraviolet (UV) light may be of some benefit.

Purpose: The purpose of the present study was to determine if UV is effective in ameliorating chronic pain in persons with FMS.

Methods: Nineteen subjects with FMS were enrolled in a controlled trial of UV and non-UV (control) tanning beds for 2 weeks, followed by randomization to receive UV or non-UV (control) exposure for 6 additional weeks. A follow-up interview was conducted 4 weeks after the last treatment. Pain was assessed with an 11-point numerical pain rating (Likert scale), a visual analogue pain scale (VAS), and the McGill Pain Questionnaire. Mood variables were also assessed.

Results: During the initial 2 weeks when subjects received both UV and non-UV (control) exposures, the 11-point Likert scale pain score decreased 0.44 points after exposure to UV from pre-exposure levels (S.E. = .095). Additionally, UV exposure resulted in greater positive affect, well-being, relaxation, and reduced pain levels when compared to non-UV (control) exposure (Odds Ratio [OR] = 2.80, $p = 0.0059$). Following the randomized treatment period, there was slight improvement in pain as measured by the McGill Pain Questionnaire in the UV group compared to the non-UV (control) group (12.2 versus 14.1; $p = 0.049$); the other pain scales yielded nonsignificant results. Assessment 4 weeks after the last treatment showed no significant differences in scores in the adjusted means for outcomes.

Conclusions: Results from this pilot study suggest that tanning beds may have some potential in reducing pain in persons with FMS.

Introduction

Fibromyalgia syndrome (FMS) is a chronic disorder characterized by widespread musculoskeletal pain and tenderness in localized areas of the neck, torso, and extremities, referred to as “tender points.”¹ People with this syndrome may also experience fatigue, sleep disturbances, morning stiffness, irritable bowel syndrome, and anxiety, among other symptoms. Approximately 3–6 million people 18 years of age and older in the United States have FMS; the condition occurs primarily women, although children, the elderly, and men may also be affected.² Although the prevalence of

FMS in the community is estimated at 2%, as many as 15%–20% of patients (90% of them women) seen in rheumatology practices have fibromyalgia.³ Alternative therapies are commonly used by patients in the treatment of this disorder, perhaps in part due to the limited effect of specific therapy for the syndrome.^{4,5}

There is limited anecdotal evidence that supports the use of indoor tanning as a treatment for chronic pain. Improvement in arthritis and back pain with tanning treatments has been reported.⁶ A common explanation for this effect is the direct effect of warmth on the subject, causing an increase in blood flow and a decrease in muscle spasm and tension.⁷

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However, in a previous blinded trial of tanning bed use, with and without ultraviolet (UV) exposure, tanning bed UV exposure had a greater relaxing effect than non-UV exposure in frequent tanners. This raises the possibility of a direct effect of UV light.⁸ One of the subjects in that trial reported relief of back pain that lasted several hours after the tanning bed exposures.⁹

The development of a blinded, controlled methodology for providing UV exposure offers a unique resource for the controlled study of effects of UV on preferences, mood, sensation, and behavior. Based on our previous work, we sought to determine whether UV light exposure from indoor tanning affects pain in persons with FMS. Such a study requires that confounders such as the warm sensation of the tanning procedure and the perceived benefits of having a tan be considered and controlled. A controlled trial was designed and carried out in which FMS subjects were exposed to two conditions, with the only difference being the presence or absence of UV exposure.

Methods

Participants

All 19 participants in this study were white women from 29 to 58 years of age (mean: 48.0 years; SD = 7.9). All participants had a Fitzpatrick skin type of II or III. Prospective participants with FMS were recruited through the Wake Forest University Medical Center clinics and also via newspaper advertisements and notices posted in the Winston-Salem community. Inclusion criteria required that candidates for the study had been diagnosed with FMS by a board-certified rheumatologist and that they met the 1990 Classification Criteria¹ as used by their rheumatologist. Exclusion criteria for this study were as follows: (1) Fitzpatrick skin type 1 ("never tan, always burn"); (2) past or present skin cancer; (3) current use of photosensitizing drugs (current use of photosensitizing drugs was evaluated via a patient questionnaire at the time of patient enrollment) and psychoactive medications (not a stable dose, defined as no change in dosage in the 4 weeks prior to study enrollment), or illicit drugs; (4) pregnant, planning to become pregnant, or breast feeding; (5) significant visual discrimination of UV versus non-UV conditions (see *Discrimination Testing* below); (6) more than six indoor tanning sessions over the past year; and (7) concurrent photosensitive disease, positive antinuclear antibody test, positive anti-Smith antibody test, or positive anti-ds-DNA test.

