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Is home-based, virtually delivered, group exercise feasible and acceptable for older patients with hepatocellular carcinoma? A non-randomised feasibility study (TELEX-Liver Cancer)

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ABSTRACT

Objectives The study aimed to assess the feasibility, acceptability and safety of delivering a home-based telehealth exercise intervention to older patients with hepatocellular carcinoma (HCC).

Design Non-randomised feasibility study.

Setting Patients were recruited from UK outpatient liver cancer clinics.

Participants Patients were aged ≥60 years with HCC, with post-treatment imaging reporting a complete response, partial response or stable disease.

Intervention and data collection Patients were invited to attend synchronous online exercise sessions, twice weekly for 10 weeks. Physical function and patient-reported outcomes were assessed pre-intervention and post-intervention. Qualitative data were collected via semistructured interviews after intervention completion.

Primary outcome measures Recruitment, retention, exercise adherence and safety.

Results 40 patients were invited to participate and 19 (mean age 74 years) provided consent (recruitment rate 48%). Patients completed 76% of planned exercise sessions and 79% returned to the clinic for follow-up. Hand grip strength (95% CI 1.0 to 5.6), Liver Frailty Index (95% CI −0.46 to −0.23) and time taken to perform five sit-to-stands (95% CI −3.2 to −1.2) improved from pre-intervention to post-intervention. Patients reported that concerns they had relating to their cancer had improved following the intervention (95% CI 0.30 to 5.85). No adverse events occurred during exercise sessions. Qualitative data highlighted the importance of an instructor in real time to ensure that the sessions were achievable, tailored and well balanced, which helped to foster motivation and commitment within the group. Patients reported enjoying the exercise intervention, including the benefits of peer support and highlighted perceived benefits to both their physical and mental health. Patients felt that the online sessions overcame some of the barriers to exercise participation and preferred attending virtual sessions over face-to-face classes.

Conclusions It is feasible, acceptable and safe to deliver supervised group exercise via videoconferencing to patients with HCC in their own homes. These findings will inform the design of a future, adequately powered randomised controlled trial to evaluate the efficacy of the intervention.

Trial registration number ISRCTN14411809.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ A strength of this study was the ability to engage a medically complex patient group who all had age-related comorbidities with an online exercise intervention.
⇒ A limitation of the study is the small sample size and lack of a non-exercise control group.
⇒ Findings from this feasibility study will be incorporated into the design of a larger scale evaluation to assess the clinical and cost-effectiveness of telehealth exercise on progression-free and overall survival in patients treated for hepatocellular carcinoma.

INTRODUCTION

Hepatocellular carcinoma (HCC) is the most common type of primary liver cancer and is in the top-five causes of cancer death in 90 countries.[1] This reflects the high incidence of HCC (seventh most common cancer globally)[2] and poor survival, with a 5-year survival rate of less than 15%.[3] Most common cancers have seen declining mortality rates over the past two decades due to improvements in early detection and treatment,[4] however, deaths from HCC are rising.[5]

HCC is generally diagnosed at an advanced stage and most patients are over 70 years old with age-related comorbidities.[6 7] Many patients with HCC experience undesirable symptoms, including pain and fatigue,[8] which impact negatively on their day-to-day functional ability and thus overall quality of life (QoL).[9] Most patients (up to 80%) are

ineligible for curative-intent treatment due to advanced disease, poor liver function and/or low physical fitness.[10] Consequently, maintaining QoL through symptom management is vitally important for patients with HCC and is often a key objective of clinical care.[11]

Exercise can improve QoL, fatigue, physical function, and symptoms of anxiety and depression in people diagnosed with cancer.[12] Supervision of exercise has been shown to be more effective than unsupervised programmes.[12] However, there are many barriers to implementing supervised exercise programmes within the clinical setting for patients with cancer. These include a lack of resources and infrastructure within healthcare systems (eg, absence of appropriately trained staff and exercise facilities) and personal barriers for patients (eg, travel distances and a lack of access to appropriate facilities),[13–15] leading to the majority of patients with cancer citing a preference for home-based exercise.[16–19] Cancer survivors also report wanting more guidance on the type, frequency, intensity and duration of exercise they can safely undertake.[20]

'Telehealth exercise' allows patients to exercise at home under the 'virtual' supervision of an exercise instructor. The instructor guides patients through the exercises in real time, mimicking the delivery of traditional facility-based training without the need for travel or access to facilities.[21] Telehealth exercise can be delivered in groups, potentially providing a peer-supportive environment and increasing the number of patients who can be included in each session. Thus, there is potential for telehealth exercise to optimise the health-related benefits of exercise through expert supervision while also circumventing common barriers to exercise and meeting the preferences of cancer survivors.[22]

