Title

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Abstract

Background: The Strengthening and Stretching for Rheumatoid Arthritis of the Hand (SARAH) programme is a tailored, progressive 12-week exercise programme for people with hand problems due to rheumatoid arthritis. The programme was shown to be clinically and cost-effective in a large clinical trial and is recommended by the UK National Institute for Health and Care Excellence (NICE) guidelines for rheumatoid arthritis in adults.

Objectives: We have developed an online version of the SARAH programme (mySARAH) to make the SARAH programme widely accessible to people with rheumatoid arthritis. The purposes of this study were to develop mySARAH and to evaluate and address its usability issues.

Methods: We developed mySARAH using a three-step process and gaining feedback from patient contributors. After initial development, mySARAH was tested in two iterative usability cycles in nine participants using a simplified think-aloud protocol and self-reported questionnaires. We also evaluated if participants executed the SARAH exercises correctly after watching the exercise videos included on the website.

Results: A preliminary version of mySARAH consisting of six sessions over a 12-week period and delivered via text, exercise videos, images, exercise plan form, exercise diaries, and links to additional information on rheumatoid arthritis was developed.
Five participants (1 male; 4 females; median age 64 years) and four participants (four females; median age 64.5 years) took part in the first and second usability testing cycles respectively. Usability issues identified from Cycle 1 such as having a navigation tutorial video and individualised feedback on pain levels were addressed prior to Cycle 2. The need for more instructions to complete the mySARAH patient forms was identified in Cycle 2 and was rectified. Self-reports from both cycles indicated that participants found the programme useful and easy to use and were confident in performing the SARAH exercises themselves. Eight of the nine participants correctly demonstrated all the exercises.

**Conclusions:** mySARAH is the first online hand exercise intervention for people with rheumatoid arthritis. We actively involved target users in the development and usability evaluation and ensured mySARAH met their needs and preferences.

**Keywords:** Rheumatoid arthritis; Hand joints; Exercise training; Online
Main text

Introduction

The Strengthening and Stretching for Rheumatoid Arthritis of the Hand (SARAH) programme is a tailored, progressive 12-week exercise programme for people with hand problems due to Rheumatoid Arthritis (RA) [1]. The SARAH programme was designed as an addition to best practice usual care (joint protection education and functional splinting and assistive devices) for adults with RA who had pain and hand function problems and had been on a stable drug regimen for at least three months. A pragmatic clinical trial [2, 3] was conducted at 17 National Health Service (NHS) sites across the United Kingdom in 490 people who were randomised to receive best practice usual care or usual care plus the SARAH programme [3].

Patients who received the SARAH programme in the trial attended six face-to-face appointments with a registered Physiotherapist or Occupational therapist who was a hand therapist or experienced in rheumatology. The programme included seven upper limb mobility exercises – metacarpophalangeal flexion, hand tendon gliding exercises (hook, straight & full fist), radial walking, finger abduction, wrist circumduction, combined shoulder movements (hand-behind-head, hand-behind-back) and four strength exercises for the hand – gross grip, pinch grip, finger adduction, eccentric wrist extension.

Integral to the SARAH programme are behavioural support strategies such as self-monitoring, goal setting and action planning to improve patients’ self-efficacy, i.e. the patients’ confidence to carry out the SARAH exercises independently. At the start of the
programme, patients were assisted by therapists to complete a personal exercise guide to set functional goals relating to their hand problems in accordance with SMART (Specific, Measurable, Attainable, Relevant, and Timely) principles and to make an exercise plan of ‘when’ and ‘where’ to do the SARAH exercises. Patients were also asked to complete an exercise diary to monitor completion of the exercises [1, 2, and 3].

During the subsequent appointments, therapists and patients jointly reviewed the exercise diary and the personal exercise guide and set new goals and a new exercise plan or modified goals and/or the exercise plan, if required. If a patient had difficulties adhering to the SARAH programme, the patient and the therapist worked together to identify barriers to completing the exercises and to discuss realistic solutions and way to maximise facilitating factors. A Barriers & Facilitators form was completed to guide this discussion. Exercises were progressed or regressed using a standardised protocol to ensure the exercises are tailored to each patient. Patients were provided with a discharge advice sheet, exercise booklet and copies of exercise diaries, personal exercise guide, and barriers and facilitators form during their final clinical appointment. They were encouraged to continue the exercises independently at home.

