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# Telehealth in sarcoidosis: a scoping review

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## Abstract

**Introduction** Sarcoidosis is an inflammatory disease that causes functional and physical limitations in patients, negatively impacting their quality of life. Telehealth can provide a solution to improve healthcare services for these patients, regardless of their social and economic status. This research explores the various telehealth technologies and their applications for patients with sarcoidosis.

**Material and methods** This scoping review was conducted in 2024 with a comprehensive search in PubMed, Web of Science, Scopus, and ProQuest databases. Following screening and duplicate removal, relevant data were extracted and analyzed.

**Results** Out of 821 studies, only 6 studies met the inclusion criteria. The findings showed that mHealth technologies have good acceptance among patients and healthcare providers in managing sarcoidosis symptoms, such as fatigue, stress, and physical activity levels, and improving quality of life. Also, activity tracker technology, alone or in combination with other remote monitoring tools, increases exercise performance, reduces fatigue, and allows for continuous monitoring of the disease status. Hence, it has the potential to be integrated into long-term care programs for patients with sarcoidosis. In addition, telerehabilitation technology could be an acceptable option for patients, but its effectiveness in improving exercise capacity and quality of life in patients with sarcoidosis requires further investigation.

**Conclusion** mHealth and activity tracker technology showed promising results in improving sarcoidosis management and increasing patients' motivation and adherence to treatment, but further studies are required to assess the effectiveness of telerehabilitation. Overall, telehealth has significant potential to improve the care of sarcoidosis patients, but further research is needed to evaluate the effectiveness of these technologies.

**Keywords** Telehealth, Sarcoidosis, Scoping review

## Introduction

Sarcoidosis is a multisystem inflammatory disease of unknown etiology, posing significant challenges in diagnosis, treatment, and management for healthcare professionals. This disease, characterized by the formation of noncaseating granulomas in affected organs, can involve almost any organ in the body but predominantly affects the lungs and intrathoracic lymph nodes [1, 2]. The extrapulmonary manifestations of this disease are observed in organs such as the heart, joints, kidneys, liver, eyes, nervous system, and skin [3].

The prevalence of this disease varies in different regions of the world. The annual incidence of this disease ranges from 1 to 15 per 100,000 people. This rate is 0.5 to 1 per

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100,000 in East Asian countries, 5 to 10 per 100,000 in North America and Australia, and 11 to 15 per 100,000 in Northern European countries [1]. Prevalence rates also vary within countries, possibly due to genetic differences, exposure to environmental factors, and different diagnostic methods for sarcoidosis [1].

Sarcoidosis patients often suffer not only from organ-related symptoms, but also from non-specific and non-organ-related symptoms such as fatigue, muscle weakness, loss of physical condition, decreased physical activity in daily life, and pain [4, 5]. These symptoms often lead to functional and physical limitations, reduced quality of life, stress, anxiety, depression, and social isolation [2, 3, 6]. Patients with sarcoidosis are physically less active than their healthy counterparts, and the lower level of physical activity in these patients is associated with higher fatigue levels [6]. Significant complications and disruption in the quality of life of these patients lead to variable periods of illness and unemployment [2, 7].

Diagnosis and treatment of sarcoidosis present several challenges. The causes of sarcoidosis are still unknown, and it is thought that the interaction between genetic factors and exposure to environmental stimuli triggers and maintains granulomatous inflammation and clinical disease [1]. The diagnosis of this disease is complicated due to nonspecific symptoms and involvement of multiple organs, requiring multiple tests including the Kveim-Siltzbach skin patch test, imaging tests such as chest X-ray, CT scan, magnetic resonance imaging (MRI), and FDG-PET scan [8]. Corticosteroids are mentioned as first-line treatment for sarcoidosis, which can lead to increased fatigue and a need for supportive care. [6] Additionally, second and third-line medications for sarcoidosis treatment may also impact fatigue, along with potential treatment-limiting side effects [6].

Due to the complex and variable nature of sarcoidosis, there is a need for a comprehensive and multidisciplinary approach to care for these patients, which includes not only pharmacological interventions but also supportive measures aimed at relieving symptoms and improving quality of life [2]. Telehealth involves using information and communication technologies to provide remote physical, mental, and social health care services through text, audio, or video formats. The use of telehealth technologies can play an effective role in improving patients' disease management and quality of life [9]. Telehealth has the potential to overcome the geographic and financial barriers of traditional programs and has been shown to lead to sustainable improvements in health. Today, with the increasing use of smartphones, the trend towards using mobile-health applications has gained many followers, especially in chronic diseases such as sarcoidosis [6].