Despite the potential of telehealth exercise, there are uncertainties regarding its feasibility and acceptability in older people diagnosed with HCC. Recent studies have demonstrated that telehealth exercise is safe and feasible in younger populations living with cancer (mean age range: 52–67 years), such as breast cancer,[23 24] advanced melanoma,[25] haematological malignancy[26] and mixed cancer types,[27–29] as well as community-dwelling older adults without cancer.[30 31] However, no studies have used telehealth exercise to support the delivery of home-based exercise for older patients with HCC, who are a complex patient group, typically presenting with frailty syndrome, poor liver function, metabolic syndrome and other medical comorbidities requiring intensive medical management.[32–34]

Therefore, this study aims to assess the feasibility, acceptability and safety of delivering a 10-week telehealth exercise intervention to older patients with HCC.[35] We also aimed to collect preliminary evidence for the efficacy of telehealth exercise for improving physical function and patient-reported outcome measures (PROMS) in patients with HCC to inform the design of a subsequent, adequately powered randomised controlled trial. Criteria for the success of the study were defined a priori based on a systematic review of recruitment, retention and exercise adherence rates in patients with advanced cancer.[36]

METHODS

Study design

This study used a prospective, single-arm, pretest–post test trial design. Patients enrolled on the study received standard National Health Service (NHS) care for HCC plus a 10-week, home-based, virtually delivered, group exercise intervention. The detailed trial protocol has been published.[22]

Participants and recruitment

Patients with HCC were recruited from outpatient liver cancer clinics at The Newcastle upon Tyne Hospitals NHS Foundation Trust (NuTH) from November 2021 to July 2022. Inclusion criteria were aged ≥60 years; clinical diagnosis of HCC and having undergone NHS standard treatment; post-treatment imaging reporting a complete response, partial response or stable disease; undergoing routine outpatient imaging at NuTH every 3–6 months, WHO performance status of 0 or 1; Childs-Pugh of B7 or lower (ie, preserved liver function); minimum life expectancy of 6 months. Main exclusion criteria were uncontrolled cardiovascular or metabolic disease; dyspnoea at rest or with mild exertion; severe hypertension (≥180/100 mm Hg at rest) or tachycardia (≥100 bpm); physical impairment that could be exacerbated with exercise; inability to follow verbal or written instructions in English.

The treating physician screened for eligible patients by reviewing post-treatment imaging reports and medical records. Those that met the eligibility criteria were sent a study invitation letter and information sheet ahead of their standard care follow-up appointment. The study was discussed with eligible patients after they had received standard NHS care and those interested in taking part were provided with more verbal information at the clinic by a member of the research team. The research team member then obtained written informed consent and initiated baseline data collection.

Baseline data collection

Height, weight and resting blood pressure were measured in the clinic as per standard clinical care. Clinical information was extracted from medical records (including date of diagnosis; treatment received; radiological response to treatment; comorbidities; medications) and sociodemographic data were collected.

Outcomes

The primary outcome was the feasibility of the exercise intervention, study procedures and data collection. Pre- and post-intervention measures of physical function and mid-upper arm circumference were collected during standard care visits to the outpatient clinic. Questionnaires and an accelerometer (for measurement of physical

activity) were given to patients in the clinic to take home and return by post in prepaid envelopes. Acceptability of the intervention was assessed using a mixed-methods approach via monthly online surveys and an exit telephone interview.

Feasibility

Recruitment rate

We recorded the proportion of eligible patients who were approached in the clinic and gave consent to participate, as well as the reasons for declining to participate.

Retention rate

We recorded the proportion of patients who provided consent and completed in-person assessments in the outpatient clinic at both baseline and 10-week follow-up.

Intervention adherence

We recorded the proportion of exercise sessions attended by patients, and the proportion of exercise sessions completed at or above the desired level of intensity.

Intervention fidelity

A research team member (not involved in intervention delivery) attending a random sample (~10%) of exercise sessions assessed intervention fidelity using a standardised checklist (see online supplemental file 1 for fidelity checklist).

Safety

Reporting of serious and non-serious adverse events was conducted in line with the study sponsor's policy on adverse event reporting for non-clinical trials of investigational medicinal products.

Acceptability

We distributed brief online surveys to patients each month via Google forms (Google, Mountain View, California, USA). Survey items related to satisfaction with the technology and exercise sessions. The survey questions are available in online supplemental file 2.

Acceptability was also assessed qualitatively with in-depth, semi-structured, one-to-one exit interviews. The interviews were conducted by a member of the research team (MCB) not involved in intervention delivery via telephone. Topics focused on patients' experience and perceived benefits of taking part, and barriers and facilitators to undertaking the intervention (see online supplemental file 3 for topic guide). The topic guide was used flexibly to allow patients to raise additional issues which they considered important to the study.

