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ARTICLE

Initial participant perspectives about participating in an online, semi-supervised, cirrhosis-specific nutrition and exercise intervention

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Abstract

Objectives: In chronic diseases, there have been issues with low levels of participant adherence and retention during well-supported lifestyle behaviour change interventional studies. Theoretically informed, the objective was to explore the types of challenges participants are experiencing to inform future designs.

Design: We conducted an exploratory descriptive study in an adult cirrhosis population after the first 4–6 weeks of a 12-week semi-supervised nutrition and exercise online program.

Methods: Participants in the parent feasibility study, assessing the nutrition and exercise intervention (Heal-Me), were eligible for this nested study. Heal-Me is a multimodal program that is tailorable to a participant's abilities through regular interaction with the study's registered dietician and exercise specialist. Interviews (~60 min) with participants were recorded then analysed descriptively, guided by the capability, opportunity and motivational behaviour change model.

Results: The 20 participants preferred the expert-led group online nutrition and exercise classes over independent activities such as protein tracking and the exercise videos. Social gamification (e.g., weekly polls on favourite things like movies or sports teams) contributed to the group experience. All except one person required program tailoring to address preferences, abilities and new onset health events. Findings led to the inclusion of 4 behaviour change techniques to the initial 17, whereas 2 others were expanded.

Conclusions: While program tailoring, awareness of cirrhosis nutrition and regular interactions with staff influenced participant retention and adherence in the first 4–6 weeks of the online program.

KEYWORDS
behaviour change, chronic liver disease, COM-B, eHealth, tailored program

What is already known on this subject?

- In cirrhosis, physical frailty is modifiable through nutrition and exercise.
- Prior cirrhosis studies indicate inconsistent adherence to the programs despite delivery modality and extent of supervision.
- To date, no study has singularly examined the participant's experience during the first weeks of an intervention to identify promising facilitators for program adherence.

What does this study add?

- The theory-informed digitally delivered nutrition and exercise intervention with 17 behaviour change techniques was well received initially by the cirrhosis participants.
- Problem solving was important to the participants to make the program relevant in this early phase.

BACKGROUND

Sarcopenia and physical frailty are experienced frequently by people living with cirrhosis, occurring in 22% to 62% (Tandon et al., 2018; Tantai et al., 2021) and 25% (Lai et al., 2019) to 38% (Berry et al., 2022), respectively. These conditions have been associated with worse clinical outcomes including longer hospital and intensive care unit stays, higher incidence of infection, reduced quality of life and increased mortality (Berry et al., 2022; Tantai et al., 2021). The causes of sarcopenia and frailty are multifactorial including factors such as inadequate nutrition, sedentary lifestyle, ageing (Cruz-Jentoft & Sayer, 2019; Dent et al., 2019) and cirrhosis-related altered metabolic function and endocrine dysfunction (Lai, Tandon, et al., 2021). Guidelines support the central role of nutrition and physical activity-based interventions as the main tenets of therapy for these conditions (Bischoff et al., 2020; European Association for the Study of the Liver, 2019; Lai, Tandon, et al., 2021), with an online delivery modality as a potential strategy to promote participant convenience and broader dissemination. Although adherence is a key factor associated with clinical benefit (Kok et al., 2021; Kruger et al., 2018; Lai, Dodge, et al., 2021), much still needs to be understood about participant perceptions and factors affecting adherence to virtually delivered nutrition and exercise programs in cirrhosis. This participant view is relevant to optimizing program delivery, adherence and impact on clinical endpoints.

Unlike nutrition interventions in cirrhosis, exercise randomized controlled trials are more likely to report adherence rates (Aamann et al., 2020; Chen et al., 2020; Kruger et al., 2018; Lai, Dodge, et al., 2021; Macías-Rodríguez et al., 2016; Román et al., 2014, 2016; Wallen et al., 2019). Those exercise interventions that were delivered in-person (e.g., supervised) have consistently high rates of adherence (range: 82%–97%) (Aamann et al., 2020; Berzigotti et al., 2017; Macías-Rodríguez et al., 2016; Román et al., 2014;

Román et al., 2016). The supervised aspect has also, however, been associated with barriers to study enrolment (e.g., willingness to participate) and adherence (e.g., issues with travel and scheduling conflicts) (Ney et al., 2017). In studies where participants exercised at home either all (unsupervised) or part of the time (semi-supervised), the adherence rates are more variable ranging from 14% (Lai, Dodge, et al., 2021) to 100% (Chen et al., 2020; Nishida et al., 2017), respectively.

Internet-connected digital platforms, such as smartphone applications ('apps'), represent an alternate delivery modality that addresses participant-specified barriers and offer new functionalities for customization. Apps have been used successfully in other chronic diseases like diabetes (Wang et al., 2020) and asthma (Poowuttikul & Seth, 2020) to support self-management activities such as medication adherence, tracking changes in biomarkers and health behaviours. In an un-supervised app-based cirrhosis study from 2021, 20 of 26 (77%) participants watched at least one exercise video on their own during a 6-week exercise and nutrition intervention. The median number of repeated viewings was 9 with a wide range from 1 to 100 views, suggesting variable participant engagement (Duarte-Rojo et al., 2021). Despite their potential for health improvement, variation in participant behaviours impact app utilization.

Behaviour change theory can inform the design of app-based lifestyle interventions to promote participant engagement (Tighe et al., 2020) and guide exploration of why participants engage with these interventions (Kok et al., 2021). For example, the Capability Opportunity Motivation-Behaviour Change (COM-B) model describes how interventions influence the behaviour of individuals (Michie et al., 2011). The COM-B has 3 major domains with 6 subdomains of capability (physical and psychological), opportunity (physical and social) and motivation (reflective and automatic). The theoretical domains framework (TDF) is a companion framework providing more specific explication of the cognitive, affective, social and environmental influences on behaviour (Cane et al., 2012). The COM-B and TDF are designed to be used together in behaviour change research, implementation and evaluation (Ellis et al., 2019; Reedman et al., 2021; Timlin et al., 2021). Constructs have been mapped to elements believed to influence behaviour change known as behaviour change taxonomies (BCTs) that have been specifically incorporated into the model.