Equipment

Two identical 32-lamp tanning beds without high-pressure facial tanners (Wolff System Sun Star® ZX32 Series Speed™ 175 System, ETS Inc., Indianapolis, IN) were used. This bed employs 16 bulbs in the canopy and 16 bulbs in the bench. The Speed™ 175 (bed bench) and Speed™ 205 (bed canopy) bulbs (ETS Inc) used are 100 W bulbs and have UV outputs of 4% in the UVB range and 96% in the UVA range (Wolff System Technology Corp, Marietta, GA). Regarding the bulbs' irradiance, UVB irradiance is 0.40 mW/cm² and UVA irradiance is 13.73 mW/cm² (Wolff System Technology Corp). Matching plastic/acrylic filters (Polycast UF3 and Polycast SUVT, Sterling Industries, Shawnee, KS) were used

in the beds. These filters are transparent to visible/infrared light; one is opaque (Polycast UF3, Sterling Industries) and the other transparent (Polycast SUVT, Sterling Industries) to UV light. Importantly, transparency to infrared light permitted both beds to provide the same heat load to the study participants. The filters used appear identical by visual examination, and the use of six sets of filters permitted replacement each week, preventing subjects from identifying subtle differences between filters that were unapparent to the investigators. Additionally, temperature of both tanning beds was programmed to reach a maximum of 100°F, and the room in which they were located was kept at a constant temperature of 70°F.

Procedure

Study participants who met the initial criteria met with the principal investigator or research associate to give informed consent. All participants provided a urine sample before testing, and this was used to screen for pregnancy if the woman was not using an acceptable method of birth control (*i.e.*, abstinence, oral contraceptives, intrauterine device, Depo-Provera, Norplant, tubal ligation, or vasectomy of her partner [with confirmed negative sperm counts]) in a monogamous relationship, and to screen for use of illegal psychoactive drugs. If a urine test was positive for pregnancy, the participant was withdrawn from the study. Random urine drug screening was performed on all study participants on a weekly basis and, if positive, that participant was removed from the study.

Discrimination testing

To make certain that participants were unable to discriminate UV from non-UV exposure by visual, tactile, or other cues that would compromise the study, a 3-filter test was performed.¹⁰ Participants, wearing protective goggles, looked at a UV source through a series of 9 sets of 3 filters. Each of these sets included two of one filter type and one of the other type. Participants were asked to tell which filter was different from the other two. Of 9 tests, 6 correct answers demonstrated significant discrimination ability ($p < 0.05$, binomial test) and excluded a participant from the study.

Tanning UV exposure protocol

Subjects received both UV and non-UV (control) stimuli at 6 evenly spaced weekly sessions over 2 weeks and then either UV or non-UV (control) at 18 evenly spaced weekly sessions over 6 weeks. Sessions were scheduled on Mondays, Wednesdays, and Fridays for 2 weeks and again on Mondays, Wednesdays, and Fridays for the next 6 weeks. Study personnel monitored each session; every participant wore UV-opaque goggles during each treatment session. Participants were asked to complete a pain questionnaire (the McGill Pain Questionnaire¹¹) at the beginning of each session and after every UV and/or non-UV (control) light exposure. The sessions were divided into two phases, as discussed in the sections that follow.

Phase I: Acclimation Phase (Monday, Wednesday, and Friday). Each participant underwent 6 tanning sessions (3 per

week for 2 weeks) at which they were exposed to both bed A and bed B. Bed A served as the non-UV control bed, and Bed B was the UV treatment bed. To acclimate subjects to UV light, the dose of UV (time of exposure) was progressively increased from 3 min to 9 min over the 6 visits. Before and after every tanning session the subject completed the McGill Pain Questionnaire.¹¹

The two goals of the sampling phase were first, to assess the immediate impact of UV tanning exposure on pain, and second, to acclimate subjects to the higher dose of UV to be used in the controlled clinical trial (Phase 2). This acclimation phase also helped to maintain the blind and to eliminate any confounding variables because all participants were exposed to equal amounts of UV and non-UV (control).

