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SYSTEMATIC REVIEW

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Mapping of rehabilitation interventions and assessment methods for patients with liver cirrhosis: a scoping review

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Abstract

Background This scoping review aimed to delineate the detailed components of exercise therapy and the evaluation methods used for patients with liver cirrhosis.

Methods The methodology involved searching the original PubMed, Web of Science, and Scopus for studies published between January 1975 and March 2025. The search was completed on 13 March 2025. Studies describing exercise therapy for liver cirrhosis patients were selected. Relevant information matching the study objectives, such as intervention duration, content, intensity setting, evaluation criteria, and outcomes, was extracted and documented.

Results Of the 2314 articles identified, 18 fit the inclusion and exclusion criteria, with a total of 950 participants. The most prevalent form of exercise therapy was a combined aerobic exercise and strength training program (55.6%). Commonly used assessment criteria included the 6-minute walking distance for endurance evaluation (44.4%) and the Chronic Liver Disease Questionnaire for quality of life assessment (33.3%). Intervention durations ranged from 30 to 60 min per day, 2 to 7 days per week, and 8 to 12 weeks. Concerning intensity setting, subjective fatigue levels and heart rate were frequently used (38.9%), though detailed descriptions were limited.

Conclusions For the establishment of effective exercise therapy for patients with liver cirrhosis, future research should concentrate on tailoring intensity settings according to individual patient needs. Additionally, standardized reporting of intervention details and assessment methods is crucial for improving the quality and comparability of studies in this field.

Keywords Patients with liver cirrhosis, Exercise therapy, FITT, Scoping review

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Introduction

Progressive liver diseases present a complex and significant health challenge, impacting over 1.5 billion people globally [1]. Liver cirrhosis, a progressive liver disease, is characterized by substantial liver fibrosis that may affect liver function [2]. Previous studies of patients with liver cirrhosis have typically emphasized sarcopenia as a decrease in muscle mass, reporting prevalence rates ranging from 30 to 70% in cirrhosis [3–6]. Sarcopenia is acknowledged as a complication that adversely affects clinical outcomes in patients with liver cirrhosis, impacting physical function, capacity, quality of life (QOL), and the incidence of other complications and mortality [7, 8]. Therefore, addressing sarcopenia associated with liver cirrhosis is crucial. In recent years, exercise therapy has been recommended as one of the treatments for sarcopenia associated with liver cirrhosis [9, 10]. The beneficial effects of exercise therapy for liver cirrhosis include improvements in muscle mass, strength, and endurance, as well as positive outcomes in mental well-being and QOL [11–13]. The effectiveness of exercise therapy in liver cirrhosis is becoming well established.

Recent reviews and systematic studies recommend resistance training and aerobic exercise (walking) as effective exercise modalities for liver cirrhosis [14–17]. Patients with decreased liver reserve in cirrhosis often develop sarcopenia due to increased skeletal muscle catabolism, decreased protein synthesis, chronic inflammation, testosterone reduction, and elevated myostatin levels, all contributing to muscle loss [15]. Previous research has reported positive effects of exercise therapy in patients with liver cirrhosis, including increased muscle mass, improved maximum oxygen consumption, and reduced hepatic venous pressure gradient [18].

In the context of exercise therapy for chronic diseases, it is generally emphasized that it should be initiated with low intensity, and progress slowly, and that attentiveness should be paid toward symptoms [19, 20]. Furthermore, each patient's prescription of exercise therapy adheres to the FITT principles (Frequency, Intensity, Time, and Type of exercise), considering these four factors [21]. Following these principles ensures the quality and reproducibility of exercise prescriptions, addressing concerns about the safety of exercise therapy in patients with liver cirrhosis, where careful evaluation and consideration of exercise intensity are crucial [6, 9, 13]. However, despite numerous reports of the effectiveness of exercise therapy in patients with liver cirrhosis, detailed intervention content and assessments based on FITT principles are scant. Therefore, this scoping review aimed to map existing evidence and elucidate the detailed intervention content and assessment methods based on FITT principles for exercise therapy in patients with liver cirrhosis.

Materials and methods

Study design

This study, designed as a scoping review, was conducted and reported according to the guidelines established by the Joanna Briggs Institute (JBI) Manual for Scoping Reviews [22]. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) checklist was also utilized to guide the reporting of each section of this report [23], and it is provided as Supplementary Material (Supplementary Material 1). The first author created the search formula, searched the databases, and performed text screening. The first and fourth authors independently reviewed all titles, selected abstracts, and papers for inclusion, and performed data charting, including the extraction and organization of relevant study details.