These technologies make it possible to monitor lung function, physical activity, symptoms, side effects, and the quality of life of patients at home, and at a lower cost [2]. For example, evidence shows the effectiveness of physical exercises and rehabilitation in reducing symptoms, improving quality of life, improving mental health and physical function, reducing fatigue, and increasing muscle strength, and the use of telerehabilitation has been recommended as a suitable alternative [7, 10]. Furthermore, smartphone or tablet apps can facilitate video consultations and physical exercise programs, and using activity trackers can help analyze the impact and status of the disease and treatment of patients [7, 11]. Since health disparities based on race, socioeconomic status, and gender are influential in sarcoidosis, telehealth services can be a solution to improve the care and treatment of these patients without considering their social and economic status [6].

According to the potential of telehealth in the management of sarcoidosis, this study was designed to comprehensively examine the various types of telehealth technologies and their applications in patients with sarcoidosis. This scoping review aims to identify gaps in current knowledge and provide a perspective for future research on improving care for patients with sarcoidosis using telehealth technologies.

## Materials and methods

For this study, the scoping review method was chosen to provide a comprehensive overview of existing evidence and to explore the potential for synthesizing findings from various types of studies. This method involves systematically identifying and mapping evidence in a particular field, as well as determining any research gaps within that field [12].

This scoping review study was conducted in 2024 based on the six-stage framework by Arksey and O'Malley and recommendations by Levac et al [13, 14]. Additionally, for further assurance and transparency in conducting the research, the comprehensive JBI Scoping Review methodology framework and the PRISMA-ScR reporting guidelines were also considered [15, 16].

### Protocol registration

The study protocol was registered on Figshare, a platform for registering scoping reviews. (Registration number on Figshare: https://figshare.com/articles/dataset/_/25826050) and the Ethics committee of Shahid Beheshti University of Medical Sciences approved this study (ethics approval code: IR.SBMU.NRITLD.REC.1403.051).

Clinical trial number: not applicable.

The stages of this study are as follows:

Stage 1: Identifying the research question.

This study's research question was, "How is telehealth used in sarcoidosis, and what is its effectiveness in managing the condition?".

Stage 2: Identifying relevant studies.

The search was conducted for relevant articles in June 2024 using PubMed, Web of Science, Scopus, ProQuest databases, and Google Scholar search engines. No restrictions were applied regrading language and time and the search keywords were selected based on MeSH and relevant studies. The keywords used included telehealth, eHealth, mHealth, telemedicine, virtual care, videoconferencing, teleconsultation, telerehabilitation, remote consultation, and sarcoidosis. Finally, a comprehensive search strategy was developed by combining keywords with "OR" and "AND" (Appendix). An example of a search strategy includes the following: ((telehealth[Title/Abstract]) OR (ehealth[Title/Abstract]) OR (mhealth[Title/Abstract]) OR (telemedicine[Title/Abstract]) OR (virtual care[Title/Abstract]) OR (videoconferencing[Title/Abstract]) OR (teleconsultation[Title/Abstract]) OR (telerehabilitation[Title/Abstract]) OR (Remote Consultation[Title/Abstract])) AND (sarcoidosis[Title/Abstract]). To make sure we included all relevant studies, we searched through the list of sources of selected studies and their citations. Additionally, we manually searched the journals of Respiratory Medicine and Research, Sarcoidosis, Vasculitis, and Diffuse Lung Diseases.

Stage 3: Study selection.

After searching the databases, articles that had been retrieved were imported into EndNote, and duplicates were removed. All the articles were screened based on the title, abstract, and full text by two reviewers (F-V) (H–S), and any disagreements were resolved through discussion between them. All studies, including quantitative and qualitative research utilizing telehealth for patients with sarcoidosis, were included. Studies involving various telehealth technologies were considered. Exclusion criteria comprised chapters of books, letters to the editor, conference papers, dissertations and theses, commentaries, experts' opinions, and protocols studies.

Stage 4: Charting the data.

The data extraction form was prepared based on the necessary data, including authors' names, study year, country name, research objective, research method, participants, type of telehealth technology, and a summary of the results for each study.

Stage 5: Collating, summarizing, and reporting the results.

Finally, the extracted data were summarized, combined, and narratively synthesized. The initial numerical analysis, research methods, type of intervention, and study results were narrated. Key research items were reported using the PRISMA-ScR checklist [15].

## Results

Out of the 821 studies identified from five databases, 71 studies were excluded due to duplication. In the next stage, the titles of the articles were reviewed, and 723 articles that did not have a title related to the study were excluded. In the second screening stage, the abstracts of 27 articles were reviewed. Of these, 20 articles were excluded because they were conference papers, dissertations and theses, or commentaries. Then, in the third screening stage, the full text of seven articles was reviewed and one article was excluded because it was a protocol [6]. Finally, six articles met the inclusion criteria for the study and their information was extracted. Two reviewers (F-V) (H–S) performed all steps independently. The full results of the search strategy and screening process of the studies are presented in Fig. 1.