Phase II: Sampling for next 6 weeks (Monday, Wednesday and Friday). The subjects who completed the acclimation phase of the study were then randomized to treatment three times per week for 6 weeks with a fixed dose (10 min⁸) of either UV (bed B) or non-UV (control) (bed A) exposure. This provided a placebo-controlled, subject-blinded test of a course of UV treatment on pain in these subjects with FMS. All subjects were treated head to toe once a week with a hypoallergenic and dye-free topical sunless tanning product (Ti-Tan Sunless Tanning Lotion (ProCyte®); active ingredient is dihydroxyacetone). Because the subjects received either UV or non-UV exposure, it may not have been possible to fully blind the study. However, we attempted to mitigate the major confounder—the development of a tan—by treating all participants with sunless tanner.

Follow-up

All subjects were scheduled for a follow-up visit 4 weeks after their last UV or non-UV (control) dose. A visit within a month of the final treatment was thought to provide an ad-

equated interval to permit assessment of whether a participant would return to the baseline level of symptoms related to the original diagnosis of FMS. At this visit each participant completed pain and health assessment questionnaires.

Measures

Pain assessment. Pain was assessed with the 11-point Leikert pain scale, where 0 = “no pain” and 10 = “worst possible pain.” The McGill Pain Questionnaire¹¹ was used to further characterize pain on a multidimensional scale; it also provided information regarding baseline pain levels reported before the start of the trial. The questionnaire consists of 3 major measures: (1) the Pain Rating Index (PRI), based on two types of numerical values that can be assigned to each word descriptor (sensory and affective); (2) the Present Pain Intensity (PPI)-Visual Analogue Scale (VAS)¹² with a scale ranging from 0 (“No Pain”) to 10 (“Worst Possible Pain”); and (3) an “Overall intensity of pain” measure based on a 0–5 intensity scale, with 0 being “no pain” and 5 being “excruciating” (Table 1).

The Fibromyalgia Impact Questionnaire (FIQ)^{13,14} is an instrument designed to measure the overall impact of fibromyalgia over many dimensions (e.g., function, pain level, fatigue, sleep disturbance, psychological distress, etc.). It is scored from 0 to 100, with the latter number being the worst case. Participants completed the FIQ and the Health Assessment Questionnaire (HAQ) at the screening visit and then throughout Phase 2. For Phase I, only the 11-point scale was completed at all sessions.

Mood assessment. Ultraviolet tanning exposure affects mood and can bias the assessment of pain. Since mood changes could include the increase of positive affect as well as the decrease of negative affect, both were assessed. The Positive and Negative Affect Scale (PANAS)¹⁵ consists of 10

TABLE 1. OUTCOMES USED IN THE SECOND PHASE OF THE STUDY

<i>Variables</i>	<i>Range</i>
11-point plan (Likert scale) questionnaire	0 No pain 10 Worst possible pain
Health Assessment Questionnaire (HAQ)	
Pain due to arthritis	0 None 100 Worst
Effects of arthritis	0 None 100 Worst
Fatigue during the last week	0 None 100 Worst
Pain score	0 None 100 Worst
Difficulty score	0 None 100 Worst
McGill Pain Questionnaire score (total pain score)	0 No pain 45 Worse pain
Present Pain Intensity (PPI)-Visual Analog Scale (VAS) pain score	0 None 10 Worst pain
Overall intensity of pain	0 No pain 5 Excruciating pain
Fibromyalgia Impact Questionnaire (FIQ)	0 No impact 100 Maximum impact

adjectives describing positive affect (satisfied, enthusiastic) and 10 adjectives describing negative affect (discouraged, angry). Respondents rated each affect on a 5-point Likert Scale¹⁶ ranging from 0 ("Not at all") to 4 ("Very much"). Three positive and three negative mood states were measured by having subjects rate each one on a 100-mm visual-analogue scale anchored at either end by "The most [alert, relaxed, happy, nervous, distressed, and sad] I could feel" and "Not at all." Scores were obtained during Phase 1 before treatment and after each exposure and during Phase 2 after each exposure.