Eligibility criteria

The eligibility criteria were structured using the PCC framework (Population, Concept, and Context) based on the JBI guidelines for scoping reviews [22]. The population of interest included adults with liver cirrhosis. The concept focused on rehabilitation interventions, specifically exercise therapy. The context involved rehabilitation settings, with an emphasis on mapping the intervention methods and assessment methods used in the included studies. This included both the types of exercise therapy applied and the motor function assessments employed across the studies.

Studies were included if they focused on interventions for liver cirrhosis patients that involved exercise therapy and reported motor function outcomes. Studies that did not meet these criteria, including those lacking relevant interventions or assessments, were excluded.

Article search

This scoping review covered original articles on rehabilitation for patients with liver cirrhosis. Two reviewers, the first and fourth authors, reviewed all titles, selected abstracts, and papers. After screening the titles and abstracts, the following articles were excluded: (1) those not written in English; (2) editorials, commentaries, conference abstracts, letters, reviews, and case reports; (3) those that did not include cases of cirrhosis; (4) those that did not include exercise therapy; or (5) animal experiments or in vitro studies. After reviewing the full text of the articles, those that only included single-day interventions, those with undescribed rehabilitation content or motor function assessment, and protocols were excluded. Discrepancies between reviewers were addressed through discussion, and if a consensus could not be reached, a corresponding author was involved in making the final decision. Duplicate checking, literature management, and screening blinding were performed using Rayyan, a web-based systematic review management tool, which is a recommended system for screening [24].

A literature search was conducted using PubMed, Web of Science, and Scopus for studies published from January 1975 to March 2025. The search was completed on March 13, 2025. A preliminary investigation was conducted into the key keywords and search terms that had been utilized in previous studies in analogous domains [25–27]. The findings of these studies were then employed to formulate a search strategy, the objective of which was to identify relevant keywords. Based on this, the following search strategy was constructed. In PubMed and Web of Science, the search terms included MeSH terms: ("Liver Cirrhosis"[MeSH Terms] OR "Cirrhosis"[All Fields]) AND ("Exercise Therapy"[MeSH Terms] OR "Exercise"[MeSH Terms]). In Scopus, the search terms used were ("Liver Cirrhosis" OR "Cirrhosis") AND ("Exercise Therapy" OR "Physical Therapy" OR "Rehabilitation" OR "Motor Function"). These search strings were then used to conduct the literature search. Additionally, we did not perform hand-searching of the reference lists of the included studies or relevant systematic/scoping reviews. All studies were identified through electronic database searches using predefined search terms, with no additional studies added through manual searching.

Data extraction

The first author extracted and recorded relevant information consistent with the study objectives, including study design, phase, sample size, intervention duration, intervention content, frequency of assessment, intervention intensity setting, and results.

Outcomes included motor function, liver function, and QOL. Due to the diversity of clinical study designs, the quality of evidence was not assessed.

Motor function outcomes included the following: Fatigue Severity Scale (FSS); maximum inspiratory pressure (Pimax); maximum expiratory pressure (Pemax); peak oxygen uptake (peak VO_2); muscle strength assessment (knee extensor strength, lower limb strength, isokinetic knee extension peak torque and hand grip); 6-minute walking distance (6MD); muscle mass (thigh muscle mass, cross-sectional area [CSA] of the quadriceps.); cardiopulmonary exercise testing (CPET); body composition test; anthropometric measurements; Liver Frailty Index (LFI); 2-minute step test; and the timed-up-and-go test (TUG).

Liver function outcomes included the following: blood tests (complete blood count); transient elastography (liver and spleen stiffness); serological tests (electrolytes, creatinine, creatinine kinase, lactic acid dehydrogenase, serum albumin, bilirubin, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and coagulogram); ascites classification; ammonia levels; serum myostatin levels; Child-Pugh class (CP); Model for End-Stage Liver Disease score (MELD); and Ammonia Metabolism/Glutamine Challenge.

QOL outcomes included the following: EuroQOl-5D (EQ-5D); Short-Form 36-Item Health Survey (SF-36); Chronic Liver Disease Questionnaire (CLDQ); sickness impact profile (SIP) questionnaire; and EQ-visual analog scale (EQ-VAS).