The key findings of the SARAH trial [3] were as follows:

- At 4 months, the group that received the SARAH programme had improvements in hand function double that of the usual care group (8.7 points improvement in the hand function sub-scale of the Michigan Hand Outcome Questionnaire (0-100) compared to an improvement of 4 points; mean difference 4.7 points)
At 12 months, the group that received the SARAH programme had improvements in hand function double that of the usual care group (7.9 points improvement in the hand function sub-scale of the Michigan Hand Outcome Questionnaire compared to an improvement of 3.6 points; mean difference 4.3 points).

The SARAH programme did not result in any adverse effects, for example, increased joint pain, stiffness or ‘flare-ups’.

The SARAH programme was cost-effective.

These findings led to an update of the NICE guidelines in 2015 recommending the SARAH programme for adults who have hand problems due to RA [4]. Following this, it was important to develop a plan to disseminate the evidence-based SARAH programme and ensure uptake by the target users i.e. people with RA, and thereby facilitate improved patient care.

The overarching purpose of this project is to evaluate the adaptation of the SARAH programme, originally designed to be delivered face to face by a therapist to a self-guided online version (mySARAH) in which people with RA undertake the SARAH programme without therapist supervision. We propose a knowledge-translation initiative of an online version of the SARAH programme (mySARAH) to disseminate the SARAH programme to the target users by taking advantage of the increasing accessibility and use of the Internet [5,6, 7].

The dissemination of mySARAH is guided by the five steps of Analysis, Design, Development, Implementation, and Evaluation (ADDIE) instructional system design model [8, 9]. We will report on the first 3 steps of this process in this paper.
Step 1: Analysis

A needs assessment was undertaken with target users. The aim was to understand what users required in a knowledge translation tool (mySARAH) to bridge the gap between knowledge (SARAH programme) and action (making the SARAH programme available in an easily accessible format for people with RA).

Step 2: Design

The online prototype of mySARAH was designed and users provided feedback.

Step 3: Development

The preliminary version of mySARAH was developed and usability issues were evaluated for a final version.

Future work will focus on the final 2 steps:

Step 4: Implementation

mySARAH will be launched, firstly with a small group of target users, and, then into the public domain.

Step 5: Evaluation

Reach, Effectiveness, Adoption, Implementation, and Maintenance of mySARAH will be measured in a small group of target users and then a large target population.
Objectives

Step 1: The needs assessment

- To collect users’ opinions and preferences for mySARAH
- To adapt the SARAH programme to fit mySARAH

Step 2: The design of mySARAH

- To design the online prototype of mySARAH
- To collect user feedback on the prototype

Step 3: The development of mySARAH

- To revise mySARAH prototype towards the preliminary version
- To evaluate and address usability issues
- To evaluate if participants could replicate the SARAH exercises correctly
- To produce the final version of mySARAH

Methods

Figure 1 presents the flow diagram of the study.
Figure 1: Study flow diagram

Step 1
Needs assessment with patient contributors (n=5)
SARAH programme adapted for online version (mySARAH)

Step 2
mySARAH online prototype produced
Prototype reviewed by another group of patient contributors (n=6)

Step 3
Prototype revised from Step 2
Preliminary version produced
Usability testing & exercise demonstration evaluation in study participants (n=9)
Final mySARAH produced
Step 1: Needs assessment of mySARAH

We invited patient contributors from the public and the local branch of the National Rheumatoid Arthritis Society (patient support group) to assist with the development of mySARAH. We conducted face-to-face or phone meetings with five patient contributors (Age range 50 to 66 years, duration range since RA diagnosis 1 to 12 years). We explained the components of the SARAH programme delivered in the SARAH clinical trial – patient advice, type of exercises, number of exercise sessions, and use of exercise diaries, goal setting and exercise planning, and how these components might be transferred to mySARAH. We explored their needs, preferences and expectations for an online hand exercise programme. We then collectively summarised their input. In response to this, the research team adapted the SARAH programme for a mySARAH online prototype. The user feedback and SARAH programme adaptations agreed by the team are presented in the Results section.

Step 2: Designing mySARAH

The common heuristic principles recommended by Baumel and Muench [10] were incorporated in mySARAH prototype- for example, simple functionality and navigation features; a tunnelled approach to every exercise and review session to respond to users’ needs with respect to the standard hand clinical appointments; ‘In-house’ tools such as ‘Contact us’ button to facilitate user engagement; automatic email reminders to remind users about
sessions that were missed or incomplete; and exercise checklist and exercise calendar features for self-monitoring.

We also reviewed the published literature [11] to identify the types of features of successful Internet delivered self-guided health interventions and included them in mySARAH. For example, 1) having progressive modules over weeks or months requiring active user engagement, 2) having external links for additional health information, 3) having cognitive behavioural strategies, 4) having self-monitoring tools, and 5) providing patient education.