In advance of conducting a feasibility study of the intervention in cirrhosis and the absence of qualitative insight in the literature, we wanted to capture early experiences of participants using an app-based program to support their nutrition and exercise self-management. The aim of the current study was to explore the early experiences (4–6 weeks) of participants enrolled in an 11-week study of the theoretically informed, web-based nutrition and exercise application Healthy Eating, Active Living, Mindful Energy (Heal-Me version 1). A 4–6-week time point was chosen to identify participant-perceived barriers and facilitators early on and to minimize the risk of losing the perspectives of participants who were unable to complete the full 11-week program. This information would help evaluate the BCTs incorporated into the Heal-Me program to change behaviour and possibly influence health outcomes.

DATA AND METHODS

This exploratory study employed a qualitative descriptive approach to capture the participants' emic experiences with and perceptions of Heal-Me (Sandelowski, 2000) to identify new viewpoints beyond those of the research team. The descriptive analysis approach allows researchers to stay close to the original data without the need to transform it or generate a theory. This analytical approach was congruent with the study goals of identifying facilitators and barriers to early program uptake and usage (Sandelowski, 2000) and facilitated the use of the COM-B and TDF to guide analysis as our main conceptual framework.

Setting

Ethics approval (Pro00087451) was received from the Health Research Ethics Board, University of Alberta. This was a nested study within the Heal-Me Cirrhosis feasibility trial (ClinicalTrials.gov #NCT05033327).

Sample

Participants were consecutively recruited (May–November 2021) from the feasibility trial for a total convenience sample of 23 participants of the first 25 going through the program. By inviting all eligible participants via telephone, this sampling approach ensured the maximal possible variation. Care partners were also invited to participate to further expand variation of experiences. Inclusion criteria for the parent trial included adults (≥18 years of age); cirrhosis (MELD-Na <26) diagnosed by imaging, medical history, transient elastography or liver biopsy; fulfilled guideline-based prophylaxis for high-risk gastroesophageal varices; provided informed written consent; could read and write in English and had access to an internet-connected digital device in their home. Ineligibility criteria included hepatocellular carcinoma (HCC) outside of the Edmonton liver transplant criteria, non-HCC malignancy, end-stage renal disease on dialysis, post liver transplant status, deemed ineligible to participate in a virtual exercise program by their medical team or listed for compassionate care.

Heal-Me cirrhosis intervention

The 15 behaviour change measures were (Carey et al., 2019) mapped to the domains in the COM-B (Michie et al., 2011) and TDF (version 2) (Cane et al., 2012) (Table 1). With nutrition and exercise interventions informed by cirrhosis practice guidelines (2019; Lai, Tandon, et al., 2021), the Heal-Me Cirrhosis intervention was delivered online over 11 weeks in a semi-supervised format. Accessed through Heal-Me, online videoconferences connected participants to the 1-to-1 check ins with a dietitian (3×) and a exercise specialist (10×). There were 5× dietitian-led nutrition education classes and 10x exercise specialist-led group exercise classes also accessed through the app. Independently, participants used the app to view their collaboratively set weekly goals, enter protein intake, access follow-along exercise videos, monitor their progress and review the resources, including recipes (Figure 1-Heal-Me Cirrhosis logic model). Polls about the program and preference questions (e.g., what is your favourite colour?) were included to familiarize participants with one another. Randomly selected answers were drawn every 2 weeks for a coffee card of nominal value to create a universal interest.

Data generation and analysis

Interviews were conducted after participants used the semi-supervised Heal-Me program for 4 weeks. During this timeframe, participants met with their trainers (i.e., the registered dietitian and exercise specialist) and set their goals, were assisted with logging into the app and familiarized with navigation and content, paired the activity tracker with the exercise specialist and attended at least one each of the online group nutrition and exercise sessions. For the interviews, participants could choose either a private telephone call or online videoconference for the 60-min interview with the option of recording or not. Before asking questions, each interviewee gave verbal consent and protection of their confidentiality was discussed. Interviews were conducted either by K.P.I. and J.C.S. together or by K.P.I. J.C.S., an expert qualitative researcher, supervised trainee K.P.I. throughout. Previously, K.P.I. met the participants at baseline in the parent feasibility study where she was a research facilitator.

The interview guide (informed by the COM-B model, TDF and the Heal-Me Cirrhosis program) was semi-structured with open-ended questions; prompts elicited extra or clarifying information (Table S1—interview guide). An outline of the interview guide (Assarroudi et al., 2018) was created after which the scripted questions and prompts were reviewed until consensus was reached amongst K.P.I., J.C.S. and P.T. Field notes were only taken during and after the interviews to inform the wording of the questions and prompts and their relevance but were not included in the data analysis. The interview guide was not modified during the study. Recordings were transcribed verbatim and reviewed for accuracy.

TABLE 1 Linkage of Behaviour Change Taxonomy v1 (93 BCTs) and mechanisms of action in the Heal-Me Cirrhosis program with the COM-B model and TDF v2.