Results

Selected studies and participants

A total of 2314 titles were retrieved, and 60 studies were selected for review. 18 publications fulfilled the inclusion criteria, with a total of 950 participants (Fig. 1). The list of studies excluded after full-text screening is provided in the Supplementary Material (Supplementary Material 2). The most common reason for exclusion was undescribed detailed interventions or motor function assessment ($n = 21$), followed by those that only included single-day interventions ($n = 14$) and protocols ($n = 7$). Of the 18 studies included, 14 (77.8%) were categorized as randomized controlled trials (RCTs), and four were clinical trials (22.2%). Patient characteristics, as shown in Table 1, were reported as either means or medians depending on the study. Reported patient ages ranged from 40 to 60 years, with mean ages typically between 40.8 and 68.1 years and median ages between 61 and 66 years. The Body Mass Index (BMI) ranged from 22 to 33, with mean values generally between 24.0 and 27.5 and median values between 23.2 and 28.0. For liver function, Child-Pugh classifications were reported in 11 of the 18 studies. Of these 11 studies, 8 exclusively included patients with Child-Pugh class A or B, suggesting that most participants had mild liver dysfunction. Two studies included a smaller proportion of patients classified as Child-Pugh C, indicating more advanced liver disease in these cases. This predominance of Child-Pugh A and B reflects a tendency to focus on patients with milder liver disease in the included studies. The MELD scores ranged from 9 to 19, with mean scores between 7.5 and 23.53 and median scores typically consistent within this range. Regarding etiology, viral was the most frequently reported cause of liver cirrhosis, but a wide variety of etiologies, including alcohol-related cirrhosis, non-alcoholic fatty liver disease (NAFLD), and others, were observed without clear consistency across studies (Table 1).

Intervention characteristics

A combination of aerobic exercise and resistance training was reported in 10 studies (55.6%), whereas aerobic exercise training alone was reported in seven studies (38.8%), and resistance training alone was reported in