We further used the Behavioural Intervention Technology model [12, 13] to schematically map the components of mySARAH (Table 1). The Behavioural Intervention Technology model summarises five components to describe an e-health intervention; aims, behaviour change strategies, elements, characteristics, and workflow. The aims and behaviour change strategies cover the conceptual aspects of ‘Why’ and ‘How’ and the other three components cover the technical aspects of ‘What’, ‘How’ and ‘When’ of an e-health intervention. The conceptual ‘Why’ define the clinical aims of the intervention and ‘How’ defines the behavioural strategies used to achieve the aims. The technical ‘What’ defines the components of the intervention; ‘How’ describes the characteristics (the medium used, the complexity of the content; aesthetics; and personalisation features) of the components; and ‘When’ defines the workflow of the intervention delivery.
Table 1: The Behavioural Intervention Technology model mapped to mySARAH

<table>
<thead>
<tr>
<th>Conceptual/Technical components</th>
<th>BITa Model components</th>
<th>mySARAHb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why (Conceptual)</td>
<td>Aims</td>
<td>- To provide adults with RAc access to the SARAHd programme as part of a strategy for self-management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To teach them to carry out the SARAH exercises correctly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To promote long term adherence to the SARAH exercises</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To improve/ maintain hand function</td>
</tr>
<tr>
<td>How (Conceptual)</td>
<td>Behavioural change strategies</td>
<td>Knowledge – Information about RA, why hand exercises are important</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Goal setting – Set SMARTe goals related to hand function</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Action planning – Plan ‘When’ and ‘Where’ to do the SARAH exercises</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Problem solving – Identify and overcome barriers to exercise adherence or to maximise the use of facilitators</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Self-monitoring – Monitor one’s own exercise adherence behaviour</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Review goals – Modify or set new SMART goals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Instruction/Demonstration – Advice on joint protection, and demonstration of SARAH exercises</td>
</tr>
<tr>
<td>What (Technical)</td>
<td>Elements</td>
<td>Reminder emails, e-diaries, messaging, session notes, summary reports, user fillable forms</td>
</tr>
<tr>
<td>How (Technical)</td>
<td>Characteristics</td>
<td>Medium –Text, images, videos</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Complexity – Easy to complete tasks, forms, and e-diaries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aesthetics – Simple and less distractive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Personalisation features- None</td>
</tr>
<tr>
<td>When (Technical)</td>
<td>Workflow</td>
<td>Tunneled, Task-Based (example: user must complete mySARAH Session 1 to access Session 2), and time-based delivery (example: Successive mySARAH Sessions scheduled based on Session 1 completion date)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continued user access to mySARAH elements after 12 weeks</td>
</tr>
</tbody>
</table>

a BIT Model - Behavioural Intervention Technology Model; b mySARAH: Online version of the Strengthening and Stretching for Rheumatoid Arthritis of the Hand (SARAH) exercise intervention; c RA: Rheumatoid Arthritis
We designed the prototype on Drupal (Version 7.0), a widely used open source content management system [14]. A simple layout and a relatively plain background were used in mySARAH. A total of six SARAH exercise and review sessions was designed over a 12-week period where users learn to perform SARAH exercises, set their own SMART goals and plan their exercise schedule. mySARAH included calendars, a pain scale; summary reports of patient completed exercise plan form; frequently asked questions section, exercise images; exercise and instructional videos; and facility to download/save a digital copy of the content of each completed session. It also has additional patient information on RA, and links to online suppliers to purchase the SARAH exercise equipment, i.e. Thera putty, gel balls or resistance bands. A multimedia approach with a combination of text, videos, and images was utilised for intervention delivery.

As the sessions are tunnel-based, i.e. users must complete a session before advancing to the next one. The consecutive session is automatically scheduled on the user’s calendar based on the completion date of the previous session. For example, on completing session one, the second session will be released to the user after a weeks’ time.

We used the professionally produced videos on joint protection advice and SARAH exercises that had been produced to train hand therapists to deliver the SARAH programme using an online training programme [15]. We also produced preliminary videos with a member of the team on goal setting, action planning, and simple ways to adhere to SARAH exercises.
We aimed to write mySARAH content in plain English language without any technical or medical jargon. We checked this using the Gunning-Fog index [16], a formula which estimates the readability of a piece of text by considering the number of words per sentence and the proportion of words which contain three or more syllables. The Fog readability index indicates the number of years of formal education required from a reader to understand the text. We used an online tool [16] to check the readability of mySARAH. In order to be readable and comprehensible to patients from a broad range of educational backgrounds, we aimed for school grades between 5 and 9 that correspond to 10 and 14 years of reading age [17].