			Capability				Opportunity		Motivation							
			Physical	Psychology			Social	Physical	Reflective						Auto	
Behaviour change taxonomy	**MoA**	**Description of heal-me cirrhosis program elements**	**S**	**K**	**BR**	**Me**	**SI**	**ECR**	**BAC**	**BCC**	**I**	**Id**	**O**	**G**	**R**	**Em**
8.1 Behavioural practice/ rehearsal (modelling)	S, BAC	N: Online group nutrition classes show performance of the behaviour with Q&As. E: Online group exercise classes show performance of the behaviour														
8.7 Graded tasks	S, BAC	N: Protein servings increased incrementally to reach behaviour outcome. E: Exercise intensity and duration increase incrementally (but NOT the number of exercise sessions per week)														
4.1 Instruction on how to perform a behaviour	K, S, BAC	N: Recipes, online education classes, informational videos and text documents. E: Explanations in the extended follow-along exercise videos, Trainer instructions during online classes to correct or modify exercises. ***Online education class about physical frailty, exercise and cirrhosis***														
6.1 Demonstration of the behaviour	K, BAC, SL	N: Cookery videos and online nutrition demonstrations. E: Demonstrate exercises or their modifications during online group sessions by lead instructor														
6.2 Social comparison	***SN, SI***	***For both N and E: Group classes: can draw attention to others' performance/ progress for self-comparison. Leaderboard: can see other's progress relatively to their own***														
6.3 Information about others' approval	***SN, I***	***For both N and E: Leaderboard feedback from participants can promote, encourage, support, and connect with other participants using emojis or premade text***														

(Continues)

TABLE 1 (Continued)

Behaviour change taxonomy	MoA	Description of heal-me cirrhosis program elements	Capability				Opportunity		Motivation							
			Physical	Psychology			Social	Physical	Reflective						Auto	
			S	K	BR	Me	SI	ECR	BAC	BCC	I	Id	O	G	R	Em
1.2 Problem solving (program adherence)	K, BAC, BR	N: Trainer collaboratively explores possible barriers to protein intake, makes relevant suggestions (e.g., other foods high protein milk, meal services, protein bars)—customization; ***After group classes, have a group discussion led by Trainer regarding issues and solutions to adherence***. E: Trainer collaboratively explores barriers, makes relevant suggestions to motivate participant to exercise (e.g., exercise with a buddy, find suitable time of day, different exercises)—customization; ***After group classes, have a group discussion led by Trainer regarding issues and solutions to adherence***														
11.3 Conserving mental resources	***BR, ECR, Me***	***E: Associate certain exercises with habitual activities. During commercials, could complete resistance exercises. While doing laundry, could do stretching or balance exercises. Parsing out exercises ensures they get done. Decreases the overall commitment time to exercising and may ease integration into existing schedules***														

TABLE 1 (Continued)

Behaviour change taxonomy	MoA	Description of heal-me cirrhosis program elements	Capability				Opportunity		Motivation							
			Physical	Psychology			Social	Physical	Reflective						Auto	
			S	K	BR	Me	SI	ECR	BAC	BCC	I	Id	O	G	R	Em
2.3 Self-monitoring of behaviour	BR	N: Participants recorded their daily protein intake for each meal or snack with the app for a minimum of 3–4 days each week—***Make reporting screens more detailed for day, week, and historical; include weight measures everyday to proactively monitor for possible weight gain***. E: ***More data displays to support personal progress tracking for day, week, and historical; Include mood surveys before and after exercise sessions which are tracked over time***			■											
3.2 Social support (practical)	ECR, SI	N: Trainer provides expert dietary and nutrition advice or suggestions; advised to engage in meal planning and preparations. E: Exercising with the Trainers and other participants; advised to get an exercise buddy					■	■								
10.4 Social reward	R, SI	N: Trainer praises nutrition efforts as merited; bimonthly draws for responders; ***participants can praise one another on the progress board***. E: Trainer praises exercise efforts as merited; bimonthly draws for responders; ***participants can praise one another on the progress board***					■								■	■
12.1 Restructured the physical environment	ECR	N and E: Live classes via Zoom videoconference where participants interact with others and Trainers; provided resistance bands for exercise						■								

(Continues)

TABLE 1 (Continued)

Behaviour change taxonomy	MoA	Description of heal-me cirrhosis program elements	Capability				Opportunity		Motivation							
			Physical	Psychology			Social	Physical	Reflective						Auto	
			S	K	BR	Me	SI	ECR	BAC	BCC	I	Id	O	G	R	Em
9.1 Credible sources	AB, GAB	N: Trainer is a dietitian; program adheres to nutrition practice guidelines for participants with chronic diseases and age-related. E: Trainer is a exercise specialist; program adheres to recommendations for participants with chronic diseases														
15.3 Focus on past successes	BAC	N: Participant recalls when they were adherent or completed certain program elements (e.g., having a late-night snack). E: Participant recalls when they were physically active or when they were successfully adherent to the programming														
9.3 Comparative imagining of future outcomes	BACo	N: Trainer helps participant compare two futures with a high versus low protein diet. E: Trainers help participant compare two futures with versus without exercising														
2.2 Feedback on behaviour	M, FP	N: Review recent protein intake; review progress relative to goal and protein tracking data; discusses participant perceptions. E: Review recent physical health, motivation, exercise intensity; discusses participant's confidence and capability for future week														
2.7 Feedback on outcome(s) of behaviour	FP	N: Points and achievements earned for protein quantity and types tracked. E: Points and achievements earned for completing the follow along exercise videos														
1.1 Goal setting (behaviour)	I, G, O	N: Agrees on number of protein servings per day informed by guidelines; rates confidence to achieve this E: Agrees on exercise intensity from level 1 to 4 and types of exercises for the following week; rates confidence to achieve this														

TABLE 1 (Continued)

Behaviour change taxonomy	MoA	Description of heal-me cirrhosis program elements	Capability				Opportunity		Motivation							
			Physical	Psychology			Social	Physical	Reflective						Auto	
			S	K	BR	Me	SI	ECR	BAC	BCC	I	Id	O	G	R	Em
13.1 Identification of self as a role model	***SIm***	***N: Liver friendly diet is beneficial to rest of household and helping them improve their health. During online group sessions, can be a model for other participants.*** **E: Exercise technique and progress can make a participant a good model for others during online exercise classes.**														
1.6 Discrepancy between behaviour and the goal	G, FP	N: Every 3 weeks, review protein intake versus set goals. E: Every week, review exercise sessions completed and perceived exertion intensity relative to set goals														
1.5 Review behaviour goal(s)	G	N: Review progress and confidence (***as needed***) with protein intake with positive outcomes leading to increased daily protein servings to reach target behaviour outcome of 1.2–1.5 mg/kg daily protein. E: Review progress and confidence (***as needed***) of doing 3 exercise sessions each week, may adjust exercise intensity but never reduce or increase number of sessions per week														

Note: the italicized, bolded text and grey cells are recommendations that reflect participant feedback.