Tanning blind. In Phase 2 we employed a weekly head-to-toe application of sunless tanner on each participant to help maintain the blind between the UV and non-UV (control) exposure groups. After each session, we asked each participant to estimate the amount of UV light exposure they thought they had just received. By choosing one of the five following answers: normal amount; more than the usual amount; less than the usual amount; no UV exposure; or do not know. Participant responses were recorded after each session.

Statistical Analysis

Phase 1. For the first part of the analysis, regression models based on generalized estimating equation procedures (GEE) were used to examine whether UV treatment decreased pain. A binary outcome variable was defined as 1 if the subject achieved an improvement in pain reported with the 11-point Likert scale pain questionnaire after a tanning session and as 0 if otherwise. For each subject, an indicator for improvement in pain score was obtained for each UV and non-UV (control) session. After adjusting for pain levels prior to exposure and subject level clustering, a logit link

function was used to relate the probability of improvement in pain to the effects of UV/non-UV tanning session. In addition, a separate GEE model was fit to relate the probability of improvement to the effects of dosage levels, restricted to only-UV sessions. One drawback of this approach is that dichotomizing puts small improvements on the same level as large improvements and is therefore not insensitive to changes in pain magnitude. To address this, we also compared continuous pain score differences. Finally, using GEE regressions and adjusting for pre-exposure pain as well as dosage levels, post-treatment continuous pain scores and other secondary outcomes were compared between UV and non-UV (control) exposures.

Phase 2. For Phase 2, 16 subjects were randomized into UV and non-UV (control) treatment groups. Regression models based on generalized estimating equations (GEE) and adjusting for subject clustering were fit on the data in order to predict the relationship between pain score, before and after exposure to tanning, with time since first session (treated as a continuous variable), UV treatment indicator, and the interaction between UV treatment and time (if significant). Secondary outcomes (Table 1) were related to the same predictors in a similar manner.

Results

Phase 1

The average fibromyalgia patient scores about 50 on the FIQ; severely afflicted patients usually have scores of 70 or greater.¹⁵ Our study participants had an average FIQ score of 64.3 (SD = 19.6) at the screening visit. At baseline, the 11-point Likert pain scale (0 as "no pain" to 10 as "worst pain")

TABLE 2. ADJUSTED MEANS OF POST-EXPOSURE OUTCOMES

<i>Post-exposure variables</i>	<i>UV adjusted means</i>	<i>non-UV (control) adjusted means</i>	<i>p-value</i>
PANAS (negative affect) (10 low–50 high)	13.15 (0.84)	13.77 (1.00)	0.0186
PANAS (positive affect) (10 low–50 high)	29.29 (1.84)	28.26 (1.75)	0.0302
Tanning bed preference (1 = Not at all, 9 = Best ever)	7.25 (0.25)	5.83 (0.31)	<0.0001
How much of a tan do you expect (1 = Minimal, 9 = Maximum)	4.00 (0.43)	3.08 (0.33)	<0.0001
How good you feel at this time (1 = Worst, 9 = Best)	5.81 (0.31)	5.33 (0.26)	0.0011
Mood (1 = Very slightly, 9 = Extremely)			
Tense	2.15 (0.34)	2.42 (0.33)	0.0207
Distressed	1.92 (0.30)	2.02 (0.31)	0.0315
Active	3.63 (0.37)	3.67 (0.37)	0.5889
Enthusiastic	4.53 (0.43)	4.48 (0.44)	0.7748
Alert	4.83 (0.38)	4.92 (0.41)	0.5684
Nervous	1.81 (0.28)	1.93 (0.30)	0.0267
Attentive	4.94 (0.40)	5.04 (0.39)	0.5525
Sad	1.81 (1.09)	1.84 (1.12)	0.6605
Relaxed	5.48 (0.39)	4.81 (0.37)	<0.0001

Note: Standard errors in parentheses. Means adjusted for pre-exposure pain and dosage levels.
UV, ultraviolet light.

average was 6.5 (SD = 2.5) and the McGill Pain Questionnaire score average was 19.3 (SD = 9.6).

