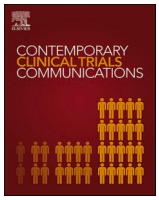
Contemporary Clinical Trials Communications 32 (2023) 101062

Contents lists available at ScienceDirect

Contemporary Clinical Trials Communications

journal homepage: www.elsevier.com/locate/conctc



Design and rationale of a pilot randomized clinical trial investigating the use of a mHealth app for sarcoidosis-associated fatigue

Jessica Chandler [a], Lillian M. Christon [b], Katie Benfield [c], Samantha Pairet [a], Maria Hoffman [c], Frank Treiber [a], Martina Mueller [a], W. Ennis James [c,*]

[a] MUSC, College of Nursing, Department of Nursing, Technology Applications Center for Healthful Lifestyles, United States
[b] Medical University of South Carolina (MUSC), College of Medicine, Department of Psychiatry & Behavioral Sciences, United States
[c] MUSC, College of Medicine, Department of Medicine, Division of Pulmonary and Critical Care Medicine, Susan Pearlstine Sarcoidosis Center of Excellence, United States

ARTICLE INFO

Keywords:
Sarcoidosis
Fatigue
Stress
mHealth
Breathing awareness meditation

ABSTRACT

Fatigue is the most reported symptom in patients with sarcoidosis (SPs) and is a significant predictor of decreased quality of life that is strongly associated with stress and negative mood states. Few medications exist for treating fatigue in SPs, and outpatient physical rehabilitation programs are limited by availability and cost. Sarcoidosis in the US predominantly impacts minorities and underserved populations who are of working age and often have limited resources (e.g., financial, transportation, time off work) that may prevent them from attending in-person programs. The use of mobile health (mHealth) is emerging as a viable alternative to provide access to self-management resources to improve quality of life. The Sarcoidosis Patient Assessment and Resource Companion (SPARC) App is a sarcoidosis-specific mHealth App intended to improve fatigue and stress in SPs. It prompts SPs to conduct breathing awareness meditation (BAM) and contains educational modules aimed at improving self-efficacy.

Herein we describe the design and methods of a 3-month randomized control trial comparing use of the SPARC App (10-min BAM twice daily) to standard care in 50 SPs with significant fatigue (FAS $\geq$22). A Fitbit® watch will provide immediate heartrate feedback after BAM sessions to objectively monitor adherence. The primary outcomes are feasibility and usability of the SPARC App (collected monthly). Secondary endpoints include preliminary efficacy at improving fatigue, stress, and quality of life. We expect the SPARC App to be a useable and feasible intervention that has potential to overcome barriers of more traditional in-person programs.

1. Introduction

Sarcoidosis is a systemic granulomatous inflammatory disease of unknown cause that can result in significant functional morbidity including fatigue, dyspnea, generalized pain, and decreased physical activity. Over 185,000 patients with sarcoidosis (SPs) seek healthcare annually and 25,000 new cases are diagnosed in the United States (U.S.) each year [1]. In the U.S., Black Americans are disproportionately affected by sarcoidosis, and are known to have higher disease prevalence and severity (more organ involvement, higher mortality rates, and are more likely to develop pulmonary fibrosis and require treatment), which is at least in part related to decreased access to timely healthcare from sarcoidosis experts [2–5].

Sarcoidosis-associated fatigue (SAF) is reported in up to 80% of SPs and is considered the most important predictor of quality of life (QOL) due to its negative effects on physical and psychological health [6–9]. The underlying etiology of SAF is complex. SAF is weakly associated with physiologic markers of sarcoidosis disease activity such as inflammatory markers, lung function and radiographic severity; however, our work and that of others has shown strong associations between SAF and stress levels, negative mood states (depression, anxiety) and low QOL. SPs are less physically active than their healthy counterparts, and lower physical activity levels in SPs is associated with worse fatigue levels but not lung function [10]. The interaction with SAF, negative mood states and physical activity in SPs results in a perpetual feedback loop ultimately resulting in ongoing symptoms and decreased QOL (Fig. 1; reprint from Christon et al., currently in print) [11].

The treatment of SAF is intended to improve QOL by "breaking" this feedback loop, but at present, management options are limited.

* Corresponding author. Medical University of South Carolina, College of Medicine, Division of Pulmonary and Critical Care Medicine, Susan Pearlstine Sarcoidosis Center of Excellence 96 Jonathan Lucas St, CSB 816, Charleston, SC, 29425-0630, United States.
E-mail address: jamesw@musc.edu (W.E. James).

https://doi.org/10.1016/j.conctc.2023.101062
Received 2 June 2022; Received in revised form 30 November 2022; Accepted 14 January 2023
Available online 16 January 2023

Abbreviations

SPs	patients with sarcoidosis
SAF	sarcoidosis-associated fatigue
QOL	quality of life
BAM	breathing awareness meditation
SPARC	Sarcoidosis Patient Resource and Companion App
FAS	fatigue assessment scale
FSE	Fatigue self-efficacy scale
PHQ-8	Patient Health Questionnaire depression scale
PSS-10	10-item perceived stress scale
KSQ	King's Sarcoidosis Questionnaire
REDCaps	Research Electronic Data Capture database

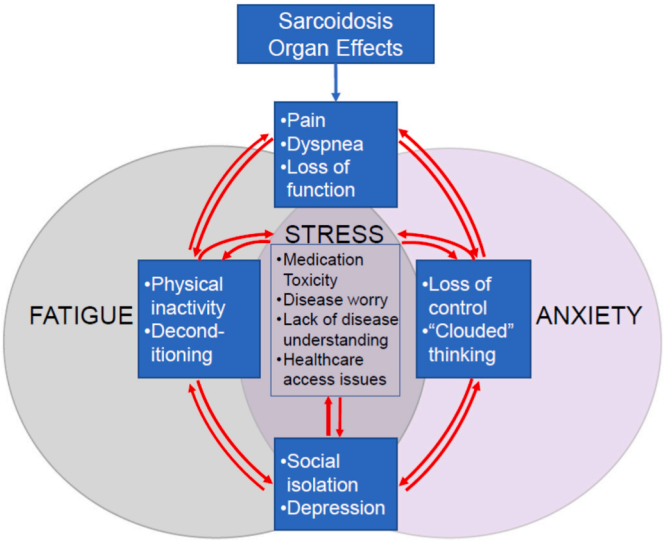


Fig. 1. Complex, cyclical nature of sarcoidosis associated fatigue [11].