Abbreviations: AB, Attitude to the Behaviour; BAC, Beliefs about Capabilities; BCC, Beliefs about Consequences; BR, Behavioural Regulation; E, Exercise Program; ECR, Environmental Context and Resources; Em, Emotion; FP, Feedback Processes; G, Goals; GAB, General Attitudes and Beliefs; I, Intentions; Id, Social/Professional Role and Identity; K, Knowledge; M, Motivations; Me, Memory, Attention and Decision Processes; MoA, Mechanism(s) of Action; N, Nutrition Program; R, Reinforcement; S, Skills; SI, Social Influences; Sim, Social Image; SL, Social Learning/Imitations; SN, Subjective Norms.

The coloured cells indicate which of the COM-B constructs have been addressed by the behaviour change taxonomy (column 1). The yellow cells should in fact be the same shade of gray as the other cells.

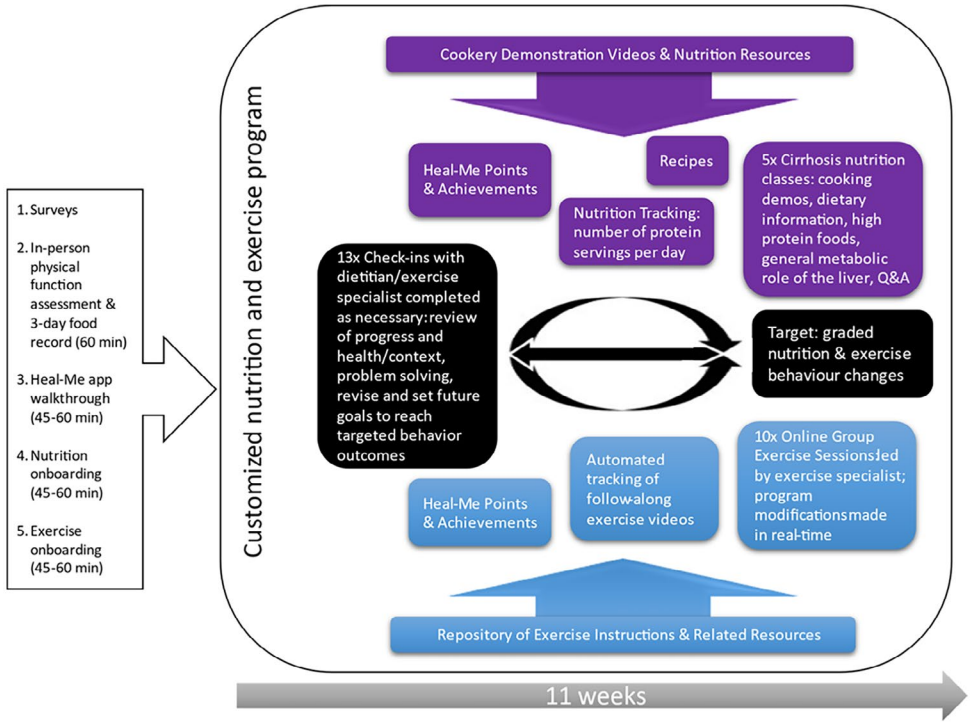

FIGURE 1 Logic model of Heal-Me Cirrhosis.

General health and cirrhosis-related data was abstracted from the participants' electronic medical records. Demographic and socioeconomic surveys were completed as part of the parent trial. To characterize the population, the proficiency for the technology device the participant used most frequently was measured: computer (CPQ) or smart device (MDPQ) (Boot et al., 2015; Roque & Boot, 2018). The EncephalApp Stroop (Bajaj et al., 2015) was used to detect covert HE at baseline. The measures for the liver frailty index (LFI) were completed by exercise specialist and interpreted using the online calculator at https://liverfrailtyindex.ucsf.edu/ (robust, LFI <3.2; pre-frail, LFI 3.2 to <4.5; frail, LFI ≥4.5) (Lai et al., 2017). Quality of life was assessed using the CLDQ (Younossi et al., 1999), EQ-5D-5L and EQ-VAS (Herdman et al., 2011). Adherence to the Heal-Me cirrhosis intervention was defined for each activity as ≥70% completed ≥75% of group nutrition and exercise classes, protein entry and follow-along exercise videos.

Data analysis

For the interview data, a coding framework reflecting the COM-B model and theoretical domains framework (TDF) components was created a priori in NVivo, version 12 (QSR International Inc., USA) to guide the directed content analysis (Assarroudi et al., 2018; Graneheim et al., 2017). As needed, new codes were developed inductively to reflect categories and subcategories which otherwise could not be coded. Coding was initially performed by K.P.I. and reviewed by J.C.S. and P.T. until consensus was reached. J.C.S. and M.L.M. provided guidance on behaviour and frailty, respectively. Representative exemplary statements for each code were selected by K.P.I., J.C.S. and P.T.

Quantitative data from surveys, assessments and medical records were collected using REDCap (Harris et al., 2009). Descriptive statistics (e.g., mean values, standard deviations [SD] and frequencies) were used to characterize the study participants (SPSS, v24 by IBM Corporation, USA).

RESULTS

Participant characteristics

Twenty participants and 3 care partners, all female spouses, were interviewed (Table 2). Three participants declined due to scheduling conflicts or health issues. Interviews were conducted when planned except for 3 delays where the participants had unrelated health complications.