Physical function

Physical function was assessed with the Short Physical Performance Battery (SPPB)[37] and the Liver Frailty Index (LFI).[38] The SPPB is a composite measure of balance, chair stands and gait speed—higher scores in the SPPB reflect better physical function. LFI can be used to identify frailty in patients with liver disease (frail LFI≥4.4; prefrail LFI 3.2–4.3; robust LFI<3.2)[39] and is a composite measure of hand grip strength, chair stands and balance—lower scores in the LFI reflect better physical function. Detailed descriptions of the methods used to measure hand grip strength, chair stands, balance, 4m gait speed and mid-upper arm circumference can be found in the protocol.[22]

Device-measured physical activity

Physical activity was measured using a wrist-worn accelerometer (ActiGraph GT9X Linkm, ActiGraph Pensacola, Florida, USA) worn for 7 days at baseline and following the intervention. Data were considered valid if participants wore the accelerometer for at least 8 hours on at least 4 days at each time point. Daily total activity counts, steps, time spent sedentary, and time spent in light, moderate, and vigorous activity were recorded. Freedson thresholds based on metabolic equivalents were used to demarcate the intensity of physical activity.[40 41]

Patient-reported outcome measures

The Functional Assessment of Cancer Therapy-Hepatobiliary (FACT-Hep) total score was used to measure disease-specific QoL[42] and covers domains relating to physical well-being (PWB subscale), social/family well-being (SWB subscale), emotional well-being (EWB subscale), functional well-being (FWB subscale) and additional concerns related to their cancer (hepatobiliary cancer subscale (HCS)). Fatigue was measured with the Functional Assessment of Chronic Illness Therapy-Fatigue (FACIT-F) total score.[43] The Activities-Specific Balance Confidence Scale (ABC Scale) total score was used to assess fear of falls and confidence in their own mobility assessed via the Falls Efficacy Scale (FES).[44] Symptoms of anxiety and depression were assessed via the Hospital Anxiety and Depression Scale (HADS) total subscale scores for anxiety and depression.[45] Self-reported physical activity was assessed with the Godin Leisure-Time Exercise Questionnaire using the total leisure activity score.[46]

Intervention

After baseline data were collected in the clinic, a research team member familiarised patients with the study exercises, videoconferencing software (Zoom Video Communications, California, USA) and the Borg 10-point rating of perceived exertion (RPE) scale. Patients received an intervention pack comprising an exercise diary, RPE scale, incremental level resistance bands (TheraBand, Ohio, USA), pedal exerciser (NRS Healthcare, Leicestershire, UK) and a pedometer (HiTRAX WALK, TFA Dostmann, Germany). Those without internet access or an internet-enabled device were loaned a tablet (Samsung Galaxy Tab A7 10.4" 4G tablet) preloaded with the Zoom app and unlimited 4G data. We asked patients to use their exercise diary to record steps (using the pedometer) as well as the type, duration and intensity (based on RPE) of exercise completed each day. Patients were offered a one-to-one introductory online session prior to joining the exercise

class which allowed the researcher to inspect the location of the exercise area in the patient's home, resolve any technical issues and ask the patient to practice a sample of the exercises, reinforcing the use of RPE to help guide exercise intensity. Patients who expressed concern over their ability to exercise safely at home or how to connect to the internet/access Zoom were offered a home visit.

Patients were invited to take part in two synchronous online exercise sessions per week for 10 weeks at home. The exercise sessions were delivered in real time via Zoom by an NHS-employed physiotherapist (KH or RF-B) or qualified exercise professional (MVM) (National Vocational Qualification Level 3). A maximum of 10 patients took part in the exercise at any one time to ensure adequate safety monitoring and provision of individualised feedback, including the correction of exercises as necessary. Each session lasted ~45 min and involved (1) 10 min dynamic warm-up comprising seated pedalling and joint mobility exercises, (2) 30 min of aerobic and resistance exercises focusing on multijoint movements recruiting major muscle groups in the upper and lower body; (3) and a 5 min cool-down of static stretching. Patients performed two sets of four aerobic exercises followed by two sets of four resistance exercises in a circuit-like manner, with each exercise performed for 60 s interspersed with short rest periods (~30–45 s) allowing the patient to ready themselves for the next exercise in the sequence. An example exercise session plan is provided in the protocol.[22]

Some patients performed exercises in a standing position while others performed chair-based exercises. This decision was based on the functional ability of the patient at baseline[22] and was reviewed on an ongoing basis as the patient progressed through the programme using patient feedback (including RPE) and observation of their functional ability during the classes. At the end of the 10-week intervention, patients were allowed to keep the exercise equipment (pedal exercisers, resistance bands) and were encouraged to continue the programme independently. Patients were asked to return the tablets.

Data and statistical analysis

Quantitative data analysis

Descriptive statistics are used to present baseline characteristics, feasibility outcomes and acceptability survey responses. A paired t-test was used to evaluate changes in outcomes from baseline to post-intervention, with the mean change and 95% CI presented. Data have been analysed using IBM SPSS V.28 (IBM).

Qualitative data analysis

Interviews were audio recorded, transcribed verbatim and analysed using reflexive thematic analysis.[47 48] All anonymised transcripts were coded independently by one research team member (MCB), with a proportion (~85%) independently coded by a second team member (KH). Throughout the process, the two researchers worked collaboratively to discuss, refine and agree on final themes and subthemes using NVivo qualitative data analysis software (Release V.1.6.1).