Pharmacologic therapy is often unsuccessful as the primary treatment approach [12,13]. Corticosteroids are considered first-line therapy for sarcoidosis, however their impact on SAF is inconsistent and may result in increased fatigue and healthcare use [14–16]. Second and third line medications for sarcoidosis may provide some benefit for fatigue, but can result in treatment-limiting side effects and there is insufficient evidence to support their use for SAF in the absence of other treatment indications for sarcoidosis [6,17]. Similarly, there is a low quality of evidence supporting the use of stimulant therapy (e.g., armodafinil) for SAF [13]. Recent guidelines have suggested pulmonary rehab programs and/or inspiratory muscle strength training (conditional recommendation, low quality of evidence) [13]. Such programs have been efficacious in reducing SAF, but often require in-person instruction and are not widely available.

Various cognitive behavioral stress management programs have demonstrated that they reduce fatigue levels and improve QOL in multiple chronic diseases; however, these programs have not been widely studied in sarcoidosis [18–22]. A common technique used in these programs involves diaphragmatic breathing (breathing awareness meditation or BAM) as the first step in mindfulness meditation. A single session of group-delivered mindfulness meditation focused upon BAM was shown to reduce fatigue in SPs [23]. However, dissemination of traditional group-based programs is limited by availability and cost in the United States where sarcoidosis disproportionately impacts minorities with high poverty rates and reduced healthcare access [3,24,25]. Health disparities by race, socioeconomic status, and gender are well described in sarcoidosis, and the fact that sarcoidosis predominately impacts working-age individuals argues that a successful intervention to address stress and fatigue would need to be accessible to all and not be a significant financial or travel burden [26,27]. While black SPs have higher rates of medication noncompliance, studies have identified relaxation and deep breathing techniques as a viable strategy for managing stress resulting from chronic dyspnea [28,29], suggesting novel methods of delivering such programs warrants further investigation.

Programs utilizing mobile Health (mHealth) have the potential to overcome geographic and financial barriers of traditional programs and have been shown to result in sustained improvements in health.[15–19] Preliminary data from a survey of 194 SPs (64% African American) published in abstract form revealed that 84% had smartphones with active data plans, reported willingness to use mHealth, and 100% agreed or strongly agreed that mHealth interventions would help them manage their stress and fatigue [30]. A three-month pilot study conducted by our team in which 18 patients used a prototype version of an mHealth App prompting patients to engage in BAM for 10 min twice daily showed preliminary acceptability and adherence, and resulted in significant reductions in reported stress and fatigue (Fig. 2) [30,31].

Given these promising preliminary findings, we embarked on a project to develop and evaluate a sarcoidosis-specific stress and fatigue mHealth App. The Sarcoidosis Patient Resource and Companion (SPARC) App was developed based on reviews of the SAF literature, which support the need for comprehensive care and support resources aimed at relieving symptoms and improving quality of life [32]. The final version of the App was created using a sarcoidosis patient- and provider-centered iterative design process involving low literacy-based strategies and guided by the principles of Self-Determination Theory [33,34]. A previously validated BAM App (i.e., Tension Tamer) designed for use in patients with stress and hypertension was demonstrated and a scripted interview was used to elicit input from SPs and healthcare providers on usability and applicability to sarcoidosis, as outlined in our previous publication [11] Only the BAM portion of Tension Tamer was incorporated into the SPARC App and was modified from its original version based on informant interviews (e.g., appearance, voice options, usability). Based on SAF literature, the SPARC also included educational content and the ability to communicate with the sarcoidosis clinic for help. Using a Fitbit watch. heart rate was recorded during the BAM sessions, which serves as a means of providing immediate positive feedback (decrease in heart rate during BAM) as well to monitor compliance with BAM sessions. Personalized text messages based in Self-Determination Theory will be used to positively reinforce or encourage compliance with twice daily BAM sessions. Self-Determination Theory focuses on developing competence (akin to self-efficacy in Social Cognitive Theory) and autonomous regulation [35]. Consistent strong effects of these Self-Determination Theory mediators have been observed for various health behavior changes (e.g., physical activity, smoking cessation, diet) [36–42].

Screenshots from the SPARC app are provided below (Fig. 3).

The SPARC App BAM module that will be tested in this trial was adapted from Tension Tamer, which was previously developed as a stress reduction tool in other chronic disease populations [31,43–45]. The randomized control trial described herein aims to evaluate the feasibility and preliminary efficacy of the SPARC mHealth app as an efficacious, safe, and easily disseminated self-management tool that may improve fatigue and stress in SPs.