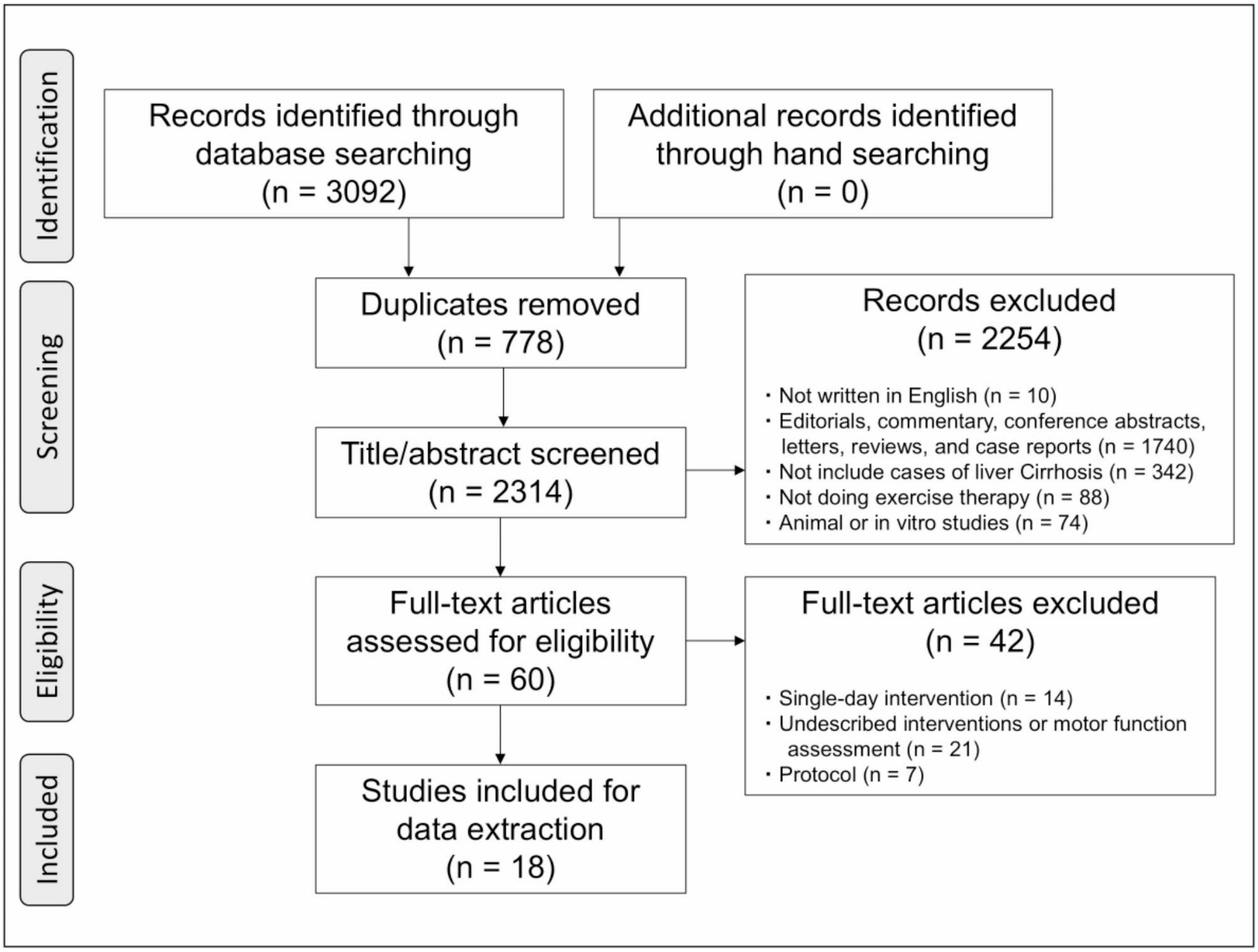

Fig. 1 PRISMA-ScR flow diagram

one study (5.6%). The detailed aerobic exercise content included training on a cycle ergometer or treadmill and walking outdoors. The detailed resistance training content included training with weights, Thera-Bands, and machines. The median frequency of interventions was three (2–7) sessions per week for 12 (8–12) weeks. The median duration of interventions was 30 (30–60) minutes. Regarding intervention intensity, load setting based on perceived fatigue and heart rate was prevalent (38.9%); however, detailed descriptions were limited, and no consistent findings were obtained regarding the relationship between intervention intensity setting and its effects. Moreover, only eight studies provided a detailed description of intervention content based on the FITT principles (Table 2).

Regarding monitoring during interventions, eight studies reported interventions conducted under the supervision of a physician or rehabilitation specialist, and 10 studies reported exercise performed without direct supervision after receiving exercise guidance.

Outcome measures

Common outcome measures used in studies of rehabilitation interventions for patients with liver cirrhosis included functional capacity tests, with the 6MD being used in eight studies (44.4%). Other functional outcomes included exercise stress tests in 5 studies (27.8%), lower limb strength tests in five studies (27.8%), balance assessments using the LFI in four studies (22.2%), grip strength in three studies (16.7%), gait speed in two studies (11.1%), and the TUG in two studies (11.1%). Liver function assessments were conducted in 13 studies, predominantly using the MELD score (61.5%). QOL assessments included the CLDQ in six studies (33.3%), the SF-36 in four studies (22.2%), and the EQ-VAS in three studies (16.7%) (Table 2).

Key findings of the included studies

The studies included in this review primarily involved patients with mild liver dysfunction (Child-Pugh A and B). The most common intervention was a combination of aerobic exercise and resistance training (55.6%).