Patient and public involvement

We actively involved patients at key stages of this project.

Study conception

The concept of the study arose from routine interactions with patients in liver cancer clinics. Patients consistently said they wanted information and support to exercise because it is one of the few things about their prognosis that they are able to control and gave them some perceived ownership of their outcome.

Feedback on our initial idea

We shared an outline of our proposal with the national patient support group, LiverNorth. Their members unanimously agreed that patients with liver cancer would embrace the opportunity to take part in online exercise sessions with other like-minded patients, particularly because of the COVID-19 pandemic, which had made many feels even more isolated.

Codesign of a prototype intervention

We convened a multidisciplinary steering group that included a patient representative. This group met online to codesign the intervention based on the best available evidence, logistical concerns, safety and ways to support adherence. We also had in-depth telephone discussions with five patients currently living with HCC (two receiving supportive care and three receiving active treatment). They expressed their views on various aspects of the intervention, such as by requesting that the online exercise be delivered 'live' in a 'group format' so they could 'follow the instructor' and supervise equipment/technique if needed. Wherever feasible, their preferences were incorporated into the research design.

Feedback on prototype intervention

Following the codesign process, we held an online focus group with patients living with cancer to gather their feedback on the prototype intervention (perspectives; https://www.sbru.org/ppi). Their feedback led to minor modifications to the protocol.

RESULTS

Baseline characteristics

19 patients provided consent and were recruited into the study (see table 1) between November 2021 and September 2022. 18 (95%) patients were male, and mean age was 74±3 years (range: 69–80 years). The mean length of time since diagnosis was 22±17 months and mean time post-treatment was 11±9 months. 15 (79%) patients received transarterial chemoembolisation, 11 (58%) ablation, 4 (21%) selective internal radiation therapy, 1 (5%) liver transplant and 1 (5%) resection. 15 (79%) patients received more than one treatment. All patients had additional long-term comorbidities (as documented in their

Table 1 Patient characteristics at baseline (n=19)

	Mean (SD) or number (%)
Age (years)	74.3 (3.2)
Sex (n) male/female	18/1
White British (%)	100
Highest level of education	
High school	42%
College	26%
Undergraduate degree	5%
Postgraduate degree	16%
Professional qualification	11%
Current employment status	
Retired	95%
Self-employed	5%
IMD (mean)	5.9 (3.0)
IMD (quintiles)	
1	4 (21%)
2	4 (21%)
3	2 (11%)
4	4 (21%)
5	5 (26%)
IMDR	17916 (9797)
Distance from treating hospital (miles)	26.0 (19.4)
Time since diagnosis (months)	22.15 (16.68)
Time since last treatment (months)	10.71 (8.84)
Response to treatment	
Complete response clear scan	9 (47%)
Complete response with area to watch	5 (26%)
Partial Response watch and wait	5 (26%)
Patients with long-term comorbidities	19 (100%)
Patients with chronic musculoskeletal conditions	17 (89%)
Patients with CVD	13 (68%)
Patients with T2DM	8 (42%)
LFI	4.4 (0.8)
Frail (≥4.4)	7 (37%)
Pre-frail (3.2–4.3)	12 (63%)
Robust (<3.2)	0 (0%)
Weight (kg)	87.75 (13.55)
Height (m)	1.74 (6.01)
BMI (kg/m^2)	29.06 (3.85)
Blood pressure	
Systolic (mm Hg)	147 (21)
Diastolic (mm Hg)	73 (11)

BMI, body mass index; CVD, cardiovascular disease; IMD, Index of Multiple Deprivation; IMDR, IMD Rank; LFI, Liver Frailty Index; T2DM, type 2 diabetes mellitus.

medical records) and 18 (95%) of patients were taking ≥2 prescribed medications (mean 6±4; range: 0–14 different medications).

Patients lived in areas across all levels of deprivation according to Index of Multiple Deprivation (table 1). The mean distance for patients to travel to the treating hospital was 26 miles (range: 4–67 miles), highlighting the large catchment area for the tertiary centre.

Feasibility

Recruitment rate

Of the 40 patients approached in the clinic to take part in this study, 19 (48%) consented to enrol. Reasons for eligible patients declining to participate in the study are listed in figure 1 and include patients being too busy to take part and patients not being keen on using the internet to access exercise classes. Figure 1 presents the patient flow through the study.

Retention

15 (79%) patients completed the intervention and returned to the clinic for in-person follow-up assessment. Of these 15, 14 (93%) completed and returned the FACT-Hep questionnaire.

Out of the four patients who did not complete follow-up assessments, three did not start the exercise intervention after consenting to take part in the study and one patient dropped out mid-way through the intervention due to repeated technical/internet difficulties accessing the virtual exercise sessions.

Intervention adherence

Patients completed 76%±13% (range: 50%–96%) of planned exercise sessions. Reasons for non-adherence to the exercise intervention were mostly due to unrelated illnesses, prearranged medical appointments or holidays. All participants reported an RPE of 3 or above during the exercise sessions (range: 3–9 RPE), demonstrating that the intended minimum exercise intensity was feasible.