2. Methods

2.1. Overview of study design, rationale, and objectives

The SPARC App trial is a two group, parallel arm, non-blinded randomized control trial of adults with confirmed sarcoidosis based on currently accepted criteria and SAF (defined as a Fatigue Assessment

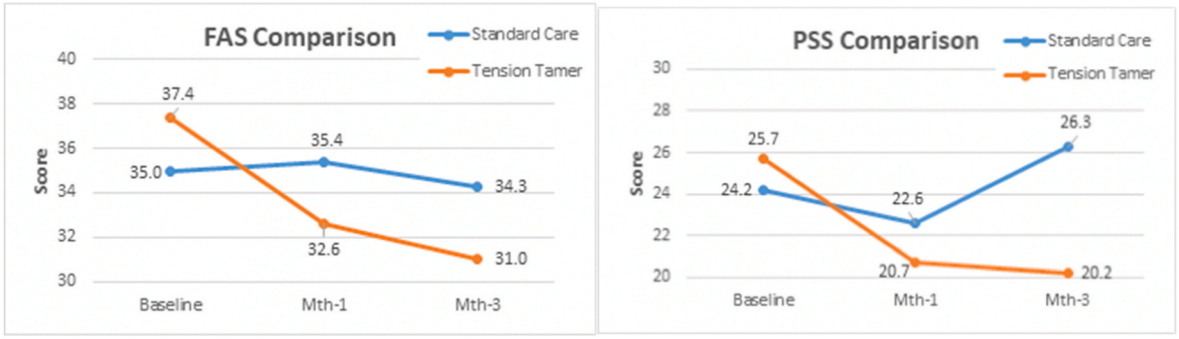


Fig. 2. Breathing awareness meditation pilot study outcomes.

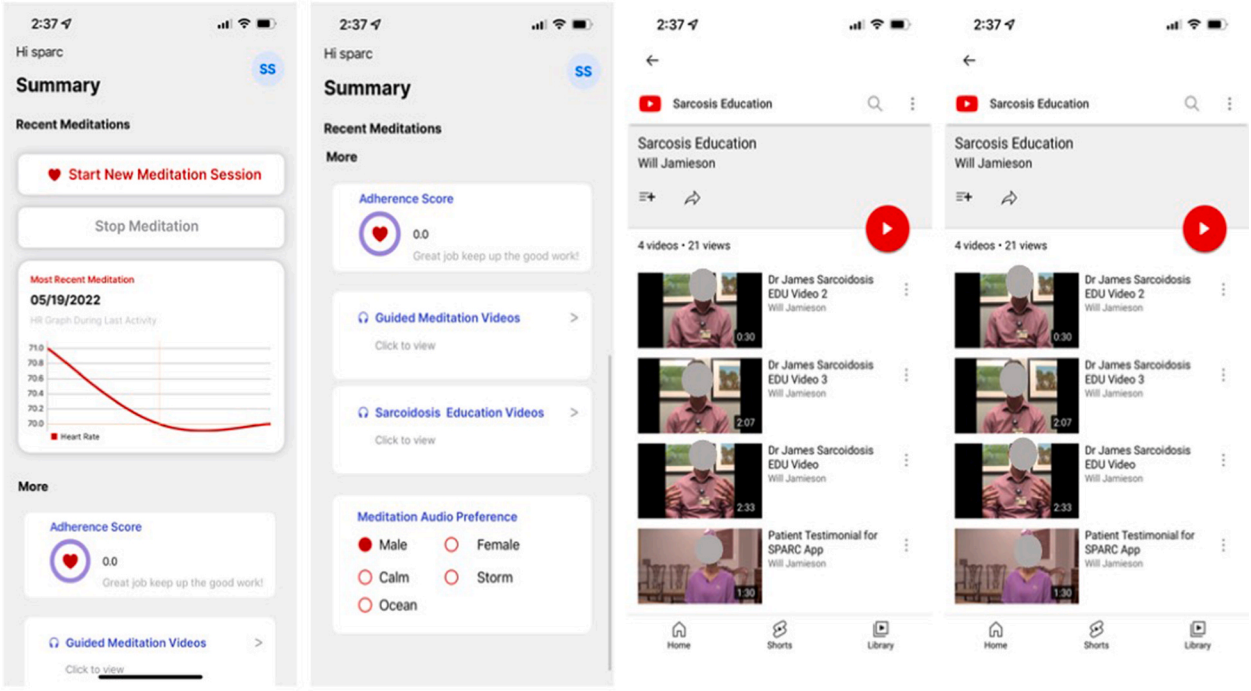


Fig. 3. Screenshots ofSPARC app.

Scale score of ≥22) [46,47]. SPs will be randomized to standard of care fatigue management or use of the SPARC App, which includes educational resources (videos) as well as a 10-min BAM module which patients will be asked to use twice daily for three months. The primary objective is to evaluate the usability and feasibility of the SPARC App. Secondary outcomes include examination of preliminary efficacy in reducing fatigue (Fatigue Assessment Scale), stress (Perceived Stress Scale), and improving QOL (King's Sarcoidosis Questionnaire). This study has been approved by the institutional review board (Pro00107105).

2.2. Participants

SPs will be recruited at the Susan Pearlstine Sarcoidosis Clinic of Excellence at the Medical University of South Carolina during their regularly scheduled visits. Flyers will be posted in all clinic rooms. Patients will also be informed of the study at Sarcoidosis Support group meetings in addition to letters sent via the electronic medical record. Patients who meet the following inclusion criteria will be eligible for the study: 1) Sarcoidosis diagnosis based on established criteria [46]; 2) ≥18 years old; 3) able to speak, hear, and understand English; 4) elevated SAF (Fatigue assessment scale score ≥22); 5) owns smartphone with current data plan; 6) willingness and ability to use app to engage in BAM. Patients will be excluded if they have a history of diagnoses of a psychotic disorder, bipolar disorder, eating disorder, narcolepsy, untreated sleep apnea, or diagnosis/treatment of cancer in the past 12 months; positive screening for current moderately severe depression symptoms (Patient Health Questionnaire depression scale [PHQ-8] score ≥15) [48,49]; sarcoidosis exacerbation in past 3 months requiring increase in sarcoidosis medications; active substance abuse or binge drinking(>21 drinks/week). The score of ≥15 on the PFQ-8 ("moderately severe depression") was chosen because the PHQ-8 includes fatigue as an item and potentially biases recruitment to exclude patients who may score ≥10 on the PHQ-8 because of severe fatigue or adjustment-related symptoms. We found that 47% of patients who did not qualify for the key informant interviews (manuscript under review elsewhere) were excluded because their PHQ-8 score was ≥10. After extensive consideration, use of the cut-off score of ≥15 was approved by our grant review board. Patients will be screened for the presence of undiagnosed sleep apnea using the STOP-BANG questionnaire [50]. These inclusion and exclusion criteria were previously piloted in an initial step of this project [11].