### Characteristics of the selected studies

Studies in the United States [5, 18, 19], Denmark [7], and Netherlands [4, 20] were conducted between the years 2019 and 2023. The studies used various methods, including quantitative and qualitative approaches [5], randomized clinical trial [7], prospective, cross-sectional study [19], proof of concept trial [18], cohort study and prospective randomized clinical trial [4] and prospective observational study [20]. The telehealth technologies used included telerehabilitation [7], mHealth [5, 18, 19], and electronic activity tracker [4, 20].

A summary of the studies and their results is presented in Table 1.

The technologies most often used by these patients were mHealth [5, 18, 19], activity trackers [4, 20], and telerehabilitation technology [7] (Fig. 2). The majority of the studies have been conducted in recent years (2019–2023).

### mHealth technology

In three different studies, mHealth (mobile health) technology was utilized to manage fatigue, stress, and measure physical activity levels in patients with sarcoidosis [5, 18, 19]. In a study by Christon et al., a mobile application was employed to facilitate "breathing awareness meditation" for managing fatigue and stress in patients. In this study, 13 patients with a mean age of 55.7 ± 13.5 years participated. The app included a video guide demonstrating

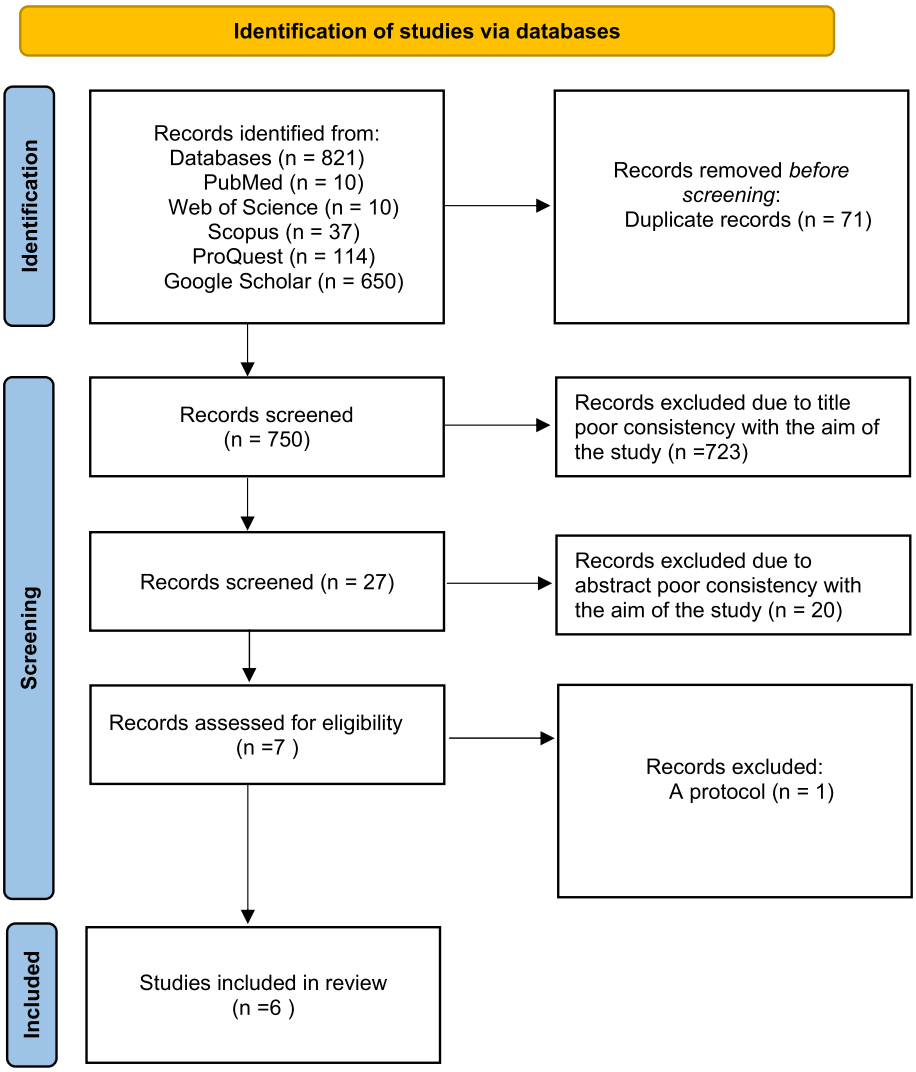


**Fig. 1** Selecting papers based on the PRISMA-ScR checklist [16, 17]

the correct breathing awareness meditation technique. A narrator described the process and visually demonstrated "belly breathing" when inhaling through the nose by expanding the abdominal area. Additionally, the app had an audio guide providing instructions and reminders for proper breathing, as well as guidance on how to refocus when distracted. This application was also connected to a smartwatch to record the heart rate during the meditation session [5].