Intervention fidelity

17 separate exercise sessions were observed, and the intervention was consistently delivered with high fidelity. Only two minor deviations from the protocol were noted, which were holding static stretches for less than the desired length of time (20s), which happened on two occasions.

Safety

There were no adverse events reported as a result of taking part in the exercise intervention or study procedures.

Acceptability

We received a total of 26 responses to the monthly online survey. Over 75% of respondents agreed or strongly agreed that the exercise equipment was easy to use, that they could clearly see the exercise instructor, the exercise sessions were easy to follow, and the variety and difficulty of exercise were right for them. A lower proportion of

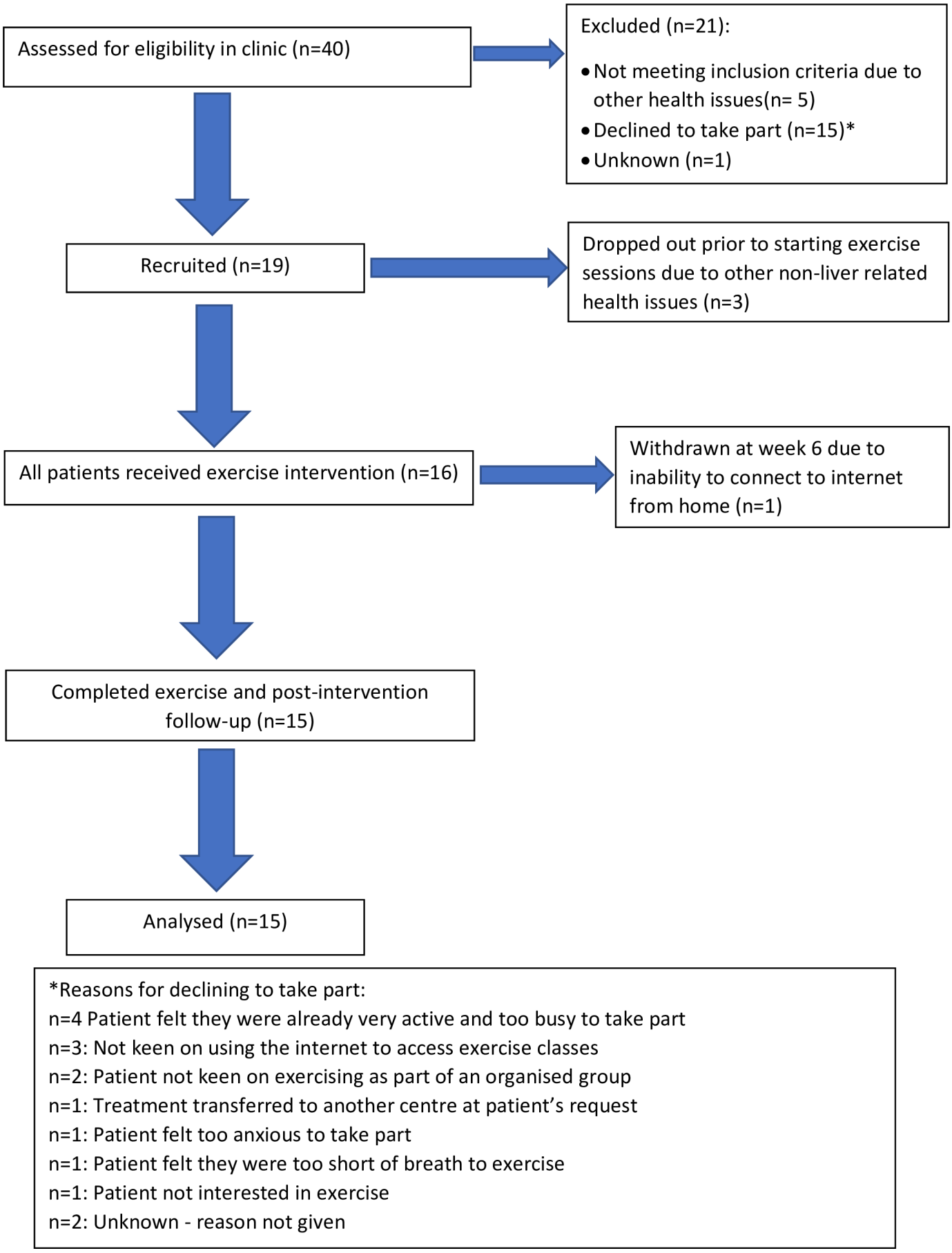

Figure 1 Patient flow throughout the study.