2.3. Randomization

All patients seen in the clinic complete the Fatigue Assessment Scale (FAS) at the beginning of their visit as part of their routine clinical care. Those patients with a score ≥22 will then be informed about the study either in person during their visit or by the research coordinator via telephone. Potentially eligible SPs will be reviewed for eligibility based on inclusion and exclusion criteria. Interested and eligible patients will then be scheduled for an in-person visit where they will complete the informed consent process, followed by depression screening questionnaire (PHQ-8). Patients who are ineligible at this point due to having moderately severe depression symptoms (PHQ-8 score >15) will be offered referral to psychiatry and other mental health resources.

Eligible and consented patients will be randomly assigned to the SPARC group or the enhanced standard care (SC) attention control group using the randomization module of the web-based Research Electronic Data Capture (REDCap) electronic data capture tools hosted by the South Carolina Clinical and Translational Science (SCTR) Institute at MUSC [51]. REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies. It provides an intuitive interface for validated data entry, audit trails for tracking data manipulation, automated export procedures for seamless data downloads to common statistical packages, and procedures for importing data from external sources. REDCap at SCTR is supported by the National Center for Advancing Translational Sciences of the National Institutes of Health under Grant Number UL1 TR001450.

2.4. Interventions

Enhanced standard of care attention control group. Those participants randomized to the enhanced standard of care group will receive what is typical in this clinic to address fatigue, as well as meeting with the research staff and receiving a FitBit. Standard of care includes education on the potential causes of and solutions for sarcoidosis fatigue, as well as recommending exercise. Contact with the research staff will include contact at study time points. Participants will be given a Fitbit Versa® watch with instructions on how to wear it properly, charge it regularly and how to navigate their Fitbit profile to customize and personalize their watch face to liking. The participants in this group will not receive reminder messages to wear and charge the Fitbit past what was provided in their enrollment visit.

SPARC App intervention group. Those participants randomized to the intervention group will have the SPARC app downloaded on their phone by the research coordinator. The SPARC App, designed with input from SPs and providers [11], includes a BAM module and other desired key features: access to a provider service line, video modules providing educational content on sarcoidosis & stress, a demonstration video of BAM, patient testimonials and graphical and text motivational feedback.

Alongside the SPARC app, participants will be given a Fitbit Versa® watch to use for the duration of the study. The Fitbit watch is linked with the SPARC App to provide time-stamped heart rate data that provides an objective measure of session adherence and serves as a feedback tool available to participants after each BAM session to demonstrate the ability of BAM to lower users' heart rates. General use of the App will be reviewed, and participants will need to show ability to navigate the app and use components without assistance prior to leaving clinic. The research coordinator will assist in ensuring the participant has performed the first BAM session properly and completed the battery of questionnaires. They will be given instructions on frequency and dosage of completion of BAM sessions at home, and these timeframes will be reinforced by the App's text messages, further described below. They will be provided $50 compensation for time and effort.

Participants will be instructed to engage in BAM sessions for 10 min, twice daily for 12-weeks. Previously, adherence ranged from 40 to 90% (median ~70%) in BAM programs lasting ≥ 3mos [31,52–54]. We anticipate the SPARC App will meet desired adherence rates (≥0.70 to BAM twice daily). SPs will have communication via phone or email links on the app to address any issues with the App or their clinical care. Clinical care questions will be routed to the sarcoidosis nurse coordinator. Technical questions will be routed to the research coordinator.

We will promote autonomous motivation by sending tailored motivational/social reinforcement text messages linking subjects' behavioral changes (e.g., adherence to twice daily BAM sessions) to their personal values, beliefs and short/long term goals derived from a branch logic questionnaire (Values, Beliefs, Goals Questionnaire) [55]. Domains identified include family, faith, friendships, community activities-membership/volunteer work; attendance and/or participation in leisure, sports & recreational activities and work related events. Domains frequently reported by subjects to be important drivers of behavior were "family, faith and friends." Further, family and community cohesiveness and support, especially activities with friends and family members were primary adherence motivators related to short-term life goals (e.g., increased time gardening, fishing, playing with grandchildren, attending church functions, etc.). Responses will guide delivery of >900 different automated motivational/social encouragement messages based upon levels of adherence to their SPARC regimen. Sample text feedback for an adherence score of 1.00 is: "*Way to go! Every day of meditation keeps you on track for (patient identified values, e.g., "many more years watching those grandkids grow up")*. If partially or completely non-adherent, he/she might receive: *"You must have been really busy yesterday. Get back on track with the SPARC App to keep reducing stress & fatigue and plan some special time with your grandkids."*

2.5. Follow-up visits

All participants will be contacted at week 4 via telephone, and will be seen at weeks 12 and 24 for routine clinical care. During those visits, based on their preference, follow-up study questionnaires will be given orally or read on their own. They will have the option to complete questionnaires using a tablet or paper version. They will be provided $50 compensation for time and effort at each evaluation.

2.6. Outcomes assessment

Table 2 presents all outcome variables, questionnaires, and timing of administration. Most scales have been used with 21 to 59-year-old African Americans and Non-Hispanic Whites and have established psychometrics. We provide brief psychometric information (e.g., internal consistency, test-retest reliability) in the table.

Measurement of adherence. Adherence with the SPARC BAM module use will be monitored based on heart rate data collected during a subject's use of the App. App usage analytics collected will assess SPARC App uptake (total engagement time) and its features (e.g., frequency of provider service line use, video modules: sarcoidosis & stress educational modules, BAM demo, patient testimonials, etc.).