The study found that 94% of sarcoidosis patients (SPs) and healthcare team members (HCTMs) considered the audio and video instructions useful. Feedback indicated that a new video was needed. Patients suggested that the video should be filmed in a more pleasant and stress-free setting than the original. Additionally, it was important to increase the clarity of the guidelines and display necessary monitoring. 94% of individuals appreciated the display of heart rate summary charts, reminders, and personalized encouragement notifications as it allowed them to see personal feedback on changes over time. This feature was identified as important for overcoming motivation or reminder issues and improving adherence [5].

Different reminders such as vibration alerts, text messages, pop-up notifications, and emails were suggested. Another suggestion was related to personalizing messages and the option to "snooze" if unable to exercise at the exact moment of the alert. Other feedback included addressing the special needs of individuals such as low vision or lack of familiarity with technology. 89% of the interviewees felt that the program helped reduce their stress levels. Overall, patients stated that practicing breathing meditation twice daily for 10 min was

**Table 1** Summarizes the studies and their results

| Author (year) | Country | Objective | Research method | Sample | Type of telehealth technology | Summary of results |
|---|---|---|---|---|---|---|
| Christon et al. 2023 [3] | United States | To obtain feedback from key informants to design and tailor a patient-centered Sarcoidosis Patient Resource and Companion (SPARC) mHealth App developed for SPs to manage fatigue and stress at home using breathing awareness meditation | Mixed-methods (quantitative and qualitative research methods) | 13 patients with sarcoidosis (≥ 18 years old) and Healthcare Team Members (HCTMs) | SPARC App-prototype and Fitbit Versa 2 | sarcoidosis patients reported elevated fatigue on the FAS (M = 32.5 ± 6.4) and depression scores on the PHQ-8 in the mild range (M = 6.4 ± 2.2). Fatigue was most frequently indicated as a significant symptom (69%; *n* = 9) of SPs, followed by painful joints/muscles (*n* = 6; 46%), breathlessness (46%; *n* = 6), and cough (24%; *n* = 3) On the Mobile Health Use and Knowledge measure , 46% of SPs had heard of Tele-health/mHealth prior to the project, and 38% had downloaded health-related Apps before mHealth App (SPARC) was reported to be user friendly and to have potential for improving fatigue/stress |
| Heras et al 2022 [4] | Denmark | To investigate the usefulness and effectiveness of telerehabilitation on exercise capacity in patients with sarcoidosis | Single-center, prospective, randomized clinical trial | 30 patients (15 patients were randomized to TR with VAPA and 15 patients to the control group) | telerehabilitation program using the VAPA platform | Differences in meters walked (6MWTD) between groups was at baseline (-28.9 m ($p = 0.58$)), after 3 (+ 25.8 m ($p = 0.57$)), 6 (+ 48.4 m ($p = 0.39$)) and 9 months (+ 77.3 m ($p = 0.18$)) follow-up in favor of telerehabilitation. No differences were observed in MVC, 7 days pedometry, SGRQ-I, KBILD or GAD7. Exercise adherence in the intervention group was 64% and average exercise time was 28 min per exercise session during the first 3 months. Patient satisfaction scored 3.8 ± 0.7. No adverse events were reported |
| Chu et al 2022 [5] | United States | To investigate whether smartphones could assess the quality of life (QoL) and physical activity of a large cohort of individuals with sarcoidosis | Prospective, cross-sectional study | 629 patients with sarcoidosis (≥ 18 years old) | mobile app (Sarcoidosis App) | Both QoL related to physical activity ($P < .001$, $\rho = 0.250$) and fatigue ($P < .01$, $\rho = -0.203$) correlated with actual smartphone-tracked physical activity |