In Phase 1, the GEE model predicting improvement in pain with the 11-point Likert scale suggested a greater likelihood of pain decrease with UV exposure (Odds Ratio [OR] = 2.80, $p < 0.006$), with 33% of UV exposures showing an improvement in pain versus 16% of non-UV (control) exposures. The 11-point Likert scale pain score showed a reduction of 0.44 points for UV exposure compared to a 0.18 decrease in non-UV (control) (p value of comparison = .06). When the data were restricted to only UV exposure episodes, increased dosage levels were not found to significantly predict an improvement in pain ($p = 0.61$).

A consistent improvement in mood, and preference with UV exposure was observed when assessing the difference in adjusted means between UV and non-UV (control) exposures (Table 2). Ultraviolet exposure resulted in increased positive affect ($p = 0.0302$) as measured by tanning bed preference ($p < 0.0001$), tanning expectations ($p < 0.0001$), well-being ($p = 0.0011$), and relaxation ($p < 0.0001$), as well as decreased negative affect ($p = 0.0186$), as represented by tension ($p = 0.0207$), distress ($p = 0.0315$), and nervousness ($p = 0.0267$).

Phase 2

Two patients did not complete the 6-week randomized treatment phase, one in the non-UV (control) group and one in the UV group. On the basis of data from the 11-point Likert scale (Table 3), post-treatment pain scores were consistently lower than pre-treatment pain scores in both the UV and non-UV (control) exposed groups (Fig. 1). Basically, the measured effect was statistically significant with the McGill Pain Questionnaire scores, but not with the other scales. Over

the 6-week course of exposures, no clear trend suggesting greater improvement in pre-post pain in the UV-treated group, as compared to the non-UV (control) group, was observed (Fig. 1), and no significant effect on post-exposure pain, pre-exposure pain, or average pain score due to time since first session, UV treatment, or the interaction between time and UV was found ($p > 0.05$). No statistically significant difference between treatment group adjusted mean outcomes at week 6 was observed, except that there was a significant (at $p = 0.05$) difference in McGill Pain Questionnaire scores favoring the UV-treated subjects (Table 3). No significant differences in scores were detected in the adjusted means for outcomes 4 weeks after the end of treatment (Table 4).

Participants were asked the amount of UV exposure they thought they had received after each session, and there was not a significant reported difference between those that received UV exposure and those who did not; the non-UV (control) treatment group had a score of 1.69 (SD = 0.68), whereas the UV treatment group had a score of 2.12 (SD = 0.55; p value t test is 0.1962, Wilcoxon rank sum test is 0.1827). Participants' degree of tanning was not recorded.

Discussion

To date, there is no optimal treatment for FMS. The etiology of this potentially debilitating condition has still not been fully elucidated, although data categorize its pathophysiology as a central pain disorder.¹⁷ Therapy is multimodal, using pharmacologic and nonpharmacologic approaches.^{18,19}

Commonly used medications to treat pain in persons with FMS include antidepressants such as tricyclic antidepressants, selective serotonin and/or norepinephrine reuptake

TABLE 3. ADJUSTED MEANS FOR PRIMARY AND SECONDARY OUTCOMES AT END OF TREATMENT, WEEK 6

	Initial session average score	Non-UV (control)	UV	p-value (UV vs. non-UV [control], week 6)
Variables				
11-point Likert Scale pre-exposure pain questionnaire	5.00 (0.60)	5.23 (0.31)	4.76 (0.29)	0.2653
11-point Likert Scale post-exposure pain questionnaire	4.63 (0.58)	4.09 (0.44)	4.10 (0.42)	0.9888
Health Assessment Questionnaire				
Pain due to arthritis	54.25 (2.39)	61.95 (4.94)	64.48 (3.04)	0.4616
Effects of arthritis	50.86 (1.91)	52.78 (4.95)	55.94 (4.07)	0.4301
Fatigue during the last week	75.86 (1.87)	64.43 (6.62)	64.62 (5.81)	0.9734
Pain score	5.27 (0.19)	4.95 (0.24)	4.55 (0.29)	0.0657
Difficulty score	4.82 (0.22)	4.60 (0.36)	4.80 (0.22)	0.5197
McGill Pain Questionnaire score (total pain score)	17.92 (1.15)	14.08 (0.99)	12.22 (1.31)	0.0487
PPI-VAS pain score	4.41 (0.23)	4.51 (0.34)	4.80 (0.62)	0.5574
Overall intensity of pain	2.19 (0.10)	1.99 (0.16)	2.02 (0.29)	0.8921
Fibromyalgia Impact Questionnaire	61.53 (2.34)	53.38 (3.49)	54.57 (2.85)	0.7358

Note: Means adjusted for initial average session scores. Standard errors in parentheses.
UV, ultraviolet light; PPI, present pain intensity; VAS, visual analogue scale.