Table 2 Summary of themes and subthemes from qualitative data analysis (see online supplemental information for a table of illustrative quotes)

Theme	Subthemes
Expectations of TELEX prior to participation	Lacking confidence in ability to take part in exercise intervention
	Perceiving benefits to joining exercise intervention
	Motivated to help others by participating in research
Instructors provided individual feedback and helped to foster motivation and discipline	Supervised sessions helped to foster motivation and discipline
	Instructors provided feedback and tailored exercises to the individual's needs
	Instructors created a friendly but professional atmosphere
Exercise sessions were enjoyable, achievable, tailorable and well balanced	Ability to personalise exercises and go at own pace
	Exercise sessions were enjoyable
	Exercise programme was well-balanced and appropriate
	Exercises were achievable
	Sessions of appropriate duration and length
Online sessions overcame barriers to participation	Being online avoided feeling self-conscious in front of others
	Being online overcame travel, distance and time issues
	Online sessions were acceptable if additional support was given where needed
	Technical issues affecting participant's experience of TELEX
Positive experiences of being in a group	Enabled comparisons to others
	Enabled social support from others
Perceived benefits and effectiveness of TELEX	Improved physical health and function
	Improved mental health and well-being
	Increased physical activity and exercise levels
Developing intentions and strategies to continue physical activity and exercise post-TELEX	Importance of motivation and intentions to continue physical activity and exercise
	Recognising the importance of physical activity and exercise
	Developing strategies to remember and prompt exercise
	Incorporating exercises into everyday life

respondents agreed or strongly agreed that videoconferencing was easy to use (69%), they could clearly hear the exercise instructor (58%) and the RPE scale was easy to use (73%) (see online supplemental file 4 for survey responses).

Thematic analysis of qualitative interview data produced seven key themes (see table 2). Some patients were anxious ahead of starting the exercise sessions but their perception of potential health benefits and willingness to take part in research meant they were prepared to participate. The majority of patients felt that it was important to have an instructor there in 'real time' to supervise and personalise the exercise programme and provide encouragement and motivation. They also reported that the sessions were achievable, tailorable to their needs and contained a good range of exercises. Overall, most patients reported enjoying the exercise programme. The benefits of peer support from the group and perceived benefits to both their physical and mental health were highlighted by most, as were their increased physical activity levels. Patients felt that the online sessions overcame some of the barriers to participation and preferred attending virtual sessions via Zoom over face-to-face classes. Most patients appreciated the value of physical activity to their health and recognised the importance of maintaining motivation to ensure the continuation of exercise beyond the course of the study, with some stating strategies that were, or could be, of use to them and others (see table 2 for summary of themes and online supplemental file 5 for a table of illustrative quotes).

Physical function

The LFI improved by −0.34 (95% CI −0.46 to −0.23) from pre-intervention to post-intervention. At baseline, 37% of patients were classed as frail and 63% pre-frail based on LFI. Post-intervention, 13% of patients were classed as frail, 80% as pre-frail and 7% as robust.

Hand grip strength improved by 3.3 kg (95% CI 1.0 to 5.6) from pre-intervention to post-intervention, as did the time it took to perform five sit-to-stands (mean change: −2.2 s; 95% CI −3.2 to −1.2).

Patients also performed better on the balance assessments post-intervention with more patients able to complete the tests (10 s in position): side-by-side (pre: 100% vs post: 100%), semitandem (pre: 89% vs post: 100%) and tandem (pre: 68% vs post: 93%).

Although SPPB score, gait speed and mid-upper arm circumference tended to improve after the intervention,

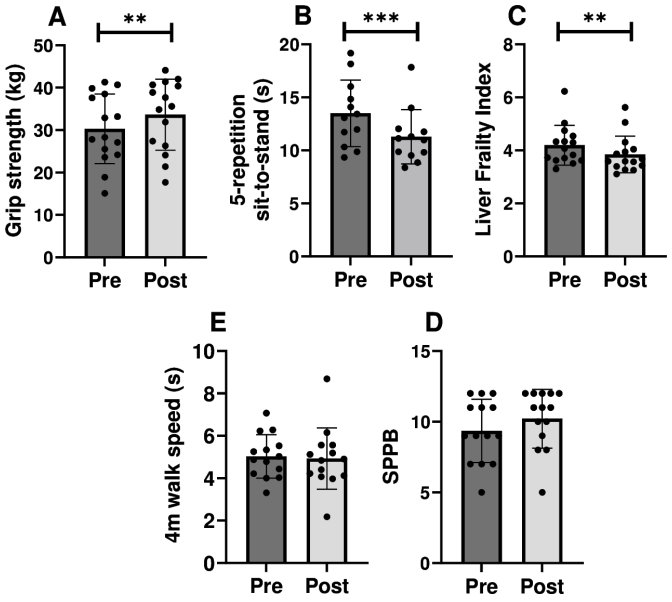

Figure 2 Changes in physical function from baseline to posti-ntervention follow-up (Short Physical Performance Battery (SPPB); **p<0.01; ***p<0.001).

pre-intervention to post-intervention changes crossed the line of no effect. The amount of time spent active did not change after the intervention, but there was a reduction in step count (−1563 steps per day; 95% CI −2658 to −468 steps per day) (figure 2 and table 3).