**Table 1** (continued)

| Author (year) | Country | Objective | Research method | Sample | Type of telehealth technology | Summary of results |
|---|---|---|---|---|---|---|
| Drent et al 2020 [6] | Netherlands | To estimate the effect of continuous activity monitoring using an electronic activity tracker (AT) on exercise performance and fatigue of sarcoidosis patients, compared to controls (cohort study), and the effect of additional personal coaching (randomized trial) over a period of 3 months | Cohort study and a prospective randomized clinical trial | 54 sarcoidosis patients | electronic activity tracker (AT) | The walking distance—both 6MWD distance and 6MWD,% of predicted—as well as the SRT and VO2max (mL/kg/min) increased significantly in the study sample wearing ATs, whereas fatigue decreased ($p < 0.01$). Patients wearing an AT and receiving personal coaching showed greater improvement of exercise capacity (SRT, $F = 4.515$, $p = 0.039$ and SRT VO2max mL/kg/min; $F = 4.945$, $p = 0.031$) over time |
| James et al 2019 [7] | United States | To explore the acceptability and preliminary efficacy of a mHealth BAM stress management tool (Tension Tamer, TT) in the management of stress and fatigue in SPs | 3-month proof of concept trial | 18 SPs with significant SAF, defined as a Fatigue Assessment Scale (FAS) score of ≥ 22 | mobile health (mHealth) | There were no significant differences ($p > 0.1$) between TT (Tension Tamer, TT) and SC (standard of care (SC)) in race (82% and 67% black, respectively), gender (91% and 83% female) and age (mean 49 and 46 years)<br>Baseline PSS (TT mean 25.5 vs 24.2) and FAS (TT mean 37.4 vs 35.1) scores were not significantly different ($p > 0.1$)<br>High acceptability (100% participation rate; 6% attrition during trial), self-efficacy for following the Tamer regimen (mean of 4.6 on a 5-point Likert scale) and adherence to the twice-daily regimen at month 1 (81%), month 2 (72%) and month 3 (65%)<br>The TT group reported greater reductions in stress (PSS) and fatigue (FAS) compared to the SC group at months 1 & 3 ($p < .05$ to $< .07$) |

**Table 1** (continued)

| Author (year) | Country | Objective | Research method | Sample | Type of telehealth technology | Summary of results |
|---|---|---|---|---|---|---|
| Moor et al 2019 [8] | Netherlands | To evaluate patient satisfaction and the feasibility of this home monitoring program, and to assess its possible role for future clinical trials and daily practice | Prospective observational study | 10 outpatients with sarcoidosis (pulmonary involvement and age above 18 years) | online eHealth application (Sarconline) | Mean adherence to daily spirometry and activity tracking was, respectively, 94.6% and 91.3% |

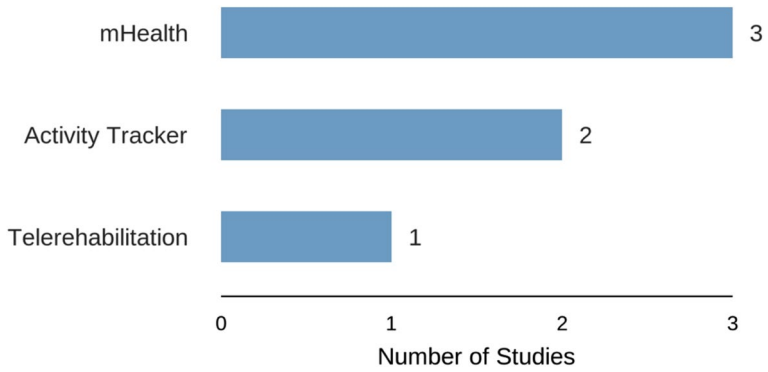


**Fig. 2** Telehealth technologies used for sarcoidosis patients

acceptable and feasible, especially with the inclusion of reminders/messages in the app [5].

In Cho et al.'s study, a smartphone application was used to measure the level of physical activity. In this prospective, cross-sectional study, 629 patients with sarcoidosis participated. Patients completed modules from the sarcoidosis assessment tool related to physical activity, such as daily step count, walking or running distance, stair climbing, exercise time, fatigue, pain, skin symptoms, sleep, and respiratory symptoms. The results showed that quality of life ($P<0.001$, $\rho=0.25$) and fatigue ($P<0.01$, $\rho=-0.20$) were significantly associated with the actual physical activity tracked by the smartphone [19].

In a study by James et al., a mobile-based stress management tool called Tension Tamer (TT) was used. In this 3-month proof of concept trial assigned 18 sarcoidosis patients with significant sarcoidosis-associated fatigue. The study found that there was no significant difference between Tension Tamer (TT) and the standard of care (SC) in terms of race (82% and 67% African American, respectively), gender (91% and 83% female), and age (average 49 and 46 years) ($p>0.1$). Baseline Perceived Stress Score (PSS) (TT mean 25.5 vs. 24.2) and Fatigue Assessment Scale (FAS) (TT mean 37.4 vs. 35.1) scores were not significantly different ($p>0.1$). The study recorded 100% participation rate, an average score of 4.6 on a 5-point Likert scale for self-efficacy in adhering to the Tension Tamer regimen, and compliance rates of 81% in the first month, 72% in the second month, and 65% in the third month. The TT group reported a greater reduction in stress (PSS) and fatigue (FAS) compared to the SC group in months 1 and 3 ($p<0.05$ to $<0.07$) [18].