FIG. 1. Phase 2 pre- and post-exposure pain levels restricted to patients who completed treatment ($n = 14$). After an initial ultraviolet light (UV) acclimatization phase in which subjects received both UV and non-UV (control) exposure for 2 weeks, they were randomized to receive either UV or non-UV (control) exposure for an additional 6 weeks. Pain was assessed with an 11-point numerical rating scale (Likert scale).

inhibitors, and anticonvulsants. Analgesics such as tramadol are commonly used, and nonsteroidal anti-inflammatory drugs (NSAIDs) provide relief in some patients. Increased physical activity, including exercise, is the foundation of nonpharmacologic treatment and reduces overall pain in persons with FMS.^{20,21} The role of acupuncture as an alter-

native therapy is questionable, with a recent meta-analysis casting doubt on its utility based on review of randomized, clinical trials.²² There is limited evidence demonstrating any positive effect of bright light on FMS, which has proved to be an effective treatment for Seasonal Affective Disorder (SAD).²³ Short wavelength light (blue) has also recently dem-

TABLE 4. ADJUSTED MEANS FOR SECONDARY OUTCOMES AT 4-WEEK FOLLOW-UP

	Non-UV (control)	UV	p-value (UV vs. non-UV [control], week 10)
Health Assessment Questionnaire			
Pain due to arthritis	53.65 (4.71)	55.12 (8.09)	0.8725
Effects of arthritis	53.45 (3.50)	47.62 (6.26)	0.4194
Fatigue during the last week	74.03 (5.48)	58.52 (10.16)	0.1892
Pain score	5.54 (0.32)	4.65 (0.56)	0.1811
Difficulty score	4.84 (0.24)	5.28 (0.35)	0.3162
McGill Pain Questionnaire score (total pain score)	16.39 (2.12)	14.38 (3.93)	0.6487
PPI-VAS pain score	4.45 (0.25)	5.55 (0.99)	0.2662
Overall intensity of pain	2.30 (0.24)	2.02 (0.38)	0.5132
Fibromyalgia Impact Questionnaire	52.71 (5.07)	42.02 (6.78)	0.2011

Note: Means adjusted for initial average session scores. Standard errors in parentheses.
UV, ultraviolet light; PPI, present pain intensity; VAS, visual analogue scale.

onstrated an improvement in SAD symptoms,²⁴ but it has not been studied in FMS.

The study of the effects of UV light, a potential alternative treatment, on acute and chronic pain in subjects with FMS was the focus of this study. Ultraviolet light, either alone or combined with chemicals, has been used for decades as an effective treatment of skin disorders²⁵; it has powerful immunomodulatory effects on skin and is a primary treatment for certain inflammatory skin diseases, particularly psoriasis.^{25–27} The mechanism by which UV light affects psoriasis is not fully understood, but early evidence suggested that the effect was a local one.^{28–30} More recent studies in humans and mice suggest that the effects of UV light on cutaneous immunosuppression involve both local and general effects and may be mediated via multiple pathways.^{30,31} The immunomodulatory effects may be mediated by effects on antigen-presenting cells in the skin, or by regulatory T cells, cytokines, vitamin D, and other cutaneous inflammatory mediators.^{32–35}