2.7. Sample size and data management/analysis

The primary focus of this project lies on assessing feasibility (recruitment, retention, and adherence rates) and usability (frequency, duration of app use; satisfaction/usability surveys-SUS, TSUQ, uMARS) rather than hypothesis-testing. Thus, sample size was determined for pragmatic reasons such as assessment of recruitment, drop-out and adherence rates [69]. For categorical feasibility measures, with 50 SPs (25 per group), we will be able to estimate proportions with precision ±0.08 to ± 0.13 for true population proportion (p) values for each outcome ranging from 0.10 to 0.30 (or correspondingly, from 0.70 to 0.90). For continuous usability measures, 95% confidence intervals (CIs) can be estimated with precisions ranging from ±0.20 to ±0.78 corresponding to estimated standard deviations (SDs) ranging from 0.5 to 2.0, respectively. For continuous impact measures (PSS,FAS, & QoL, FSE &

Table 2
Measurement/Instruments and time points for feasibility trial.

Outcomes	Psychometrics	Time
Primary Outcomes		
Feasibility and System Usability	• % Recruitment • drop-out rate • System Usability Scale (SUS) [56,57] • User Version of Mobile App Rating Scale (uMARS; α = .90, test-retest [2,3 mos] .66, .70) [58,59] • Patient/Provider SPARC Treatment Satisfaction & Usability Scale (TSUQ; α = .82-.96, test- retest [1wk] .98) [60,61] • Adherence to SPARC BAM module and App usage statistics: % adherence to BAM dose (10 min BID for 12 weeks)	Week 12
Secondary & Exploratory Outcomes		
SDT Constructs:	• Competence/self-efficacy: Fatigue Self-Efficacy Scale (FSE; α = 0.89–0.94) [62] • Autonomous Self-Motivation (TSRQ; α = .81- .84) [39,63] • Values, Beliefs, Goals Questionnaire (VBG; α = .72-.93; Test-retest (2 week) .52-.89) [55]	Week 0 &12
Fatigue, QOL, Stress, Physical activity	• Fatigue Assessment Scale (FAS; 10 items, α = 0.8–0.89; Test-retest 0.89) [64] • QoL scale in King's Sarcoidosis Health Questionnaire (KSQ) [65,66] • Stress (PSS-10 items; α = 0.78) [67] • International Physical Activity Questionnaire: test-retest (8–10days) .8) [68]	Week 0, 4, 12 & 24
Demographic Variables	Age, sex, race, income, education level, employment	Week 0

TSRQ change scores), in intent-to-treat analyses, 95% CI estimates of *within-group* change scores (pre-to post-treatment) will have precisions ranging from ±0.1.5 to ±2.4 corresponding to estimated SD of change scores ranging from 3.7 to 6.1, respectively; *between-group* change scores differences will have precision estimates from ±2.8 to ±3.7 for SDs of differences in scores from 5.0 to 6.7 SD units.

The REDCap system will be used for data collection and as the primary database, including assignment of variable names and coding, design of data entry forms, automated data entry error checks, quality control checks, and database access and locking. All assessments and clinical data will be entered into a standardized password-protected database behind MUSC's firewall. Data will be reviewed on a twice-monthly basis. Outlying, inconsistent data values, as well as missing data, will be targets of the data quality review. Issues will be communicated by the data management service to Drs. James, Chandler, Christon, and Mueller for resolution.

The primary outcomes for this study will be usability/feasibility of the SPARC App. Based upon our proof of concept trial(n = 18), we anticipate acceptable participation rates (>80%), low drop-out rates (<20%), adherence rates (≥0.70 to twice daily 10 min BAM sessions), and usability/satisfaction scores (>75% will score above average on SUS (>68), uMARS (>64)& TSUQ (>60)).We anticipate signals of improvement in the SPARC group in secondary outcomes compared to SC group including changes in fatigue (FAS),stress (PSS), self-efficacy (FSE), autonomous motivation (TSRQ) and QOL.

Descriptive statistics will be calculated for all measures and variables. We will use 95% CIs for proportions to estimate dichotomous feasibility outcomes (e.g., proportion who agree to participate out of total approached, proportion adherent to SPARC protocol, and proportion who drop out). Frequency distributions will be developed describing participants' reasons for non-adherence and discontinuation of SPARC app use and problems/issues encountered with the app. For continuous usability measures (e.g., frequency, duration of use; surveys: SUS, TSUQ, uMARS), frequency distributions & median and mean responses (with 95% CIs) will be obtained. Mean change and difference in change between the groups from pre-to-post intervention along with their 95% CIs will be reported for all continuous secondary (impact) outcomes (change in PSS-10, FAS, QoL, FSE & TSRQ scores).

Preliminary analyses will examine a) underlying distributional properties of all outcome variables b) patterns of missing data, and c) patterns of attrition. Linear mixed-models for repeated measures will be used for the continuous impact measures to obtain estimates of intra-cluster correlation (ICC) & variance estimates along with covariance structure of longitudinal scores used as critical information for sample size calculation of a future efficacy RCT. Based upon Shieh's work [70], we have inadequate sample size & lack of adequate power to run formal moderator analyses. These analyses will be run in the future appropriately powered RCT to examine impact of socio-demographic variables as potential adherence barriers, as well as potential moderating effects of disease severity (i.e., lung function), fatigue-inducing medications, and BAM adherence on secondary outcomes.

3. Discussion

This study is the first investigation of the feasibility of a mHealth App in SPs and has great potential to make self-management interventions accessible to a population that has been underserved. Previous research has shown the ability of mHealth interventions to improve quality of life in other chronic diseases.[15–19] Sarcoidosis is a rare disease that overwhelmingly impacts working-age, underserved minorities in the U. S., and exploration of novel interventions is an important step towards the goal of improving outcomes in all sarcoidosis patients regardless of socioeconomic status. As a mHealth tool, the SPARC App has the potential to improve stress and fatigue in SPs by improving self-efficacy while overcoming the limitations and barriers of traditional treatment options.