The prototype and mySARAH logo were reviewed by another group of six patient contributors (Age range 59 to 75 years, duration since RA diagnosis 1 to 5 years) in a half-day meeting. Following this meeting, we produced additional preliminary videos featuring them to describe their experiences how RA affects their hand function, and why exercising the hands is important.

The modifications made in mySARAH prototype are presented in the Results section.

Step 3: Developing mySARAH

Guided by Step 2, we modified the prototype and developed the preliminary version of mySARAH. We then tested mySARAH to identify and resolve usability issues for producing the final version. The usability testing protocol was reviewed and approved by the Medical Sciences Inter-Divisional Research Ethics Committee, University of Oxford (R52172/RE001).
Based on the existing evidence that 80% of usability issues can be identified with five participants and 95% with nine participants [18, 19], we proposed a convenience sample of 10 participants for usability testing. Adults having problems with hand function due to RA and living within 2 hours of travel to the study site were considered eligible to participate in the usability testing. Participants were invited via online advertisements, e-newsletters, local patient groups, and social media of Arthritis Research UK, National Rheumatoid Arthritis Society and Patients Active in Research organisations, and by word of mouth. We asked interested volunteers to contact the SARAH implementation team directly by email or phone. Appointments were arranged for the individual volunteers to attend a one-off 90-minute usability testing session at the study site.

Two researchers from the SARAH implementation team conducted the sessions. One observed and took notes while the other researcher was a session facilitator.

The facilitator explained the testing procedures to each participant, emphasising that it is the evaluation of the website and not the user. Participants were asked to provide information on their age, gender, educational level, employment status, and ethnicity, years since RA diagnosis, and hours spent on Internet each day. We conducted two iterative cycles, the first cycle with five volunteers and the second with four volunteers. We used the following procedures in our usability testing:

1) Simplified concurrent think-aloud protocol

The facilitator asked participants to navigate through mySARAH, complete assigned tasks [20, 21], e.g. creating an account, watching videos and completing a session and
simultaneously talk about what they feel, see or think while browsing. When participants had difficulties verbalising, the facilitator encouraged them by a ‘Keep talking’ signboard and assisted with prompts only if required. The think-aloud sessions were audio-recorded.

2) Exercise demonstration

Next, the facilitator asked participants to watch one SARAH exercise video at a time and repeat the exercise while watching. The video was then closed, and the facilitator asked them to demonstrate 3 repetitions of the exercise they had just watched.

The facilitator also monitored participants for pain or discomfort in their fingers and/or wrists while demonstrating the exercises, for example, if they are stretching out a stiff joint. If a participant reported pain beyond slight discomfort, we reduced the number of repetitions from 3 to 1 or discontinued the demonstration session.

The note-taker observed participants’ ability to correctly demonstrate each exercise including choosing the right baseline resistance level for strength exercises and documented any difficulties, doubts, and comments reported. A simple 1-3-point scale (1 =correctly demonstrated, 2= assistance required from evaluator or by replaying the video, and 3=difficulty demonstrating the exercise correctly after being assisted) developed by the SARAH implementation team was used to rate the correct execution of exercises and baseline load setting.

3) Subjective reports
We used the Computer System Usability Questionnaire [22] to evaluate user satisfaction, ease of use, information, and interface of web programme with an 8-point Likert scale, 1 representing ‘Strongly disagree’ and 7 representing ‘Strongly agree’. We measured perceived usefulness with a 1-5 Likert scale that is scored from 1=Not at all useful to 5= Extremely useful; ease of use with a 1-5 Likert scale that is scored from, 1= Very difficult to 5= Very easy; and confidence in doing the SARAH exercises with a 1-5 Likert scale that is scored from 1=Not at all confident to 5= Very confident.

The findings from this step are presented in the Results section.

Data analysis

We listened to the audio files of the think-aloud sessions along with notes from each session and created a list of key usability issues reported by participants. The demographic characteristics of usability testing participants were summarised, and questionnaire scores were reported as median and interquartile ranges.

Results

Step 1: Needs assessment of mySARAH

The patient contributors preferred a hand exercise website having the following features:

- A simple layout
- Short exercise and instructional videos
- Brief paragraphs with content written in clear, straightforward language
- Links to additional information on rheumatoid arthritis
- Email reminders with option to select the frequency of reminders received
- Simple screening process with questions confirming age and RA diagnosis
- A separate section for ‘Frequently asked questions’.