These mechanisms of UV exposure do not easily explain effects on FMS, which is thought to be a central pain syndrome, i.e., a syndrome of central sensitization. Central sensitization contributes to the hyper-responsive conditions of postoperative pain, migraine, neuropathic pain, fibromyalgia, and gastrointestinal tract pain.³⁶ Central sensitization amplifies and facilitates the synaptic transfer from the nociceptor central terminal to dorsal horn neurons.³⁶ The skin is a complex neurocutaneous organ, and it is possible that mediators are released that have central effects.³⁷ Ultraviolet light modulates cutaneous neuropeptides and neuroendocrine hormones, which affect cytokines and other regulators of signal transduction.³⁸ A large variety of cells, including non-neural cells, such as macrophages, lymphocytes, keratinocytes, and Langerhans cells, secrete and/or react to these mediators. On exposure to noxious stimuli, such as UV, unmyelinated c-fibers and myelinated A δ -fibers of sensory nerves, derived from dorsal root ganglia, release a variety of neuropeptides.³⁸ This type of neurologic pathway between the skin and the central nervous system could produce a central pain syndrome like FMS.³⁹ In support of a central effect, we have previously observed that there is a UV-specific relaxation effect of tanning bed exposure in frequent tanners.⁸

Another mechanism that deserves consideration is vitamin D level. Low vitamin D levels have been significantly associated with muscle and bone pain (osteomalacia) that is often misdiagnosed as fibromyalgia, chronic pain syndrome, or depression.^{40–41} Vitamin D deficiency has also been found to be present in individuals with a diagnosis of fibromyalgia.^{42,43} Also of interest is the fact that UVB exposure has been found to increase vitamin D levels.⁴⁴ We did not assess vitamin D levels in the present study; however, the role of vitamin D as a potential mediator in pain syndromes is worthy of further evaluation.

Quantitatively, tanning bed exposure had a weak effect on pain in our subjects with FMS. Qualitatively, it appeared to be clinically significant, as many of the study subjects reported that the tanning bed exposures helped their pain. In the initial blinded control period, UV exposure specifically contributed to the improvement in pain. Greater improvements in mood with UV compared to non-UV (control) treatment further supported the apparent subjective beneficial ef-

fect of UV. In the subsequent randomized phase, we found that tanning bed treatments offered a degree of transient pain improvement (evidenced by the lower post-treatment compared to pre-treatment pain scores); however, it appears that that effect was largely independent of UV exposure, as participants were exposed both to UV light and non-UV (control) light.

Testing the effects of UV exposure in this study required controlling for effects of UV light on cutaneous pigmentation (i.e. the degree of tanning) and appearance motivation, including the subjects' reaction to their own tan and others' reaction to their tan. This control was achieved in the Phase I UV-accommodation phase by providing UV exposure during each session. Thus, psychosocial variables associated with changes in skin pigmentation could be eliminated as a potential source of bias. To assess the effect of an entire course of UV versus non-UV (control) treatments, however, tanning differences between the groups could bias the outcome; we therefore attempted to control for the tanning effect by treating both groups with a topical sunless tanning product. To assess our success in this Phase II, we evaluated participant perception of the amount of UV exposure between subjects who received UV and those who did not. The UV group had slightly higher scores (more perceived UV), but the difference was not statistically significant. It is possible that the lack of statistical significance is due to the small sample size, and the difference in perceptions of UV exposure could also indicate that the blind was broken. Nevertheless, the difference could also be the inevitable result of the specific relaxation effect of the UV or to pain relief associated with UV exposure.

Limitations in the study design may have affected our findings. In the first phase, we did not take into consideration order effects, as all patients were first treated to non-UV (control) and then to UV exposure during a session. The benefits of UV exposure found in this study may therefore be biased by carryover effects. In the controlled phase, we found only a marginal improvement with UV compared to non-UV (control) exposure that barely achieved statistical significance. The small size of this study sample is probably appropriate for a preliminary study of a speculative treatment. However, we did find statistically significant effects of UV exposure in Phase 1, and of tanning in general in Phase 2. The 8-week study duration does not allow us to assess whether there is any change, better or worse, in the effect of the treatment over longer durations, or about the cost/benefit of tanning as compared to other treatments for FMS.

While a modest effect on FMS from tanning was found, this study was not designed to provide an explanation for this effect. Future larger studies can better define the magnitude of the effect and explore possible explanations, such as vitamin D production, that may underlie the phenomenon. This study provides important pilot data on estimated effect size for future power calculations that may be needed for studies of UV effects on FMS-associated pain.

Disclosure Statement

The Center for Dermatology Research is supported by an educational grant from Galderma Laboratories, L.P.

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