A Feasibility Study Evaluating Mindfulness-Based Intervention Assessing A Wearable Wellness Brain Sensing Device (Muse-S™) in Fibromyalgia Patients.

Study Protocol

NCT04720053

06/24/2024

General Study Information

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Protocol date of most recent review and approval: 24 June 2024

Research Question and Aims

Hypothesis: Patients with fibromyalgia often deal with continual stress, sleep issues, and pain symptoms. We postulate that using the novel muse headband can provide mindfulness training to benefit the quality of life and sleep, and decrease stress and pain.

Aims, purpose, or objectives:

1. To study the feasibility of a wearable brain sensing wellness device to provide mindfulness training to fibromyalgia patients.
2. To assess the association between duration of active state and calm state as measured by the Muse-S™ Headband System, and quality of life (QOL), subjective stress, sleep, and pain in fibromyalgia patients.

The primary outcome will be the change in wide pain index (WPI) and stress over time.

Background:

Up to 8% of the population has fibromyalgia. These patients often have stress[1], poor coping and adaptation skills[2]. Many of these patients also have multiple constitutional symptoms including irritable bowel syndrome[3], chronic headaches[4], depression and anxiety[5,6,7].

Mind body therapies have become a popular treatment option with practitioners and patients[8]. Integrative medicine interventions including, yoga, Tai Chi, hypnosis, acupuncture, meditation, and other modalities have shown to improve physical and emotional well-being[9]. Muse-S™ is a clinical grade, headband-style wireless EEG system designed to interact with a mobile device (a smartphone or tablet). In combination with the Muse-S™ app running on iOS or Android smartphones, Muse-S™ converts EEG signals measured over the frontal and temporal cerebral cortices into measures of brain state. Calibrated to an individual user, Muse-S™ distinguishes between active and calm brain states to provide real-time performance feedback, and helps users realize the benefits of mindfulness practice in an engaging and accessible manner. This has been tested in a prior study with patients undergoing breast cancer surgery[10].

Study Design and Methods

Methods:

All study participants will receive the Muse S™ Headband system and will be asked to use the program daily.

We will assess the following:

- Changes in QOL, sleep, stress, and WPI
- These changes will be measured through week 2, month 1, month 3 and month 6.

	Consent /screen /baseline	**Treatment Phase**			**Follow up Phase**
	1	**2**	**3**	**4**	**5**
Visit Type	**Face to Face**	**Phone/ email**	**Phone/ email**	**Face to Face/phone/ email**	**Face to face/phone/ email**
Visit Days	**0**	**14**	**30**	**90**	**180**
Informed Consent	X				
Inclusion/Exclusion	X				
Demographic and History Form	X				
Numeric Pain Intensity Scale (NPIS)	X	X	X	X	X
Center for Epidemiology Studies Depression (CES-D)	X			X	X
Widespread Pain Index (WPI)	X			X	X
Linear Analogue Self-Assessment (LASA - QoL)	X	X	X	X	X
Stress Scale (PSS)	X	X	X	X	X
Pittsburgh Sleep Quality index (PSQI)	X	X	X	X	X
Satisfaction Survey (WIWI)					X
Adverse Events [1]		X	X	X	X
Concomitant Medication [2]	X	X	X	X	X
Instructions for Muse-S™	X				
End of Treatment/End of Study Forms				X	X

1 = For visit 5, only serious adverse events will be newly collected; **2** = For visit 5, only newly added concomitant medications for fibromyalgia symptoms will be collected

Study Visit Windows:
Each visit will have a window from midpoint of prior visit to midpoint of latter visit.

Data Collection:
Subjects will have the options of completing study surveys/questionnaires online via email link to REDCap prior to study visit. If not completed by time study visit takes place, the coordinator can provide the Ipad digital version of the survey/questionnaire to the subject for the in-person visits or can interview the patient via phone for the telephone visits.

Data Collection in this study will utilize REDCap.[11] All other data collection will be entered directly into this password protected system.

Assessments:
Safety:

- CES-D (Center for Epidemiological Studies – depressed Mood Scale): A validated and frequently used self-report measure of depressive symptoms.[12]

Outcomes:

- Demographics Form: This form collected demographic and other lifestyle history of the research subject.
- Linear Analogue Self-Assessment (LASA)[13-15]: A six-item measure of quality of life (QOL), in which QOL is conceptualized as a multidimensional construct with five domains (physical, functional, emotional, spiritual, and social). This data will be collected at screen (prior to any treatment), day 14, day 30, day 60, end of treatment day 90, and at end of study day 180 (6 months post last treatment).
- Stress: Will be evaluated through the Perceived Stress Scale (PSS)[16,17]. The PSS is a 10-item Likert scale that measures global life stress by assessing the degree to which experiences are appraised as uncontrollable or unpredictable. Scores can range from 0 to 40, with higher scores indicating greater perceived stress. Reliability is reported as 0.85, with Cronbach alphas ranging from 0.75-0.86.
  - Widespread Pain Index (WPI)[18]: defined as a 4-quadrant plus axial pain, measuring widespread pain in 19 specific places on both sides of the body, above and below the waist This data will be collected at screening, end of treatment day 90, and at the end of study day 180 (6 months post last treatment).
  - Numeric Pain Intensity Scale (NPIS): 0-10 pain assessment scale. Participants rate their pain on a scale of 0 to 10. Zero means "no pain," and 10 means "the worst possible pain".
  - Sleep Quality: *The Pittsburgh Sleep Quality Index (PSQI)[27-29]* is an effective instrument used to measure the quality and patterns of sleep in adults. This is a 9-item, likert scale, validated, scoring system. It differentiates "poor" from "good" sleep quality by measuring seven areas (components): subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction over the last month.
- Satisfaction with the program: *Was it Worth it Questionnaire (WIWI)*[19] This satisfaction survey will be administered to the participants after completing intervention and at the end of the study, probing their satisfaction with the research study. These data could be used to assess the feasibility of the intervention by asking the patient if the entire research experience was worth it for them.

Adherence to Intervention:

- Adherence to the Muse-S™ will be assessed by de-identified data available within the cloud, provided by InteraXon. InteraXon only has information per subject through subject ID only (as was provided by Mayo Clinic site), so when the cloud data is provided to Mayo, it will be linked to each subject through their study ID.

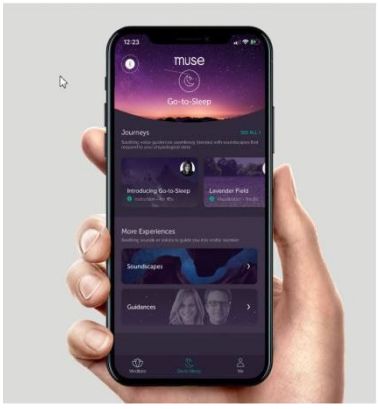
Intervention:

- *The Muse-S™ Headband system:*
  The Muse-S™ Headband system is a brain sensing headband that measures brain activity by detecting electrical impulses created by the brain. The Muse-S™ Headband system uses a series of focus attention training methods to train the brain. Each focus attention session takes approximately a minimum of 5 minutes, and has been shown to reduce stress, anxiety, and improve focus and productivity. The Muse-S™ Headband system has seven sensors with four channels of EEG data for an accurate, high-quality experience. The battery life is approximately five hours and uses an industry-standard micro-USB charger. Forty Muse-S™ Headband systems will be provided by the manufacturer at no cost in support of this study.

Use of Muse-S™ Headband systems will be demonstrated to each participant prior to their first mindfulness practice session, which will be completed during the baseline visit with the study coordinator. The study coordinator will present the participant with detailed instructions on how to begin each session. The frequency of the sessions thereafter will be at the participant's discretion according to the study's requirements (daily practice). Mindfulness training will follow the protocol in the Muse-S™ app, which follows a standard breathing exercise with EEG brain state feedback through the mobile device, as designed by a panel of experienced mindfulness practitioners. In short the Muse-S™ is a *FitBit* like device for the brain.

The study participants can access 3 different types of meditation while using the Muse-S™ Headband system. They are as follows:

- **Mind Meditation** uses the Muse-S™ headband to track the user's brain activity during meditation and translates the brain's activity into guiding sounds. Users get real time feedback to know when their mind is focused and when it's distracted, and are cued to return to a state of focused attention (meditation state). Users also see data from their brain after the meditation. Real time feedback during Mind Meditation is the Muse-S™ signature meditation and teaches the fundamentals of a meditation practice- remaining in a calm focused attention state and being able to move your mind away from distracting thoughts.



- **Guided Meditations.** Guided meditations are narrated meditations on a range of subjects like stress, focus, breath, and body practices.
- **Go-to-sleep Meditations** use the headband and are guided meditations that can be combined with an audio sound scape generated from your biosignals (heart rate, brain, and movement). Sleep Journeys are designed to help you fall asleep faster. They are intended to be used in bed while you fall asleep to help calm your body and mind and entrain you into sleep. If you fall asleep with the headband on you can wear it through the night if you wish. Some people find Go-to-sleep journeys deeply relaxing and use them during the day as a relaxation tool as well.

All study participants will have access to The Muse-S™ Headband system's customer service team based in Toronto, Canada, by telephone and email for assistance should they experience technical problems with the device.