In addition to the above, the following modifications were made from the SARAH programme in the trial for mySARAH prototype:

- In the clinical trial, participants attended face-to-face appointments with a hand therapist at Weeks 1, 2, 4, 6, 9 & 12. For mySARAH, we made some modifications to the timing of sessions to better fit the online delivery of the programme. mySARAH sessions were scheduled to occur at Weeks 1, 2, 3, 6, 9, & 12
- We used a simple lay term ‘exercise plan form’ for ‘personal exercise guide’
- We simplified the personal exercise guide by removing the confidence scale asking patients how confident they were to achieve their goals and the exercise contract section between patient and therapist
- We used instructional videos to provide tips on adhering with the programme instead of using the barriers and facilitators form
- We designed a distinct mySARAH logo

Step 2: Designing mySARAH
Analysis of the text (excluding tables, figures, hyperlinks) contained in mySARAH produced a Gunning Fog readability index approximately ranging from 7.9 and 11 years of education which corresponds to an approximate reading age between 13 and 16 years. Some text was higher than ideal, but this was due to high proportion of polysyllabic words and medical terms (examples: exercise, rheumatoid arthritis) that could not be modified further. We provided simple explanations of any medical terms.

The approximate session-wise Gunning Fog indexes are as follows: Session 1: 9.6 (reading age: 15 years); Session 2: 7.9 (reading age: 13 years); Session 3: 10.6 (reading age: 16 years); Session 4: 10.8 (reading age: 16 years); Session 5: 11 (reading age: 16 years); and Session 6: 11 (reading age: 16 years).

The patient contributors who participated in the half-day meeting liked the layout and look of the website. They felt the information and the language were clear and easy to follow. They liked the features of exercise calendar, email reminders, exercise videos, frequently asked questions section, and facility to have a summary record of their goals. They also agreed on one of the two mySARAH logos produced by the team. The following revisions were suggested:

- Break long paragraphs into shorter paragraphs
- Use bullet points to breakup lengthier sections of text
- Ensure pages are not cluttered
- Proof-read the pages
- Add contact details of exercise equipment suppliers
- Add more details at the end of the programme about continued access to mySARAH
Step 3: Developing mySARAH

The preliminary version of mySARAH was produced incorporating the revisions suggested by users in Step 2. The resultant version still closely resembled the prototype. We enrolled ten participants in the usability testing which took place in two cycles. A total of nine participants completed the testing as one volunteer withdrew after consenting due to family member’s sickness.

The demographic characteristics of participants taking part in usability testing Cycle 1 and Cycle 2 sessions are presented in Table 2. Participants felt that the mySARAH website was self-explanatory, easy to use and contained all the information it needed about the SARAH programme. They reported that the registration process was straightforward; the goal setting and exercise planning form and -exercise calendar was helpful; the website content was relevant; the exercise and other videos were helpful and engaging; and the forms were easy to fill out. The main usability issues identified by each cycle participants and the subsequent revisions made are listed in Table 3.
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Cycle 1</th>
<th>Cycle 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Age: Median (IQR(^2)) years</td>
<td>64 (60-66)</td>
<td>64.5 (55-70.5)</td>
</tr>
<tr>
<td>Male/Female</td>
<td>1/4</td>
<td>0/4</td>
</tr>
<tr>
<td>Educational qualification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- High school</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>- Bachelor</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>- Doctoral</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>- Certificate course</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- White British</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>- Indian</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Employment status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Retired</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>- Part-time</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>- Full-time</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>- Not working</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Duration since diagnosis:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (IQR) years</td>
<td>17 (12-25)</td>
<td>12 (4-26)</td>
</tr>
<tr>
<td>Internet use/day:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (IQR) hours</td>
<td>3 (2-6)</td>
<td>1 (1-1.5)</td>
</tr>
</tbody>
</table>

\(^2\)IQR=Interquartile range

Table 2: Characteristics of the participants taking part in mySARAH Usability Cycles 1 & 2
Table 3: Main usability issues and rectifications made in mySARAH