Three participants had a history of hepatic encephalopathy of which 2 were on lactulose or rifaximin during the study. The most common morbidities other than cirrhosis were arthritis ($n = 10$), hypertension ($n = 10$) and diabetes ($n = 9$). The baseline LFI scores were robust = 2, pre-frail = 16 and frail = 2; 5 participants fell at least once in the past year. The CLDQ, scored on a Likert scale from 0 to 7 (best quality of life), had a mean score of 4.5 suggesting a poor quality of life. This was consistent with the Child-Pugh and MELD-Na scores indicating one-year survival rates of 80%–100%. Three people were meeting their recommended daily protein intake according to the 3-day food records. No participants met the guideline-based exercise recommendations of 150 min of aerobic exercise and 2 days of resistance training per week (Lai, Tandon, et al., 2021). The proportion of participants' EQ-5D-5L health-related quality of life measures ranging from 'moderate' to 'severe' for mobility, pain and discomfort and anxiety or depression were 6 (30%), 10 (50%) and 5 (25%), respectively.

Ten participants were employed, of which 9 worked full-time. Annual household incomes were above $70,000 for 14 participants. The 3 people with the lowest (<60%) digital proficiency scores successfully completed the online app training session and remarked it was easy to use. While the participants were diverse with respect to living arrangements, employment, ages, technology proficiency and household incomes, data saturation was reached with no new codes or categories created after 14 interviews.

Participants' perspectives

Interview data were mapped to every domain in the COM-B model and TDF and there were no coding conflicts between K.P.I., J.C.S. and P.T. Following data interrogation, no patterns or trends were found between participant characteristics and experiences. All participants remarked they derived benefit from the program for their cirrhosis self-management (Table 3) although not everyone fulfilled the adherence criteria. By week 6, adherence rates for the 20 people were: group classes—nutrition 90% and exercise 75%; protein entry 55%; follow along exercise videos, 40%. All participants successfully used the app independently based upon the variety of activities they completed. Common reasons for non-adherence were work-related time pressures or unexpected health events. Participant #7 thought it was very positive they never 'felt pressured' or 'made to feel guilty' if they missed a group session. Influencing adherence was that only one participant did not require tailoring of their nutrition or exercise program. Even by week 4, adjustments were still being made by the trainers.

COM-B and TDF outcomes (Table 4)

Capability—Physical

The nutrition and exercise components (i.e., diet, goals, exercise videos and 1-to-1 check ins with dietitians and exercise specialists) accommodated the broad range of dietary issues faced by participants with cirrhosis, such diabetes, nausea and loss of appetite ('*I can eat… I just have no appetite*'. *Participant #17*) and physical needs, such as arthritis or mobility limitations ('[*The trainer*] *will change the exercises in place of the ones that I can't do, that do the same thing, but on a very light scale kind of thing*'. *Participant #10*). Some

TABLE 2 Participant characteristics ($n = 20$) at baseline.

Characteristics	Mean (SD)
Age (years)	60.4 (11.4), range: 30–79
Female sex (*n*)	8 (40%)
Cirrhosis aetiology (*n*)	
• NAFLD	12 (60%)
• Alcohol related	5 (25%)
• Autoimmune hepatitis	1 (5%)
• Primary biliary cholangitis	1 (5%)
• Hepatitis C	1 (5%)
MELD-Na	9.0 (2.0)
Child-Pugh A:B (*n*)	13 (65%):7 (35%)
Listed for liver transplant, yes (*n*)	2 (10%)
Ascites history, yes (*n*)	6 (30%)
HCC, yes (*n*)	2 (10%)
CHE, yes (*n*)	9 (45%)
Liver Frailty Index	3.9 (.5), range: 3.1–4.9
EQ-5D VAS	66.7% (18.9)
CLDQ	4.5 (1.2)
Device proficiency (CPQ or MDPQ)	85.7% (18.8), range: 45%–100%
Post-secondary schooling, yes (*n*)	12 (60%)
Employed, yes (*n*)	10 (50%)
Living with another person, yes (*n*)	16 (80%)

Abbreviations: CHE, covert hepatic encephalopathy measured with the EncephalApp Stroop test; CLDQ, chronic liver disease questionnaire; CPQ, Computer Proficiency Questionnaire; HCC, hepatocellular carcinoma; MDPQ, Mobile Device Proficiency Questionnaire; MELD-Na, model for end-stage liver disease adjusted for sodium; NAFLD, non-alcoholic fatty liver disease; VAS, visual analog scale.

TABLE 3 Participants' feedback to the Heal-Me Cirrhosis nutrition and exercise program.

'I think it's colourful and interactive. It definitely opens your eyes up to have someone weekly checking in with you to ask how are you doing and what can you do to increase it. So, it was really easy [to follow] once I got into a routine with it. I think it's really great to get people involved. I really like the biweekly draw'. *Participant #4*
'It is an easy [to use] program'. *Participant #10*
'Yes, I enjoy it. It builds me up, yes it does'. *Participant #15*
'I think, overall, it's quite a good program. I find it quite beneficial. I learned a lot from it'. *Participant #8*
'I definitely think I've been more immersed in the nutrition aspect of it. I think it has definitely been more beneficial for me. Especially now… understanding more about cirrhosis than I did before'. *Participant #17*
'I really think it's very well done. All the other things just make it work… it's a bit of variety!' *Participant #12*
'Kind of an awareness, kind of knowing what's going on, where you need to go with it [cirrhosis self-management]'. *Participant #9*
'I have all the support you know, and I talk with people, and I'm not alone'. *Participant #13*
'This program is a "good thing"'. *Participant #16*
'I don't know exactly what I was expecting coming into it, but I'm not disappointed so that's a good thing. The app, it's very easy to use, so that's good'. *Participant #1*
'I'm grateful for the fact that things [cirrhosis nutrition and exercise] are explained better than what I've gotten before'. *Participant #3*
'I think a group setting is helpful and when you're not face to face with people it's just that much easier. It's not that I'm anti-social or anti-people. It's just more comfortable when you can do it in your own setting'. *Participant #17*
'Because it's an organized class, it gives me some accountability'. *Participant 3*

TABLE 4 COM-B and TDF facilitators and barriers for Heal-Me Cirrhosis.