- Server Data: As the patients complete the 10 minute sessions, the information from these sessions will be uploaded to the Muse-S™ secure cloud servers hosted by Google. Individual subject data will be visible to each subject at the end of each session, and data from the previous session stored in the "me" tab in the app. Study organizers will have ongoing access to each subject's data to monitor compliance and performance. These data can include the study-specific identification number, gender, and age of the subject, the time and duration of each session, EEG data, heart rate (PPG) data, and the performance ('percent calm') score per session. Interaxon's privacy policy, which can be found at www.choosemuse.com/privacy will apply to Interaxon's use of the subjects' data. In order to maximize protection of the individual's privacy, the study organizers will ensure that the subjects are assigned anonymized email address and names for use in the Muse -S™ application and when contacting the Muse-S™ customer support. To ensure that no health

data is shared with Interaxon, the study organizers have agreed to ensure that no health data will be shared with Interaxon.

- Additionally, the data will be made available for aggregate download by specific members of the research team, from a secure server at regular intervals until and shortly after the study's conclusion. The study coordinator may view the patient's activity via a web browser.
  The Muse-S™ steps include: 1) Open the Muse-S™ App on your phone. 2) select meditation type 3) if meditating with the headband, turn on the Muse-S™ headband. It will pair via Bluetooth to the app 4) put on headband (if doing a meditation with headband) 5) meditate for minimum of 5 minutes or longer 6) add any journal or mood entry if desired 7) review results.
- Cleaning the Muse-S™: Each patient will be given a brand new, out-of-the-box Muse-S™ Headband system. If cleaning must occur, the entire Muse-S™ including the head set can be wiped down with a standard disinfectant wipe. The band can also be hand-washed gently with soap and water. The module on the band is not waterproof but can be wiped with disinfectant.

Subject Retention:
Participants will not be remunerated for participating in this study, but they will be allowed to keep the Muse-S™ Headbands.

Resources:
The data entry screens used will be developed via REDCap for the online forms. Clinician investigators will provide medical oversight. The Muse-S™ Headband systems are provided at no cost through the manufacturer (InteraXon) for use during study participation.

Check all that apply. If none apply, leave blank:
☒ The research involves contact or interaction with subjects, for example, surveys, questionnaires, observation, blood draw.

Study Design:
We will use standardized procedures to ensure uniform instructions and support for all subjects for the recruitment, screening, and study entry.

Recruitment:
Subjects will be recruited from the Fibromyalgia Clinic. The provider will inform patients of the study at time of their clinical appointment, and if the patient indicates interest the research staff will meet with the patient to begin the consent process.

Consent and Screen:
Study coordinator will meet with the potential subject who has expressed an interest in participating in the study. The study coordinator will begin by introducing the study details, and after determining that the subject has continued interest in study participation, will move on to the study consent. If the subject chooses to consent, the study coordinator will screen the participant for study entry inclusion/exclusion criteria. If the study entry criteria are met, the subject will begin their study participation. They will be asked to complete the study surveys/questionnaires.

Please note: Patients must have access to an iOS or Android capable device in order to take part in this study in order to interact with the Muse-S™ Headband system.

Treatment phase:
During the first three months of study, subjects will be asked to complete the online study intervention, using the Muse-S™ headband. Patients will be contacted via telephone and online (REDCap) for study visits at day 14 and 30. At day 90, they will be asked to return to the clinic for an in-person visit (telephone and online will be alternatives).

Study Follow-Up Visits:
The study will consist of a 6-month visit post baseline (3-month post end of intervention). Patients will be asked to return to the clinic for an in-person visit, if possible (telephone and online will be the alternative).

Subject Information

Target accrual: We plan to recruit 43 patients diagnosed with fibromyalgia.

Subject population: A total of 43 adult patients diagnosed with fibromyalgia at Mayo Clinic that meet the following study criteria:

Inclusion Criteria:
1. 18 years of age or older at time of consent
2. Diagnosed with Fibromyalgia
3. Not pregnant by subject self-report at time of consent
4. Have the ability to provide informed consent
5. Have the ability to complete all aspects of this trial
6. Have access to a iPhone, iPad, Android device
7. Has no contraindicating comorbid health condition as determined by the clinical investigators

Exclusion Criteria:
1. Used or been enrolled in any treatments for fibromyalgia or pain within the past 30 days, other than the Mayo Clinic Treatment program.
2. Used an investigational drug within the past 30 days
3. Currently (within the past 3 weeks) been practicing mindfulness training on a weekly/regular basis
4. Currently (within the past 3 weeks) been undergoing an additional program (e.g. CAM) to improve quality of life or sleep.
5. Currently (within 3 weeks) been enrolled in another clinical or research program (e.g. CAM) which intervenes on the patients' QOL, sleep, or stress
6. An unstable medical or mental health condition as determined by the physician investigator

Review of medical records, images, specimens

☒ The study involves data that exist at the time of IRB submission **and** data that will be generated after IRB submission.

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