<table>
<thead>
<tr>
<th>Usability issues Cycle 1 (n=5)</th>
<th>Rectifications after Cycle 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10 numerical pain scale was not clear</td>
<td>Verbal descriptors were added to 0-10 pain scale</td>
</tr>
<tr>
<td>The background colour is very plain</td>
<td>A pleasant blue background was added</td>
</tr>
<tr>
<td>A feedback report on pain levels would be helpful</td>
<td>A graph feature to provide a visual feedback on pain levels recorded every session was added</td>
</tr>
<tr>
<td>There is no separate section for email reminders</td>
<td>A separate section with option for selecting frequency of reminders was added</td>
</tr>
<tr>
<td>A separate patient video demonstrating wrist backward bends exercise would be helpful</td>
<td>An additional patient video was added</td>
</tr>
<tr>
<td>The size of some images is too small</td>
<td>Small images were increased in size</td>
</tr>
<tr>
<td>The progression bar across sessions is not noticeable</td>
<td>Progression bar was increased in width</td>
</tr>
<tr>
<td>Some pages are too wordy</td>
<td>Bullet points were used</td>
</tr>
<tr>
<td>A navigation tutorial video would be helpful</td>
<td>A preliminary navigation tutorial video was added</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Usability issues Cycle 2 (n=4)</th>
<th>Rectifications after Cycle 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>The instructions for completing forms/exercise calendar is not adequate</td>
<td>Clear instructions for completing forms/exercise calendar were added</td>
</tr>
<tr>
<td>There is too much scrolling in some pages</td>
<td>Page screen spaces were managed to reduce scrolling</td>
</tr>
<tr>
<td>Try more colours with pages- add 1 or 2 images on the landing page</td>
<td>A welcome image was added on the landing page</td>
</tr>
<tr>
<td>How do you know if a mistake is made on a form?</td>
<td>A pop-up message was set up to notify any omission or error prior to submission</td>
</tr>
</tbody>
</table>
The Computer System Usability Questionnaire and Likert Scale scores from both cycles of usability testing are listed in Table 4. All participants had good agreement (with scores above 6) on almost all the items of the Computer System questionnaire, especially in terms of satisfaction, ease of use, and the content. Three participants found Item 8, “I believe I became productive quickly using this system” irrelevant to the tasks they completed and therefore did not score it. Seven participants felt that Item 9 stating “The system gives error messages that clearly tell me how to fix problems” was not relevant as they did not encounter any issues while filling in the fields in mySARAH forms. Therefore, we have not reported these two items. However, participants raised the concern of being notified to rectify any errors while filling the forms. We duly addressed this usability issue by adding pop-up error notifications in the final version.

The Likert scale scores indicate that all users found the programme useful, easy to use and were confident in their ability to do the SARAH exercises themselves.
### Table 4: Questionnaire scores of mySARAH usability testing, n=9

<table>
<thead>
<tr>
<th>Computer System Usability Questionnaire items on 1-7 scale</th>
<th>Cycle 1 Median (IQR)</th>
<th>Cycle 2 Median (IQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Overall, I am satisfied with how easy it is to use this system</td>
<td>6.5 (6-7)</td>
<td>6.5 (6-7)</td>
</tr>
<tr>
<td>2) It was simple to use this system</td>
<td>6 (6-7)</td>
<td>6.5 (6-7)</td>
</tr>
<tr>
<td>3) I can effectively complete my work quickly using this system</td>
<td>6 (5.1 - 6.3)</td>
<td>6 (6-6.3)</td>
</tr>
<tr>
<td>4) I am able to complete my work quickly using this system</td>
<td>6 (5.1 - 6.3)</td>
<td>6 (6-6.3)</td>
</tr>
<tr>
<td>5) I am to efficiently complete my work using this system</td>
<td>6.5 (5.5 -7)</td>
<td>6 (6-6)</td>
</tr>
<tr>
<td>6) I feel comfortable using this system</td>
<td>6 (6-7)</td>
<td>7 (6.8 - 7)</td>
</tr>
<tr>
<td>7) It was easy to learn to use this system</td>
<td>6 (6-7)</td>
<td>6.5 (6-7)</td>
</tr>
<tr>
<td>8) I believe I became productive quickly using this system</td>
<td>6 (5.5 – 6.5)</td>
<td>6 (6-6.5)</td>
</tr>
<tr>
<td>9) The system gives error messages that clearly tell me how to fix problems</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>10) Whenever I make a mistake using this system, I recover easily and quickly</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>11) The information (such as online help, on-screen messages, and other documentation) provided with this system is clear</td>
<td>6.5 (5.5 - 7)</td>
<td>7 (7-7)</td>
</tr>
<tr>
<td>12) It is easy to find the information I needed</td>
<td>6 (6-7)</td>
<td>6.5 (6-7)</td>
</tr>
<tr>
<td>13) The information provided for the system is easy to understand</td>
<td>6 (6-7)</td>
<td>7 (6.8 - 7)</td>
</tr>
<tr>
<td>14) The information is effective in helping me complete the tasks and scenarios</td>
<td>6 (6-7)</td>
<td>7 (6.8 - 7)</td>
</tr>
<tr>
<td>15) The organization of information on the system screens is clear</td>
<td>6 (6-7)</td>
<td>6.5 (6-7)</td>
</tr>
<tr>
<td>16) The interface of the system is pleasant</td>
<td>6 (6-7)</td>
<td>6 (6-7)</td>
</tr>
<tr>
<td>17) I like the using the interface of this system</td>
<td>6.5 (5.8 - 7)</td>
<td>6 (5.8 – 6.3)</td>
</tr>
<tr>
<td>18) This system has all the functions and capabilities I expect it to have</td>
<td>6.5 (5.8 - 7)</td>
<td>6 (5.5 – 6.3)</td>
</tr>
<tr>
<td>19) Overall, I am satisfied with this system.</td>
<td>6.5 (6-7)</td>
<td>6 (6-6.3)</td>
</tr>
</tbody>
</table>