COM-B	TDF	Learnings
Capability-Physical	Skills/Abilities	Modify baseline data collection tools to improve initial customization of programming. Offer 2 nutrition check-ins during the first 5 weeks to improve customization.
Capability-Psychology	Knowledge	Include a group education class about the relationship between exercise, cirrhosis, frailty, ageing and health outcomes Have trainer-led informal discussions to foster group cohesion and social interaction. Prevent unwanted outcomes by proactively addressing them as part of the program (e.g., unwanted weight gain)
	Behavioural Regulation	Offer shorter but more frequent exercise sessions cued to daily activity (e.g., toothbrushing) to promote routine. Send reminders via the app for time-sensitive activities. Increase the frequency of online group exercise classes recognizing the independent activity change is difficult
	Memory, attention and decision	Exercise and nutrition online programming is accessible independent of hepatic encephalopathy. Make data entry simple to do in real-time to prevent errors or data loss
Opportunity-Physical	Environment, context and resources	Simple to use data entry and navigation is critical to app use. Be aware that education specific to other morbidities and cirrhosis complications may be needed. Frontload trainer check-ins to customize programs. Offer program variety (e.g., exercise sessions of various durations and frequencies)
Opportunity-Social	Social Influence	Provide regular, safe opportunities for participants to interact
Motivation-Automatic	Emotion/Reinforcement	Include non-serious gamification elements to promote app use. Capture participant emotions or feelings in relation to an app activity to form positive emotions about a healthy behaviour. Share relative progress meters Include real-time progress indicators to help participants reach goals
Motivation-Reflective	Intentions, Optimism Beliefs about capabilities	Tailor the program to address the motivations for participation (e.g., increased strength, fall prevention, weight loss) Share program successes with new participants Regardless of aetiology, find a common reference for all participants, such as ageing and its relation to frailty

participants saw their nutrition program as 'impossible goals' that they could not reach for reasons such as symptoms (e.g., fatigue, nausea and early satiety) or external demands on their personal schedules. In the first 4 weeks, unrelated health events required modifications to the exercise program for several participants ('*When I had my back injury* [*study week 3*], *I went down to Level One exercises which were much easier*'. *Participant #8*). Despite program adjustments, a few participants desired even more tailoring: '*I don't like to push and ask for more modifications. It just seems like I'm asking for too much*'. *Participant #17.*

Capability—Knowledge

Understanding the connections between nutrition, the liver's role in digestion and the metabolic changes due to the cirrhotic liver was important and valued: '*Being aware of the amount of protein needed; I don't think I knew that before*'. *Participant #8 and spouse nods head.* Preconceptions of already meeting healthy eating targets

were notable barriers to learning. '*I think our diet is fairly reasonable all considered*'. *Participant #9 and spouse smiles and says yes*. Conversely, less feedback was provided about exercise or acquiring new skills although the participants were informed to assess their perceived exertion and exercise frequency as part of their weekly goals. The comments regarding ease of use of the app and degree of engagement did not vary substantially between participants who tested positive for covert HE at baseline (9/20).

Capability—Behavioural regulation

Several participants experienced unwanted weight gain in the first weeks. '*I found that increasing the protein was leaving little room for fruits and vegetables*, *so I've been consuming more calories*'. *Participant #8*. By increasing daily protein intake, most participants had to rebalance their calories. Several believed this was a potentially avoidable consequence. Some expressed challenges with integrating the exercise videos into their schedules while others '*squeezed in*' the workouts. Overall, adherence to Heal-Me required participants to think ahead and plan their weekly activities (e.g., check ins, classes, individual activities): '*What I am getting out of it*, *is back into a routine again*'. *Participant #6*.

Capability—Memory, attention and decision processes

According to the EncephalApp Stroop test, 9/20 participants had CHE at baseline. While some commented about their memory ('*I'll write it down somewhere. I have the perfect memory. It's right here* [*waves a sheet of paper*]!' *Participant #13*) or attention ('*I'm horrible at recording stuff*'. *Participant #15*), they were still able to use the Heal-Me app for nutrition and exercise and connect to group sessions according to usage data. Tracking protein intake and eating frequency across the day helped participants realize where they could improve: '*I saw many dietitians and they all pushed the high protein*, *but it didn't really stick until I started really tracking it*'. *Participant #4*. Protein tracking was a skill that could be acquired in a short time: '*When I first started*, *I needed the* [protein] *tracking to know. But I'm getting to the point now where I kind of know already before I track it*'. *Participant #8*. During the first 4 weeks, several participants had life events occur including loss of a family member, starting a new job, ER admittance or were hospitalized. Participants temporarily halted the Heal-Me program ('*It is taking all my strength to focus on this* [*life event*] *right now*'. *Participant #20*) and when they resumed (usually 1–2 weeks later), they needed the trainer's expertise to retailor their exercise program.

Opportunity—Environment and resources

By the time of the interview (4–6 weeks), 95% (19/20) attended the live nutrition class and 75% (15/20) attended 3 or more of the 5 group exercise classes. The dietitian/exercise specialist check-ins were unique compared to usual health care services and provided feedback within a reasonable timeframe: '*A dietitian will just tell you*, *but there's no follow-up typically*'. *Participant #4*. Others appreciated the relevance of the program customized to their situation and cirrhosis: '*When I talk to the Trainer*, *it's about the program and how to make it work best for me*'. *Participant #12*. Some indicated the weekly exercise check-ins were too frequent after the third week. All acknowledged that their program time was worthwhile ('*Oh yeah. I know it is*!' *Participant #15*) and estimated they spent 2 to 10 h per week. This exceeded the intended 4 to 5 h. Some commented: '*It's fairly intense*!' *Participant #10*. Most participants constructively mentioned that the protein entry could be improved: '*I have trouble with the app for entering the food… I have gotten a little confused with that*'. *Participant #17*. Two participants at the lower end of the digital technology range had their spouses do the protein tracking for them. All liked the 'at home' convenience of Heal-Me and appreciated that they did not have to be at the clinic or hospital ('*…that place that I hate*'. *Participant #13*).