Patient-reported outcome measures

Patients reported that concerns they had relating to their cancer had improved following the intervention (HCS score: mean change: 3.08; 95% CI 0.30 to 5.85). Although QoL (FACT-Hep total score), fatigue (FACIT-F total score), anxiety and depression (HADS), confidence in ability to balance (ABC) and self-reported physical activity all showed signals of improvement after the intervention, changes from pre-intervention to post-intervention crossed the line of no effect (table 3).

DISCUSSION

This is the first study to demonstrate that home-based, virtually delivered, group exercise is feasible, acceptable and safe for older patients with HCC. 48% of eligible patients provided written consent to take part in the feasibility trial (target ≥40%); adherence to the exercise sessions was 76% (target ≥70%); there were no serious adverse events attributable to the intervention or study procedures.

A strength of this study was the ability to engage a medically complex patient group (mean age 74 years) who all had age-related comorbidities (frailty affecting 37%; pre-frailty affecting 63%) with an online exercise programme. These are a group at high risk of physical deconditioning and subsequent loss of independence and reduction in QoL. Supporting patients with cancer to increase their physical activity levels through structured, supervised exercise is recommended to improve QoL, fatigue, physical function, anxiety and depression.[12] A further strength of the study was the feasibility to deliver the intervention within the standard NHS clinical pathway without the need for additional visits, and that there was no need for specialised exercise equipment, other than resistance bands and pedals, which contributes to the relatively low cost for implementation.

Previous studies have demonstrated that virtual exercise is safe and feasible in younger populations living with cancer[23 25 27 28] but to date, this has not been assessed in older patients with HCC. The recruitment rate in the current study was similar to that of other telehealth exercise studies.[25 27] However, the adherence rate to exercise sessions in the current study was lower (76%) than that reported in other telehealth studies ranging from 88% to 94% in younger patients with cancer[23 25–27] and older adults without cancer ranging from 79% to 90%.[30 31] This may be due to the fluctuating symptoms associated with HCC, chronic liver disease and comorbidities within our cohort, which require frequent medical appointments. Similar reasons have been reported for missing exercise sessions during in-person exercise studies.[15] A systematic review of recruitment and adherence rates to in-person exercise interventions for patients with advanced cancer[15] reported a mean recruitment rate of 49% (range 15%–74%) and levels of adherence ranging from 44% to 95%. The design of future exercise interventions for older people with HCC may benefit from building in flexibility to allow patients to attend another session if they miss one either on another day that week or at the end of the programme.

Patients perceived supervision of exercise to be important. Qualitative data highlighted the benefits of having an instructor delivering the exercise in 'real time' who could correct exercise technique, monitor exercise intensity, provide encouragement and offer alternative exercise options for people with mobility restrictions and low physical fitness. The exercises were able to be tailored to each individual within the group, allowing people of mixed abilities to take part together. Similar themes were identified in a study exploring participant perceptions of virtual exercise for people with multiple myeloma[49] who found that programmes should use tailoring, active support and employ personnel to run the sessions who were both knowledgeable and empathetic. Patients perceived that the instructor was important to help motivate the group and generate a peer-supportive environment, which has previously been highlighted as being important for people living with cancer.[49]

Patients were recruited across a range of levels of deprivation, and many lived a long distance from the treating hospital so the virtual nature of the programme enabled them to take part, removing barriers related to transport and costs. These benefits have been highlighted in other studies[27 28 49] and were confirmed by our qualitative findings. A study investigating barriers to implementing virtual exercise for cancer services highlighted issues

Table 3 Changes in physical function, daily physical activity and PROMs from baseline to post-intervention follow-up