**Likert scale of perceived usefulness, ease of use of and confidence**

<table>
<thead>
<tr>
<th></th>
<th>Median (IQR)</th>
<th>Median (IQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>On a scale of 1-5, with 1 representing 'Not at all useful' and 5 representing 'Extremely useful', how would you rate the overall usefulness of mySARAH? (1-Not at all useful; 5-Extremely useful)</td>
<td>5 (4 -5)</td>
<td>5 (4.8 - 5)</td>
</tr>
<tr>
<td>On a scale of 1-5, with 1 representing 'Very difficult' and 5 representing 'Very easy', how would you rate the overall ease of use of mySARAH? (1-Very difficult; 5-Very easy)</td>
<td>4 (3 - 4)</td>
<td>4.5 (4 - 5)</td>
</tr>
<tr>
<td>On a scale of 1-5, with 1 representing 'Not at all confident' and 5 representing 'Very confident', how would you rate your confidence in doing the SARAH exercises by yourself? (1-Not at all confident; 5- Very confident)</td>
<td>4.5 (4 - 5)</td>
<td>5 (5-5)</td>
</tr>
</tbody>
</table>
Eight of the nine participants (89%) correctly demonstrated all 11 SARAH exercises, scoring 1 on the 1-3 exercise demonstration scale. One participant required a little guidance for ‘Spread fingers’ and ‘Hand squeeze’ exercises and found holding the resistance band between fingers for the ‘Wrist backward bends’ strength exercise difficult to demonstrate.

After addressing Cycle 2 usability issues, a few additional revisions were made by the research team in the final version of mySARAH:

- A ‘Go to homepage’ tab was created to signpost to respective sessions on logging in.
- mySARAH promotional video, navigation tutorial video, and informational videos on clinical aspects of RA, behavioural strategies for exercise adherence were professionally filmed and produced
- A patient video demonstrating the wrist backward bends exercise showing how to hold the resistance band, how to set baseline load and how to perform the exercise was additionally produced (Multimedia Appendix 1)
- Therapist-patient and patient demonstrated videos for wrist backward bends exercise was combined as a single video and added to mySARAH
- Pages were proof-read by a patient volunteer and a member of the research team
Final version of mySARAH

A brief description of mySARAH (Multimedia Appendix 1) and screenshots of mySARAH (Multimedia Appendix 2) are presented. Table 5 provides an overview of the final mySARAH sessions’ content. Sessions are accessed by users on a pre-set timetable, so they have adequate time to perform the exercises between sessions. Figure 2 shows the navigation pathway of mySARAH.
<table>
<thead>
<tr>
<th>Session</th>
<th>Suggested week of completion</th>
<th>Outline of content</th>
</tr>
</thead>
</table>
| One     | Week 1                      | ▪ Users fill out demographic information and hand function questionnaire  
▪ Users rate the pain in their hands on a 0-10 numerical scale  
▪ Information is provided about the clinical aspects of RA and its management.  
▪ The SARAHb mobility exercises are introduced  
▪ Users are taught how to set SMARTc goals and plan when and where to complete exercises.  
▪ Users are encouraged to complete the mobility exercises daily from this point onwards. |
| Two     | Week 2                      | ▪ The SARAH strength exercises are introduced  
▪ Users are taught baseline setting for strength exercises  
▪ Users review and update their goal and plan at the end of each session from this point onwards. |
| Three   | Week 3                      | ▪ Covers how and when users should adjust their exercises if they:  
▪ Are finding them too challenging  
▪ Need to make them harder |
| Four    | Week 6                      | ▪ Encourages users to consider any barriers to completing their exercises which have become apparent since beginning the programme.  
▪ It also asks users to think about how they have overcome barriers and what else they could do in the future. |
| Five    | Week 9                      | ▪ Discusses the challenges to adhering to the programme in the long-term.  
▪ Users are taught how to re-start the programme if they need to stop for any reason. |
| Six     | Week 12                     | ▪ Focusses on the continuation of the exercises after completion of the programme.  
▪ Users are encouraged to continue to access the resources on the website if they need to. |
- Users complete the Michigan hand function sub-scale, Global Rating of Change scale to measure their progress.