The findings suggest that mobile health (mHealth) technologies have great potential in managing symptoms of sarcoidosis, such as fatigue, stress, and physical activity levels. These technologies are well-received by both patients and healthcare providers and can contribute to improving patients' quality of life. However, there is a need for ongoing improvements in the design and usability of these tools to better meet the needs of sarcoidosis patients.

#### Activity tracker technology

Two studies examined the use of activity tracker technology in managing sarcoidosis [4, 20]. These studies demonstrated that utilizing this technology could have a positive impact on sports performance, fatigue, and at-home monitoring for patients [4, 20]. Drent et al.'s study involved a 12-week sports performance program conducted as a cohort study and a prospective randomized clinical trial. Fifty-four sarcoidosis patients in the intervention group received activity trackers, one group of 27 personal coaching and the other group of 27 without personal coaching. The intervention group used an electronic activity tracker (AT) and received personal coaching, with Fitbit-measured parameters and brief daily questions accessible to the physiotherapist via a web-based dashboard. The coaching process included planning weekly exercises and providing feedback, modeling behaviors, problem-solving, and individual decision-making through email or phone. Other participants in the intervention group utilized a Fitbit and a monitoring program to track their performance, questionnaire results, and progress. The intervention group exhibited a significant increase in outcomes of the 6-min walking distance (6MWD), predicted percentage of the walking distance, Steep Ramp Test (SRT), and maximal oxygen uptake (VO2max) compared to the control group. Patients in the intervention group who used electronic activity trackers and received personal coaching showed greater improvement in exercise capacity over time Additionally, fatigue levels decreased in both intervention groups and 6MWD, and the predicted percentage of 6MWD increased in both intervention groups [4].

In a prospective observational study conducted by Moore et al., 10 outpatients with pulmonary sarcoidosis

used a home monitoring program known as "Sarconline" for a period of one month. Sarconline provided a secure personal platform that included online patient-reported results, real-time wireless home spirometry, an information library, and an option to contact healthcare providers electronically. Additionally, patients utilized an activity tracker. The patients' experiences were evaluated through a telephone interview, and the results indicated that the program was well-received. Specifically, 90% of patients found the program easy to use, none found the daily measurements complicated, and all patients expressed willingness to continue with the program after the study. The average adherence to daily spirometry was 94.6%, and for activity tracking, it was 91.3% [20].

These results indicate while activity trackers can provide valuable data, effective management of patients typically necessitates additional interactions, such as coaching, interpretation of data, and goal setting and activity trackers should be part of a broader management strategy that includes these interactive elements.This technology not only helps enhance sports performance and decrease fatigue but also allows for continuous monitoring of the disease's status. Moreover, the high level of patient acceptance and adherence to this technology suggests its potential for integration into long-term care programs for sarcoidosis patients.

#### Technology Tele-rehabilitation

In the research conducted by Heras et al., they looked into the use of telerehabilitation technology in managing sarcoidosis [7]. The study aimed to assess the effectiveness of telerehabilitation in improving exercise capacity in patients with sarcoidosis. In this single-center, prospective, randomized clinical trial, 30 patients were included. In the intervention group, 15 received telerehabilitation, and in the control group, 15 received conventional rehabilitation. The intervention involved a 12-week telerehabilitation program using the VAPA platform, while the control group received usual care without rehabilitation or structured physical training. The intervention featured a service platform that allowed therapists to design personalized rehabilitation programs, conduct video consultations, access e-learning materials, create physical exercise programs, administer online questionnaires, maintain digital patient records, and utilize live chat functionality, all within the same tool. The intervention group was provided with a mobile application that patients could easily install on their smartphones or tablets. This application was directly linked to a biometric sensor that could be attached to the patient's chest, arms, or fingers to collect data and establish the rehabilitation program simultaneously. After the three-month telerehabilitation period, the follow-up results were assessed at three and six months. The difference in the 6-min-walk-test (plate number 1) between the groups was -28.9 m at baseline ($p=0.58$), +25.8 m after 3 months ($p=0.57$), +48.4 m after 6 months ($p=0.39$), and +77.3 m after 9 months of follow-up ($p=0.18$) [7]. The exercise capacity appeared to improve slightly at the 3, 6, and 9-month follow-ups, but these improvements were not statistically significant. Meanwhile, the control group experienced a decrease in exercise capacity. The intervention group had a 64% exercise adherence rate, with an average exercise time of 28 min per session during the first 3 months. Overall, the patients were highly satisfied with the intervention and had acceptable adherence to the treatment. No changes were observed in quality of life, maximum voluntary capacity (MVC), or 7-day step counting. Telerehabilitation with VAPA was found to be safe, with high patient satisfaction and acceptable adherence rates. However, no significant beneficial effects of telerehabilitation with VAPA were shown in patients with sarcoidosis. These results suggest that while telerehabilitation technology may be an acceptable option for patients, further investigation is needed to determine its effectiveness in improving exercise capacity and quality of life for patients with sarcoidosis [7].