Funding acknowledgement

This project was supported by the National Institute of Biomedical Imaging and Bioengineering (NIBIB) of the National Institutes of Health under award number 5R21EB025525-02.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

We are grateful to the patients and healthcare team members who contributed to this project.

References

[1] R.P. Baughman, S. Field, U. Costabel, R.G. Crystal, D.A. Culver, M. Drent, et al., Sarcoidosis in America. Analysis based on health care use, Ann.Am. Thorac. Soc. 13 (8) (2016) 1244–1252.
[2] D.L. Rabin, B. Thompson, K.M. Brown, M.A. Judson, X. Huang, D.T. Lackland, et al., Sarcoidosis: social predictors of severity at presentation, Eur. Respir. J. 24 (4) (2004) 601–608.
[3] B. Rybicki, M. Major, J. Popovich, M. Maliarik, M. Iannuzzi, Racial differences in sarcoidosis incidence: a 5-year study in a health maintenance organization, J. Epidemiol. 145 (3) (1997) 234–241.
[4] Kajdasz D, Judson M, Mohr LJ, Lackland D. Geographic Variation in Sarcoidosis in South Carolina: its Relation to Socioeconomic Status and Health Care Indicators. vol. 150(3):271-278.
[5] A.K. Gerke, M.A. Judson, Y.C. Cozier, D.A. Culver, L.L. Koth, Disease burden and variability in sarcoidosis, Ann Am Thorac Soc 14 (Supplement_6) (2017) S421–S428.
[6] M. Drent, E.E. Lower, J. De Vries, Sarcoidosis-associated fatigue, Eur. Respir. J. 40 (1) (2012) 255–263.

[7] H.J. Michielsen, T. Peros-Golubicic, M. Drent, J. De Vries, Relationship between symptoms and quality of life in a sarcoidosis population, Respir.Int. review.Thorac. Dis. 74 (4) (2007) 401–405.

[8] J. De Vries, M. Drent, Quality of life and health status in sarcoidosis: a review of the literature, Clin. Chest Med. 29 (3) (2008) 525–532.

[9] R.G. Marcellis, A.F. Lenssen, M.D. Elfferich, J. De Vries, S. Kassim, K. Foerster, et al., Exercise capacity, muscle strength and fatigue in sarcoidosis, Eur. Respir. J. 38 (3) (2011) 628–634.

[10] P.S.P. Cho, S. Vasudevan, M. Maddocks, A. Spinou, S. Chamberlain Mitchell, C. Wood, et al., Physical inactivity in pulmonary sarcoidosis, Lung 197 (3) (2019) 285–293.

[11] L.M. C, J. C, K. B, S. P, M. H, F. T, et al., Perceptions of the fatigue experience and a breathing awareness meditation-integrated mHealth app for fatigue and stress in patients with sarcoidosis, Fatigue: Biomedicine, Health & Behavior (2022) (in press).

[12] C. Atkins, A.M. Wilson, Managing fatigue in sarcoidosis - a systematic review of the evidence, Chron. Respir. Dis. 14 (2) (2017) 161–173.

[13] R.P. Baughman, D. Valeyre, P. Korsten, A.G. Mathioudakis, W.A. Wuyts, A. Wells, et al., ERS clinical practice guidelines on treatment of sarcoidosis, Eur. Respir. J. 58 (6) (2021), 2004079.

[14] A.N. Aggarwal, K.K. Sahu, D. Gupta, Fatigue and health-related quality of life in patients with pulmonary sarcoidosis treated by oral Corticosteroids. Sarcoidosis, vasculitis, and diffuse lung diseases, official journal of WASOG 33 (2) (2016) 124–129.

[15] M. Judson, H. Chaudhry, A. Louis, K. Lee, R. Yucel, The effect of corticosteroids on quality of life in a sarcoidosis clinic: the results of a propensity analysis, Respir. Med. 109 (4) (2015) 526–531.

[16] M. Fleischer, A. Hinz, E. Brahler, H. Wirtz, A. Bosse-Henck, Factors associated with fatigue in sarcoidosis, Respir. Care 59 (7) (2014) 1086–1094.

[17] C. Atkins, A.M. Wilson, Managing fatigue in sarcoidosis - a systematic review of the evidence, Chron. Respir. Dis. 14 (2) (2017) 161–173.

[18] M. Dharmawardene, J. Givens, A. Wachholtz, S. Makowski, J. Tjia, A systematic review and meta-analysis of meditative interventions for informal caregivers and health professionals, BMJ Support. Palliat. Care 6 (2) (2016) 160–169.

[19] J. Ploeg, M.U. Ali, M. Markle-Reid, R. Valaitis, A. Bartholomew, D. Fitzpatrick-Lewis, et al., Caregiver-focused, web-based interventions: systematic review and meta-analysis (Part 2), J. Med. Internet Res. 20 (10) (2018), e11247.

[20] A. Norweg, E.G. Collins, Evidence for cognitive-behavioral strategies improving dyspnea and related distress in COPD, Int. J. Chronic Obstr. Pulm. Dis. 8 (2013) 439–451.

[21] M. Zakerimoghadam, K. Tavasoli, A.K. Nejad, S. Khoshkesht, The effect of breathing exercises on the fatigue levels of patients with chronic obstructive pulmonary disease, Acta Med. Indones. 43 (1) (2011) 29–33.

[22] R. Tkatch, D. Bazarko, S. Musich, L. Wu, S. MacLeod, K. Keown, et al., A pilot online mindfulness intervention to decrease caregiver burden and improve psychological well-being, J Evid Based Complementary Altern Med 22 (4) (2017) 736–743.

[23] L. Saketkoo, J. Young, R. Adell, A. Karpinski, M. Walker, A. Russel, Perceptions of A modified mindfulness training (mt) program in sarcoidosis, Am. J. Respir. Crit. Care Med. 193 (2016) A2688.