RA: Rheumatoid arthritis
SARAH: Strengthening and Stretching for Rheumatoid Arthritis of the Hand (SARAH) exercise intervention; SMART - Specific, Measurable, Achievable, Relevant, Timely

**Figure 2:** Navigation workflow of mySARAH
Discussion
The objectives of this study were to develop a web version of the evidence-based SARAH hand exercise programme in collaboration with patients with RA (target users of mySARAH) and to identify and address its usability issues for a refined final version.

Principal findings

In general, patient contributors wanted a simple, less cluttered and less wordy website. They were pleased with the purpose and content of the mySARAH prototype and found it a useful resource for people having hand function difficulties due to RA. Participants from the usability testing sessions also found mySARAH a useful tool for people with RA, easy to use and were confident to execute the SARAH exercises and set their baseline load for strength exercises on their own.

We wanted to develop a user-centred mySARAH website and hence involved patient contributors in the initial phases of developing mySARAH. This is one of the very few web-based systems that were formally tested in adults with RA [21, 23]. As mySARAH is self-directed in nature, users are expected to learn the SARAH exercises correctly, do them daily, and progress or regress the dosage according to their capabilities. Therefore, in addition to the usability testing of the website, we captured how far people managed to learn and perform the exercises correctly and set their baseline load for each strength exercise. We believed evaluating this at these earlier stages would inform whether participants found the exercise demonstration videos easy to follow and replicate them as intended.

RA is a chronic condition so long-term adherence is required to maintain joint mobility and muscle strength. From the findings of the SARAH trial, we know that participants found it
challenging to continue the exercises long-term and by 2 years follow up many had ceased to continue their exercises [24]. One of the major strengths of mySARAH is that it will allow users continued access to the SARAH exercises from home without the need for hospital appointments overcoming practical problems such as transportation difficulties or lack of availability of hand therapy appointments. This access also gives them access to videos and information if they need reminding of the exercises if they take a break. They can continue to use the exercise calendar to potentially promote long term adherence with the programme.

The other strength is that the programme has been built upon a theoretical model incorporating heuristics principles towards a user needs-based intervention.

Limitations

This study has some limitations. Due to resource and time restraints, we did not transcribe the think-aloud sessions or code their content. The exercise demonstration evaluation scale used in this study was not a validated scale but this evaluation was done by experienced physiotherapists and the scale was designed as a simple, pragmatic tool to record the evaluation. We intended to include people from a wide range of educational and computer literacy backgrounds. However, eight out of nine participants (89%) were White British women, and four (67%) had Bachelor to Doctoral levels of formal education. The median number of years since participants were diagnosed with RA was greater than 10 years in both usability cycles. Therefore, we are uncertain whether men, people from other cultural or educational backgrounds or those diagnosed more recently would offer a different perspective on mySARAH. Our sample size still meets the recommended number for testing usability issues.
Next steps

We plan to carry out further testing to address these issues including whether users can not only demonstrate the exercises but progress them over the duration of the programme by carrying out a proof of concept study.

Conclusions

Involving target users in the development process ensured mySARAH resulted in a user-centred and user-friendly online exercise resource. Results from the usability testing show mySARAH to be an efficient and user-friendly programme. A proof-of-concept study is underway to determine the feasibility and acceptability of mySARAH prior to extensive testing in larger population.

Multimedia Appendix 1: Brief description of mySARAH

Multimedia Appendix 2: mySARAH screenshots

Conflicts of interest

None.

Acknowledgements
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**Abbreviations**

1) ADDIE: Analysis, Design, Development, Implementation, and Evaluation  
2) BIT model: Behavioural Intervention Technology model  
3) mySARAH: Online version of the Strengthening and Stretching for Rheumatoid Arthritis of the Hand (SARAH) exercise intervention  
4) NHS: National Health Service  
5) NICE: National Institute for Health and Care Excellence  
6) RA: Rheumatoid Arthritis  
7) SARAH: Strengthening and Stretching for Rheumatoid Arthritis of the Hand exercise intervention  
8) SMART: Specific, Measurable, Achievable, Relevant, and Timely

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