## Discussion

This scoping review aimed to examine the use of telehealth in patients with sarcoidosis. The results showed limited evidence regarding the use of telehealth for patients with sarcoidosis, particularly from 2019 onward. The findings suggest that while telehealth technologies are relatively new, they are growing and becoming increasingly used in the management of sarcoidosis. These technologies, including mHealth [5, 18, 19], activity trackers [4, 20], and telerehabilitation [7], have primarily been implemented in developed countries. As a result, there may be limitations in extrapolating the results to other communities and health systems.

Sarcoidosis imposes a substantial economic and social burden, primarily due to hospitalizations, costs of medication, and work disability. This condition also causes disabling symptoms like fatigue and physical activity limitations, which often lead to psychological challenges and a reduced quality of life (QoL) [2, 4]. As sarcoidosis mainly affects people of working age, it's important to make interventions to relieve fatigue and stress accessible to everyone without significant financial and travel costs. Treatment should focus on restoring organ function, reducing symptom burden, and improving quality of life [2, 6]. The use of telehealth has been recommended as a valuable option to care and self-management of patients, improving their quality of life because it overcomes geographical and financial barriers of traditional

rehabilitation and leads to improved health [6]. As that telehealth in other chronic lung diseases has increased the quality of life and cost-effectiveness and reduced costs [21, 22].

In the field of mHealth technology, applications have been used to provide breathing awareness meditation exercises, measure physical activity levels, and stress management tools in managing disease symptoms [5, 18, 19]. The results showed that the use of these applications, especially when the exercises were provided in shorter durations and at consecutive times throughout the day, reduced the stress and fatigue levels of the patients and improved their quality of life [5, 18]. These findings suggest that short-term and frequent interventions through the app can effectively manage sarcoidosis symptoms.

Smartwatches, along with apps that record and display the patient's heart rate objectivly, has become more appealing. Enhanced features of mobile apps, such as instructions, personalized reminders, and heart rate summaries, have created a positive experience for patients. [5] Additionally, personalized reminders and notifications within the app were found to be important for increasing motivation, reminding users, and improving adherence to treatment [5, 19].

The information presented is in line with a study conducted by Kovach et al., indicating that typical features found in apps for managing chronic respiratory diseases include tracking symptoms, providing medication reminders, offering educational resources, and providing clinical support. All of these elements contribute to the effectiveness and suitability of this technology for patients with chronic respiratory conditions [23]. Additionally, since the cost of mindfulness-based treatments for stress reduction is often not covered by insurance, mobile health (mHealth) meditation programs have the potential to offer a cost-effective and affordable alternative for managing the complex medical conditions of sarcoidosis patients. This allows them to engage in exercises at home and according to their own schedules. [5] It's important to note that the effectiveness of smartphone applications for patients with sarcoidosis is particularly influenced by old age, limited technological literacy, and socioeconomic status [19].

A study on activity tracker technology found that using this technology, especially with personal coaching, improved the 6-min walking distance, Steep Ramp Test, and maximal oxygen uptake. This resulted in enhanced sports performance and reduced fatigue in patients [4]. Additionally, the technology increased mean adherence to daily spirometry and activity tracking [20]. It seems that this technology can offer unique insights into the impact of the disease on performance that cannot be captured by existing clinical measures for sarcoidosis [4]. These findings align with Klein et al.'s study, which demonstrated that activity trackers can help analyze the effect of disease status and treatment on patients in clinical practice [24]. Moreover, the trackers provide greater motivation for extended activity, especially when connected to a mobile app with integrated reminders and alerts to encourage activity [20]. These results are supported by Gill et al.'s study, which showed that HealtheSteps™ was effective in increasing the activity levels of chronic patients (measured by the number of steps per day) and reducing sitting time on weekdays [25].

The findings regarding telerehabilitation technology suggest that it was not effective in treating patients with sarcoidosis [7]. These results were contradictory to the study by Karadal et al., which found that in-person rehabilitation led to a significant improvement in exercise capacity for sarcoidosis patients after six weeks [26]. Another study by Gober et al. demonstrated that pulmonary rehabilitation improved 6MWD in patients with sarcoidosis [27]. These varying results may stem from factors such as the selection of patient types, the severity of their pulmonary involvement, the age of the patients, the type of aerobic and anaerobic exercises, and the duration of the exercise used in telerehabilitation for sarcoidosis patients [7]. These findings suggest the need for carefully designed telerehabilitation programs tailored to the individual characteristics of patients. Additionally, due to the small number of participants in these studies, there is a need for more extensive clinical trial studies with a larger sample size, longer duration of exercises, and patients with more severe disease [7].