Outcome	Baseline		Post-intervention		Change	
Physical function	**n**	**Mean±SD**	**n**	**Mean±SD**	**n**	**Mean (95% CI)**
5-repetition sit-to-stand (s)	15	14.16±4.07	12	11.29±2.57	12	−2.21 (−3.23 to −1.19)
Hand grip strength (kg)	19	28.76±8.67	15	33.63±8.35	15	3.32 (1.03 to 5.62)
4 metre gait speed (s)	17	5.38±1.56	14	4.93±1.45	14	−0.10 (−0.76 to 0.56)
Short Physical Performance Battery	17	8.88±2.80	14	10.21±2.08	14	0.86 (−0.02 to 1.73)
Liver Frailty Index	19	4.35±0.77	15	3.85±0.69	15	−0.34 (−0.46 to −0.23)
Mid-upper arm circumference (cm)	19	29.74±2.71	14	30.61±2.95	14	0.57 (−0.68 to 1.82)
Daily average physical activity						
Wear time (min)	10	1267±204	9	1212±308	9	50 (−90 to 190)
Time spent active (min)	10	607±86	9	545±130	9	−57 (−126 to 13)
Time spent sedentary (min)	10	659±176	9	667±269	9	7 (−151 to 165)
Time spent in light activity (min)	10	540±83	9	491±120	9	- 41 (−113 to 31)
Time spent in moderate activity (min)	10	67±53	9	54±37	9	−16 (−38 to 7)
Time spent in vigorous activity (min)	10	0±0	9	0±0	9	NA
Steps per day	10	8343±1919	9	7000±2070	9	−1563 (−2658 to −468)
PROMs						
FACT-Hep total score	14	146.56±22.36	14	149.28±21.65	12	5.61 (−0.28 to 11.50)
PWB subscale	16	24.38±4.44	14	24.25±3.13	14	0.43 (−0.66 to 1.51)
SWB subscale	16	23.72±3.12	14	22.55±3.78	14	1.2 (−0.22 to 2.62)
EWB subscale	15	19.07±4.42	14	19.50±5.88	13	0.15 (−2.12 to 2.43)
FWB subscale	15	20.65±6.40	14	21.93±6.22	13	0.28 (−1.02 to 1.59)
HCS subscale	15	60.62±9.27	14	61.23±8.76	13	3.08 (0.30 to 5.85)
FACIT-F total score	16	39.19±10.52	14	41.64±7.70	14	1.00 (−2.79 to 4.79)
ABC scale total score	15	79.27±23.81	14	85.67±15.11	13	2.81 (−7.08 to 12.70)
FES total Score	13	17.27±13.80	14	16.64±9.29	12	0.58 (−3.79 to 4.96)
HADS						
Total score	16	8.56±6.22	14	6.86±4.50	14	−0.50 (−1.78 to 0.78)
Anxiety score	16	4.50±3.10	14	3.50±2.47	14	−0.43 (−1.48 to 0.63)
Depression score	16	4.06±3.32	14	3.36±2.65	14	−0.07 (−0.80 to 0.66)
Godin physical activity total score	15	26.33±17.83	12	29.50±20.05	12	0.08 (−14.22 to 14.38)

ABC, Activities-Specific Balance Confidence Scale; EWB, emotional well-being; FACT, Functional Assessment of Cancer Therapy; FES, Falls Efficacy Scale; FWB, functional well-being; HADS, Hospital Anxiety and Depression Scale; HCS, hepatobiliary cancer subscale; NA, not available; PROMS, patient-reported outcome measures; PWB, physical well-being; SWB, social well-being.

around accessibility for patients without appropriate WIFI or internet-enabled equipment at home.[50] As part of the current study, we offered all patients loan of an internet-enabled device with preloaded internet access for the duration of the study, if required. However, only one patient accepted this offer, and 3/40 (8%) of patients approached to take part in the current study declined as they were not keen on using the internet despite the offer of additional support to access the intervention. Other research suggests some patients cite a self-perceived lack of digital ability and literacy,[28] therefore, simply providing patients with equipment may not offer a solution if they do not have the confidence or ability to use it, aligning with the wider evidence base around digital exclusion.[51] In our study, patients also reported occasional technical difficulties in accessing the sessions, most of which were overcome with help from family members, but this needs addressing in future work to prevent study withdrawal. Digital inclusion is vitally important to avoid increasing health inequalities within this patient population and should be factored into further evaluation/any plans for implementation.

This study provides a preliminary signal that the telehealth exercise intervention improves physical function, grip strength and balance. Patients perceived improvements in their ability to perform daily activities and in their mental health, with many reporting an increase in confidence, improvements to their mood and the

positive impact of having something to focus on (see online supplemental information for a table of illustrative quotes). A review of telehealth exercise studies for patients with cancer found that most of the studies were effective in improving function, QoL, pain, satisfaction and muscle strength[52] and clinical guidelines recommend the inclusion of physical activity/exercise as an integral part of clinical care for people with cancer.[12] Improvements in physical fitness may not only enable to patients to remain independent for as long as possible, thus improving overall QoL, but may also improve candidacy for further treatment if required.

Telehealth exercise has the potential to be delivered at scale in the NHS for older patients with HCC as it does not require exercise facilities, travel for patients, specialised equipment and can be delivered from one central location so is flexible to adapt to local healthcare contexts. A larger scale evaluation is required to assess the clinical and cost-effectiveness of telehealth exercise on progression-free and overall survival in patients treated for HCC. Research is needed to establish whether patients are able to maintain changes to their physical activity levels in the longer term and whether this leads to clinically important improvements in QoL and impacts clinical outcomes, such as eligibility for second-line treatment and progression-free or overall survival.

A limitation of the study is the small sample size which may not be truly representative of the larger population of patients presenting with HCC. The lack of a control group may have resulted in the recruitment of patients who were more interested in exercise and motivated to attend the online classes which could have positively influenced adherence. These factors will be considered ahead of designing the definitive randomised controlled trial and incorporated into future sample size calculations.

CONCLUSIONS

Telehealth exercise was feasible, acceptable and safe for older patients with HCC to complete at home. The inclusion of a synchronous exercise instructor appears to be important to facilitate tailored exercise and positive exercise experiences. Data collection was feasible within the standard clinical pathway and did not require additional research visits. Some patients found using videoconferencing challenging—supporting digital inclusion is important to prevent increasing health inequalities within this patient population, which needs to be incorporated into a future definitive trial.

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