[24] D.K. Kajdasz, M.A. Judson, L.C. Mohr Jr., D.T. Lackland, Geographic variation in sarcoidosis in South Carolina: its relation to socioeconomic status and health care indicators, Am. J. Epidemiol. 150 (3) (1999) 271–278.

[25] D.L. Rabin, B. Thompson, K.M. Brown, M.A. Judson, X. Huang, D.T. Lackland, et al., Sarcoidosis: social predictors of severity at presentation, Eur. Respir. J. 24 (4) (2004) 601–608.

[26] C.M.R. Hendriks, L.A. Saketkoo, M.D.P. Elfferich, J. De Vries, P.A.H.M. Wijnen, M. Drent, Sarcoidosis and work participation: the need to develop a disease-specific core set for assessment of work ability, Lung 197 (4) (2019) 407–413.

[27] M. Sharp, M.N. Eakin, M. Drent, Socioeconomic determinants and disparities in sarcoidosis, Curr. Opin. Pulm. Med. 26 (5) (2020) 568–573.

[28] M. Nield, Dyspnea self-management in African Americans with chronic lung disease, Heart Lung 29 (1) (2000) 50–55.

[29] M. Sharp, T. Brown, E.S. Chen, C.S. Rand, D.R. Moller, M.N. Eakin, Association of medication adherence and clinical outcomes in sarcoidosis, Chest 158 (1) (2020) 226–233.

[30] W. James, J. Chandler, B. Brunner-Jackson, L. Sox, M. Swerm, A. Neely, et al., Acceptability and efficacy of a mHealth app for sarcoidosis associated fatigue, Am. J. Respir. Crit. Care Med. 199 (2019) A3059.

[31] M.J. Gregoski, A. Vertegel, A. Shaporev, F.A. Treiber, Tension Tamer: delivering meditation with objective heart rate acquisition for adherence monitoring using a smart phone platform, J. Alternative Compl. Med. 19 (1) (2013) 17–19.

[32] C.C. Moor, V. Kahlmann, D.A. Culver, M.S. Wijsenbeek, Comprehensive care for patients with sarcoidosis, J. Clin. Med. 9 (2) (2020).

[33] R.M. Ryan, E.L. Deci, Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being, Am. Psychol. 55 (1) (2000) 68–78.

[34] D. Markland, R. Ryan, V. Tobin, S. Rollnick, D.S. Zingmond, N.S. Wenger, Motivational interviewing and self determination theory, Arch. Intern. Med. 24 (6) (2005) 811–831.

[35] J.L. Harmon, J. Barroso, B.W. Pence, J. Leserman, N. Salahuddin, Demographic and illness-related variables associated with HIV-related fatigue, J. Assoc. Nurses AIDS Care : JANAC 19 (2) (2008) 90–97.

[36] E.L. Deci, R. Koestner, R.M. Ryan, A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation, Psychol. Bull. 125 (6) (1999) 627–668. ; discussion 92-700.

[37] R. Ryan, J. Kuhl, E. Deci, A.E. Magnusson, D.K. Nias, P.D. White, Nature and autonomy: an organizational view of social and neurobiological aspects of self-regulation in behavior and development, J. Psychosom. Res. 9 (4) (1997) 701–728.

[38] R. Ryan, H. Patrick, E. Deci, G. Williams, Facilitating health behaviour change and its maintenance: interventions based on self-determination theory, Eur. Health. Psychol. 10 (1) (2008) 2–5.

[39] G.C. Williams, G.C. Rodin, R.M. Ryan, W.S. Grolnick, E.L. Deci, Autonomous regulation and long-term medication adherence in adult outpatients. Health psychology : official journal of the Division of Health Psychology, Am. Psychol. Assoc. 17 (3) (1998) 269–276.

[40] G.C. Williams, M. Gagne, R.M. Ryan, E.L. Deci, Facilitating autonomous motivation for smoking cessation. Health psychology : official journal of the Division of Health Psychology, Am. Psychol. Assoc. 21 (1) (2002) 40–50.

[41] J. Ng, N. Ntoumanis, C. Thøgersen-Ntoumani, E. Deci, R. Ryan, J. Duda, et al., Self-determination theory applied to health contexts: a meta-analysis, Perspect. Psychol. Sci. 7 (4) (2012) 325–340.

[42] I. Ajzen, N.L. Muller, J.B. Mawson, J.R. Mathieson, R. Abboud, D.N. Ostrow, et al., The theory of planned behavior, Radiology 50 (2) (1991) 179–211.

[43] Z.W. Adams, J.C. Sieverdes, B. Brunner-Jackson, M. Mueller, J. Chandler, V. Diaz, et al., Meditation smartphone application effects on prehypertensive adults' blood pressure: dose-response feasibility trial, Health Psychol. : Off. J. Div. Health Psychol., American Psychological Association 37 (9) (2018) 850–860.

[44] M.J. Gregoski, M. Mueller, A. Vertegel, A. Shaporev, B.B. Jackson, R.M. Frenzel, et al., Development and validation of a smartphone heart rate acquisition application for health promotion and wellness telehealth applications, 2012, Int. J.Telemed. Appl. (2012), 696324.

[45] M. Gregoski, J. Sieverdes, B. Brunner-Jackson, L. Davidson, B. Egan, F. Treiber, Smartphone breathing meditation application proof of concept: linkage between nighttime blood pressure reduction and salivary alpha-amylase awakening response, Ann. Behav. Med. 45 (S2) (2013) s240.

[46] E.D. Crouser, L.A. Maier, K.C. Wilson, C.A. Bonham, A.S. Morgenthau, K. C. Patterson, et al., Diagnosis and detection of sarcoidosis. An official American thoracic society clinical practice guideline, Am. J. Respir. Crit. Care Med. 201 (8) (2020) e26–e51.

[47] J. De Vries, H. Michielsen, G.L. Van Heck, M. Drent, Measuring fatigue in sarcoidosis: the fatigue assessment scale (FAS), Br. J. Health Psychol. 9 (Pt 3) (2004) 279–291.