Opportunity—Social

Seeing other participants, hearing their questions and the polls used in the bimonthly draws fostered camaraderie. '*The sense of community it brings*, *like we're all kind of battling this together*'. *Participant #4*. The visual impact of other participants helped to normalize their situations and challenges and focused their attention on health improvements. '*If I'm keeping up with some of the other participants and the Trainer*, *then I know that I'm doing them* [*the exercises*] *the right way. It's not my own interpretation*'. *Participant #13*.

Motivation—Automatic

Reflex reactions, like self-satisfaction or thrill, were evoked upon receiving an achievement, reviewing answers to the poll questions or winning the $15 coffee card in the biweekly draw. '*Kind of like that little kid feeling when you get a gold star on the wall*'. *Participant #4*. Trainer check ins and group classes created feelings of accountability and responsibility, automatic emotional reactions in response to trainer interactions.

Motivation—Reflective

Each of the five domains (i.e., intentions, beliefs about capabilities and consequences, reinforcement and optimism) were coded. By the study interviews, participants remained motivated with their programs, had good intentions to reach their well-defined goals and were optimistic. Beliefs about their capabilities and consequences were informed by Heal-Me education and experiences. Reinforcement by protein tracking increased dietary awareness sensitizing them to their liver needs complimented with new knowledge from the nutrition classes. Most found the check ins and classes as positive reinforcements: '*Because it's an organized class*, *it gives me some accountability*'. *Participant #3*. Low adherers to the at-home follow along exercise videos had negative comments like: '*I don't like exercising*' *Participant #3* or '*They* [the exercise videos] *are dull. Repetitive*' *Participant #14*. Conversely, other participants focused on the larger picture and thought the scheduling flexibility of when and where they did their exercise videos helped their adherence.

Data that did not fit into the TDF domains were inductively coded: (1) 'access to Heal-Me' with most commenting they would have liked this program within the first 6–12 months after being diagnosed with cirrhosis. '*When I first started seeing this specialist and everything because of the problems I had*, *I was more concerned in just not dying at the moment. So*, *I guess I wasn't looking at the big picture*'. *Participant #1*; (2) 'long-term access'—several believed the Heal-Me program content could help sustain their behaviour change. '*I think the one thing that I'm a little disappointed with this is that we don't get access to the stuff after the study's over*'. *Participant #8*; (3) In response to an interview question (if you had a magic wand how would you improve Heal-Me?) suggestions for future Heal-Me iterations ranged from proposing participant-initiated informal social interactions via an online forum or encouraging participant-to-participant conversations during group classes, offering more group exercise classes each week and enhancing the in-app progress reporting.

DISCUSSION

Feedback from 20 participants and 3 spouses about their early experiences using an online nutrition and exercise program (Heal-Me cirrhosis version 1) used a theoretically focused approach to identify facilitators and barriers to adherence. Nearly half of the participants had covert HE at baseline while 3 others were taking medications for prior overt HE. Those with covert HE fully participated in the interviews for the full duration.

The study population had medical symptoms like those reported in other cirrhosis studies. The EQ-5D-VAS population mean for Albertans (45 to 65 years) was 83, while the study participants had a low

score of 69 (Team, 2020). This discrepancy in quality of life between the general and cirrhosis populations aligns with a previous finding (Cortesi et al., 2020). Protein intake reflected other well described cirrhosis populations. As cirrhosis is a medically complex condition, characterization of this study's participants is consistent with the literature.

Overall, participants were positive about the Heal-Me cirrhosis program. They believed the app was easy to use commenting on its ease of navigation and intuitive design, both of which are key elements known to affect usability and acceptability of mobile apps in older adults (Hsieh et al., 2018; Portz et al., 2018). There were constructive comments about areas that could be redesigned to improve the users' experience, mainly the protein tracking screens. Challenges with daily protein entry were reflected in the low adherence rate of 55%. Monitoring dietary protein intake was beneficial for participants and this feature will be improved.

Group sessions had the highest attendance rates with nutrition classes being the most popular. Participants were keen to visually connect with one another and with the weekly polls, this helped to foster a sense of community. Despite being scheduled during working hours, these classes were prioritized while the more flexible, yet independent follow along videos had low adherence rates. During the group sessions, participants valued the 'new' cirrhosis-specific nutrition information and the opportunity to ask questions. Similarly, in a cardiac rehabilitation program, participants expressed the need for relevant nutrition and health information ($n = 26$) (Elnaggar et al., 2021), showcasing how knowledge acquisition can motivate behaviour change. In the current study, few questions were asked about exercise, but there was no formal exercise education component which may have been a missed opportunity. For instance, in a coronary artery disease population ($n = 492$), the greatest improvement in functional walking capacity, controlled risk factors and morbidity reduction was in the exercise + education arm relative to the exercise only and usual care (Hu et al., 2021).

Tailoring the nutrition and exercise programs by the dietitian and exercise specialist, respectively, was frequently required. Despite baseline measures to inform programming, subsequent tailoring was needed for all except one participant to accommodate their preferences, health needs and environmental pressures. Regular engagement with a health care practitioner is known to be more effective for behaviour change than usual care (Greene et al., 2016). Similarly, in the EL-FIT cirrhosis study, participants receiving enhanced care from health care practitioners improved outcomes (Duarte-Rojo et al., 2021). Several participants, including the two who later dropped out, perceived the program tailoring to be overly cautious. Prescribing resistance training is challenging as a recent study reported that even experienced resistance-trained persons underestimate the exercise intensity during a training session (Dos Santos et al., 2022).