Overall, it appears that using mHealth and activity tracker technologies in managing sarcoidosis holds significant potential. These technologies can offer a cost-effective alternative for managing the complex medical condition of sarcoidosis patients. They allow patients to exercise at home according to their own schedule, which can be especially beneficial for those facing financial constraints, travel difficulties for treatment, and limited work leave.

### Limitations

One of the limitations of this study was the small number of available evidence. Additionally, the sample size of the included trials was limited. It appears that the use of telehealth technologies for this condition has gained more attention in recent years than in the past.

### Suggestions

Given that sarcoidosis outcomes can vary based on factors such as race, gender, age, disease severity, regional

and cultural differences, and socioeconomic status, further research is recommended to explore the utilization of telehealth technology across all cultures and socioeconomic groups. This will help ensure that the patients studied are a more accurate representation of the entire patient population. Additionally, more research is necessary to determine the most effective type of exercise training for sarcoidosis patients and to identify methods for maximizing the long-term benefits of these exercises. Furthermore, there is a need for more diverse studies using different research methods to investigate the use of telehealth and its applications, as well as a greater focus on telerehabilitation to enhance patient care. Therefore, it is important for physicians and policymakers to prioritize the use of telehealth technologies in managing this disease.

## Conclusion

The study examined the use of telehealth technology in patients with sarcoidosis using a scoping review method. Currently, telehealth technologies have been utilized to a limited extent in patients with sarcoidosis. The results indicate that certain technologies, such as mHealth applications, are easy, acceptable, and effective, and their special features can help motivate patients to adhere to effective treatment. Additionally, the use of activity tracker technology improves exercise performance in these patients and helps with adherence to spirometry and daily activities. However, telerehabilitation technology is not effective in these patients, and further studies in this area are necessary. It appears that the use of various telehealth technologies and different types of exercises in these patients is influenced by the severity of the disease and pulmonary involvement, the patients' age and gender, economic status, and the duration of the exercises. Therefore, longitudinal, multicenter studies using different technologies and diverse target groups with various exercises are essential to validate the long-term effectiveness of these technologies in managing sarcoidosis. Also, when designing telemedicine interventions, it is necessary to implement real-time monitoring features to track patient health metrics continuously, use customized notifications to remind patients about medication adherence and upcoming appointments and develop interactive platforms that facilitate communication between patients and healthcare providers. Furthermore, policymakers and health administrators should consider integrating telehealth technologies into the clinical guidelines for chronic respiratory diseases.

## Appendix

**Table 2** Search strategy

| Database | Search strategy | Number |
|---|---|---|
| PubMed | ((telehealth[Title/Abstract]) OR (ehealth[Title/Abstract])) OR (mhealth[Title/Abstract])) OR (telemedicine[Title/Abstract])) OR (virtual care[Title/Abstract])) OR (videoconferencing[Title/Abstract])) OR (teleconsultation[Title/Abstract])) OR (telerehabilitation[Title/Abstract])) OR (Remote Consultation[Title/Abstract])) AND (sarcoidosis[Title/Abstract]) | 10 |
| Web of Science | TS = (telehealth OR ehealth OR mhealth OR telemedicine OR "virtual care" OR videoconferencing OR teleconsultation OR telerehabilitation OR "Remote Consultation")) AND TS = (sarcoidosis) | 10 |
| Scopus | ( TITLE-ABS-KEY ( telehealth OR ehealth OR mhealth OR telemedicine OR "virtual care" OR videoconferencing OR teleconsultation OR telerehabilitation OR "Remote Consultation") AND TITLE-ABS-KEY ( sarcoidosis)) | 37 |
| ProQuest | (telehealth OR ehealth OR mhealth OR telemedicine OR "virtual care" OR videoconferencing OR teleconsultation OR telerehabilitation OR "Remote Consultation") AND sarcoidosis | 114 |
| Google Scholar | telehealth AND sarcoidosis | 650 |

**Abbreviations**

| | |
|---|---|
| MRI | Magnetic resonance imaging |
| mHealth | Mobile health |
| SPs | Sarcoidosis patients |
| HCTMs | Healthcare team members |
| MVC | Maximum voluntary capacity |
| TT | Tension tamer |
| SC | Standard of care |
| PSS | Perceived stress score |
| FAS | Fatigue assessment scale |
| AT | Activity tracker |
| 6MWD | 6-Minute walking distance |
| SRT | Steep Ramp Test |

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L.F: Conceptualization, methodology, formal analysis, writing-review & editing, supervision. F.V: Conceptualization, methodology, data exteraction, formal analysis, writing-original draft preparation, writing-review & editing. H.S:Conceptualization, methodology, data exteraction, formal analysis, writing-original draft preparation, writing-review & editing.

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