[48] K. Kroenke, T.W. Strine, R.L. Spitzer, J.B. Williams, J.T. Berry, A.H. Mokdad, The PHQ-8 as a measure of current depression in the general population, J. Affect. Disord. 114 (1–3) (2009) 163–173.

[49] K. Kroenke, R.L. Spitzer, J.B. Williams, The PHQ-9: validity of a brief depression severity measure, J. Gen. Intern. Med. 16 (9) (2001) 606–613.

[50] F. Chung, H.R. Abdullah, P. Liao, STOP-bang questionnaire: a practical approach to screen for obstructive sleep apnea, Chest 149 (3) (2016) 631–638.

[51] P.A. Harris, R. Taylor, R. Thielke, J. Payne, N. Gonzalez, J.G. Conde, Research electronic data capture (REDCap)–a metadata-driven methodology and workflow process for providing translational research informatics support, J. Biomed. Inf. 42 (2) (2009) 377–381.

[52] V.A. Barnes, H.C. Davis, J.B. Murzynowski, F.A. Treiber, Impact of meditation on resting and ambulatory blood pressure and heart rate in youth, Psychosom. Med. 66 (6) (2004) 909–914.

[53] V.A. Barnes, R.A. Pendergrast, G.A. Harshfield, F.A. Treiber, Impact of breathing awareness meditation on ambulatory blood pressure and sodium handling in prehypertensive African American adolescents, Ethn. Dis. 18 (1) (2008) 1–5.

[54] L. Wright, M. Gregoski, M. Tingen, V. Barnes, F. Treiber, Impact of stress reduction interventions on hostility and ambulatory systolic blood pressure in African American adolescents, J. Black Psychol. 37 (2) (2011) 210–233.

[55] S.N. Lukwago, M.W. Kreuter, D.C. Bucholtz, C.L. Holt, E.M. Clark, Development and validation of brief scales to measure collectivism, religiosity, racial pride, and time orientation in urban African American women, Fam. Community Health 24 (3) (2001) 63–71.

[56] J. Brooke, K.D. Everett, P.J. Brantley, C. Sletten, G.N. Jones, G.T. McKnight, SUS-A quick and dirty usability scale, Usability evaluation in industry 189 (194) (1996) 4–7.

[57] J. Lewis, J. Brown, D. Mayes, Psychometric evaluation of the EMO and the SUS in the context of a large-sample unmoderated usability study, Int. J. Hum. Comput. Interact. 31 (8) (2015) 545–553.

[58] S.R. Stoyanov, L. Hides, D.J. Kavanagh, O. Zelenko, D. Tjondronegoro, M. Mani, Mobile app rating scale: a new tool for assessing the quality of health mobile apps, JMIR mHealth and uHealth 3 (1) (2015) e27.

[59] S. Stoyanov, L. Hides, D. Kavanagh, H. Wilson, Development and validation of the user version of the mobile application rating scale (uMARS), JMIR mHealth and uHealth 4 (2) (2016) e27.

[60] G. Demiris, S. Speedie, S. Finkelstein, A questionnaire for the assessment of patients' impressions of the risks and benefits of home telecare, J. Telemed. Telecare 6 (5) (2000) 278–284.

[61] S. Bakken, L. Grullon-Figueroa, R. Izquierdo, N. Lee, P. Morin, W. Palmas, et al., Development, validation, and use of English and Spanish versions of the telemedicine satisfaction and usefulness questionnaire, J. Am. Med. Inf. Assoc. 13 (6) (2006) 660–667.

[62] B. Brasher, W. James, Preliminary Evaluation of a Fatigue Self-Efficacy Scale in Sarcoidosis, 2017 [Oral Presentation]. In press.

[63] G.C. Williams, V.M. Grow, Z.R. Freedman, R.M. Ryan, E.L. Deci, Motivational predictors of weight loss and weight-loss maintenance, J. Pers. Soc. Psychol. 70 (1) (1996) 115–126.

[64] J. De Vries, H. Michielsen, G. Van Heck, M. Drent, Measuring fatigue in sarcoidosis: the fatigue assessment scale (FAS), Br. J. Health Psychol. 9 (Pt 3) (2004) 279–291.
[65] A.S. Patel, R.J. Siegert, D. Creamer, G. Larkin, T.M. Maher, E.A. Renzoni, et al., The development and validation of the King's Sarcoidosis Questionnaire for the assessment of health status, Thorax 68 (1) (2013) 57–65.
[66] R.P. Baughman, M.A. Judson, J.L. Beaumont, L.A. Maier, N.J. Sweiss, D.A. Culver, et al., Evaluating the minimal clinically important difference of the king's sarcoidosis questionnaire in a multicenter prospective study, Ann.Am. Thorac. Soc. 18 (3) (2021) 477–485.
[67] S. Cohen, G. Williamson, V.J. Strecher, B.M. DeVellis, M.H. Becker, I. M. Rosenstock, Perceived stress in a probability sample of the United States, in: S. Spacapan, S. Oskamp (Eds.), The Claremont Symposium on Applied Social Psychology the Social Psychology of Health, Sage, Thousand Oaks, CA, 1988, pp. 31–67.
[68] C.L. Craig, A.L. Marshall, M. Sjöström, A.E. Bauman, M.L. Booth, B.E. Ainsworth, et al., International physical activity questionnaire: 12-country reliability and validity, Med. Sci. Sports Exerc. 35 (8) (2003) 1381–1395.
[69] A.C. Leon, L.L. Davis, H.C. Kraemer, The role and interpretation of pilot studies in clinical research, J. Psychiatr. Res. 45 (5) (2011) 626–629.
[70] G. Shieh, Sample size determination for confidence intervals of interaction effects in moderated multiple regression with continuous predictor and moderator variables, Behav. Res. Methods 42 (3) (2010) 824–835.