The constructs of modelling and social influence affected motivation and acceptance of programming in our study. Here, the participants were committed to attending group classes and were motivated to engage in exercise by seeing participants, like themselves, and trainers during group classes. In previous trials, participants have requested the functionality to interact with other study members, such as social forums or direct messaging (Duarte-Rojo et al., 2021; Elnaggar et al., 2021). The corollary of this is the potential importance of visual context on motivation. For instance, in a cirrhosis randomized controlled trial ($n = 80$), participants were to use the 'Strong for Life' exercise videos in their homes as part of the intervention. This video series featured older adults (>60 years) in what looked to be a seniors' residence performing light exercises. The videos may not have resonated with the cirrhosis participants who were younger (median age, 62 years, IQR: 56, 66) and could have contributed to the low (14%) video adherence rates (Lai, Dodge, et al., 2021). In the current study, exercise videos intentionally included participants of various ages and genders to make them more relatable to others living with cirrhosis.

COM-B and TDF

Facilitators and barriers to early participant engagement with Heal-Me cirrhosis were identified using COM-B and TDF. While data were coded to each of the domains and recommendations, the three most valuable takeaways pertain to the domains of capability-physical (e.g., program tailoring),

opportunity-social influence (e.g., modelling and interactions) and capability-knowledge (e.g., having relevant information). By designing a behaviour change intervention based on COM-B and BCTs, this facilitates its subsequent assessment at any time in the research trajectory. Furthermore, assessment outcomes are readily associated with intervention components that merit further refinement or development in a transparent manner.

In response to the findings, 2 BCTs were expanded in scope and 4 others were added. Problem solving was the most compelling BCT for early engagement in this group of individuals. For comparison, in a systematic review of 19 articles from 9 trials categorized 3 BCTs as potentially promising to improve physical activity behaviours in people with dementia (mean age, 79.7; mean intervention duration: 5 months; range: 2 to 12 months): 1.1 goal setting, 3.1 social support and 9.1 credibility of source material (Nyman et al., 2018). In a review of 11 randomized controlled trials that focused on improving physical activity and nutrition in breast cancer survivors, each trial included the 2.3 self-monitoring BCT albeit in a variety of formats (e.g., step counts, weight records) (Perperidi et al., 2023). The trials used a range of 10 to 23 BCTs and higher numbers were associated with improved outcomes. It should be noted that all trials lasted at least 16 weeks (mean: 26 weeks). While the current study used 17 BCTs with intention to expand 2 and include 4 new ones, this total (i.e., 21) was not outside the range reported (Perperidi et al., 2023). It is likely that BCTs specific to different phases of a program provide different utility regarding behaviour change and adherence and current findings indicates the potential value of including problem solving at study initiation to make the program relevant for each participant.

The app health industry has been successful in incorporating user feedback to drive app uptake and micro transactions in the short term (Duffy et al., 2021). Conversely, health care app research needs to focus on extending the window where participants routinely engage with the app in the immediate- to long-term periods to achieve health behaviour changes and improved health outcomes. This requires theory-informed intervention design and iterative evaluation in a robust research framework for which the COM-B was found to be well suited.

Study strengths

The care partners corroborated the participants' comments and their presence was valued by the participants. Participant characteristics were consistent with other cirrhosis populations regarding symptoms, quality of life, physical performance and technology proficiencies. Limited transferability of study findings to other cirrhosis populations may be possible based on these characteristics. The focus on early experiences with the intervention was novel as it identified the value of proactive engagement with participants. Early interactions enabled the team to identify and implement program adaptations satisfactory and relevant to the participants which, in turn, minimized potential issues with adherence and retention. The qualitative approach allowed participants to express their experiences and feelings which explained how they interacted with the intervention; something which is challenging to 'quantify'.

Limitations

There were 23 eligible individuals for enrolment from the parent study, yet only 20 participants (and 3 care partners) were interviewed for this nested study. Another limitation pertained to scheduling online group classes during business hours due to study team availability and wanting a critical mass (at least 5 people) for the sessions. Adherence to group sessions may have increased if more sessions at different times and days were offered. Recruitment of participants with high-speed internet prevented rural residents participating thereby limiting the generalizability of outcomes further. Issues pertaining to the usability of the Heal-Me program were documented, largely around the number of clicks required for protein tracking. The time commitment required each week was more intensive than anticipated for some. A slower, staged introduction to the intervention may be beneficial in future work.

In conclusion, this qualitative study provides a unique behaviourally focused lens on the early beliefs of participants participating in an online nutrition and exercise-based intervention. The three key items that influenced participant retention and adherence during the first 4–6 weeks of the intervention were participant-centred: responsive tailoring of the program to meet the participant's needs and expectations (environmental context), regular engagement between participants and trainers and other participants (social influence, behavioural regulation) and increased awareness of nutrition in cirrhosis (knowledge-psychology). Semi-supervised online interventions were relevant and may be the preferred mode of delivery of scalable wellness programs in chronic disease. Subsequent online self-management programs should build upon these findings to improve early acceptance and adoption as they relate to improved adherence throughout the interventional period.

AUTHOR CONTRIBUTIONS

Kathleen P. Ismond: Conceptualization; investigation; writing – original draft; methodology; visualization; writing – review and editing; formal analysis; data curation. **Margaret L. McNeely:** Methodology; supervision; resources; writing – review and editing. **John C. Spence:** Methodology; writing – review and editing; investigation. **Jude A. Spiers:** Investigation; writing – review and editing; methodology; validation; formal analysis; data curation; supervision. **Puneeta Tandon:** Supervision; data curation; resources; formal analysis; conceptualization; investigation; funding acquisition; methodology; validation; visualization; writing – review and editing.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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