Table 1 Characteristics of patients in the included studies

Author (Years)	Design, sample size	Group	Age		Body Mass Index		Child-Pugh class		Model for End-Stage Liver Disease score		Etiology (viral/ alcohol/ NAFLD/ others)
			Exercise arm	Control arm	Exercise arm	Control arm	Exercise arm	Control arm	Exercise arm	Control arm	
Q. Xiang (2024)[69]	Clinical Trial, $n=124$	group 1	56.29 ± 9.88	-	23.09 ± 2.83	-	A: 22, B: 19	-	-	-	(68/ 23/ 26/ 7)
		group 2	57.12 ± 7.76	-	22.37 ± 2.83	-	A: 28, B: 14	-	-	-	
		group 3	55.78 ± 9.01	-	22.64 ± 3.04	-	A: 21, B: 20	-	-	-	
E. Sobhy (2024)[70]	RCT, $n=220$	group 1	62.18 ± 8.03	-	28.38 ± 3.66	-	B: 25 C: 30	-	23.53 ± 5.99	-	-
		group 2	60.73 ± 8.29	-	27.83 ± 4.21	-	B: 34 C: 21	-	21.60 ± 7.80	-	-
		group 3	59.80 ± 8.04	-	28.77 ± 3.77	-	B: 35 C: 20	-	22.38 ± 7.82	-	-
		group 4	61.51 ± 8.02	-	28.14 ± 3.54	-	B: 32 C: 33	-	21.76 ± 6.90	-	-
L. Skladany(2024)[71]	RCT, $n=80$	-	56.51 ± 11.9	55.29 ± 13.20	26.46 ± 6.09	27.07 ± 5.45	-	-	15.78 ± 5.60	18.83 ± 6.84	(0/ 43/ 0/ 37)
E. Román (2024)[67]	RCT, $n=32$	-	63.5 ± 7.1	68.1 ± 9.3	27.5 ± 5.2	28.9 ± 3.3	-	-	8 (7–10)	7.5 (6–9)	(0/ 22/ 3/ 7)
P. Sirisunhirun (2022)[47]	RCT, $n=40$	-	55.6 ± 8.9	57.1 ± 6.7	25.3 ± 2.7	25.2 ± 3.4	-	-	7.95 ± 1.5	7.95 ± 1.3	(37/ 2/ 1/ 0)
D. Rossi (2022)[72]	RCT, $n=25$	-	58.7 ± 7.7	56.5 ± 8.8	27.8 ± 3.9	28.4 ± 4.9	A: 10, B: 2	A: 12, B: 1	12.3 ± 4.4	11.0 ± 4.2	(15/ 2/ 3/ 5)
S. Mohta (2022)[73]	RCT, $n=60$	-	42.26 ± 10.07	40.83 ± 9.80	23.8 ± 5.2	23.5 ± 5.4	A: 12, B: 18	A: 9, B: 21	10.2 ± 2.8	12.2 ± 3.5	(24/ 19/ 7/ 10)
J. C. Lai (2021)[36]	RCT, $n=83$	-	62 (56–66)	61 (42–72)	28 (26–33)	28 (26–33)	B: 13, C: 12	B: 31, C: 27	12 (6–32)	13 (6–23)	(31/ 17/ 10/ 25)
M. Hernández-Conde (2021)[74]	RCT, $n=32$	-	69.0 ± 9.7	61.0 ± 9.4	26.0 ± 4.7	28.6 ± 4.6	A: 11 B: 4	A: 10 B: 5 C: 2	10.7 ± 4.4	11.0 ± 3.4	-
C. M. Morkane (2020)[75]	Clinical Trial, $n=33$	-	55.6 ± 7.8	55.6 ± 7.8	30.9 ± 5.6	27.0 ± 4.6	-	-	13.7 ± 4.6	13.2 ± 3.7	(0/ 12/ 5/ 16)
H. W. Chen (2020)[76]	RCT, $n=17$	-	55 ± 7	54 ± 11	31 ± 8	29 ± 4	B: 7, C: 2	B: 4, C: 4	16 ± 4	19 ± 3	(6/ 4/ 7/ 3)
L. Aamann (2020)[32]	RCT, $n=39$	-	61.7 ± 7.8	63.0 ± 7.0	-	-	A: 10, B: 10	A: 10, B: 9	10.8 ± 2.7	10.7 ± 2.8	(3/ 31/ 1/ 4)
C. Kruger (2018)[37]	RCT, $n=40$	-	53.0 ± 8.3	56.4 ± 8.5	-	-	A: 14, B: 6	A: 14, B: 6	9.05	9.7	(12/ 11/ 10/ 7)
A. Hiraoka (2017)[77]	Clinical Trial, $n=33$	-	66 (62–70)	-	23.2 (20.8–25.1)	-	A: 30, B: 3	-	12 (6–32)	-	(28/ 2/ 0/ 3)
A. Berzigotti (2016)[78]	Clinical Trial, $n=33$	-	56 ± 8	-	33.3 ± 3.2	-	-	-	9.0 ± 2.6	-	(18/ 19/ 12/ 1)
E. Román (2016)[11]	RCT, $n=23$	-	62.0 ± 2.4	63.1 ± 2.3	31.5 ± 1.6	30.3 ± 1.4	-	-	8.2 ± 0.4	9.1 ± 0.4	(3/ 17/ 0/ 3)
L. Zenith (2014)[12]	RCT, $n=19$	-	56.4 ± 7.7	58.6 ± 5.8	-	-	-	-	9.7 ± 2.4	10.2 ± 1.9	(6/ 6/ 0/ 7)
E. Román (2014)[79]	RCT, $n=17$	-	65.5 (46–72)	61 (43–75)	-	-	A: 7, B: 1	A: 7, B: 2	9.5(7–12)	9.0(7–13)	(4/ 13/ 0/ 0)

Data as mean ± standard deviation or median (min-max)

Abbreviations: NAFLD, Non-Alcoholic Fatty Liver Disease.

Functional capacity was frequently assessed using the 6MD (44.4%), while QOL was commonly evaluated using the CLDQ (33.3%). Intervention durations varied from 30 to 60 min per session, 2 to 7 days per week, and lasted for 8 to 12 weeks. Intensity was typically regulated using subjective fatigue levels and heart rate, although detailed descriptions of intensity settings were often lacking.

Discussion

This scoping review aimed to map existing evidence and elucidate detailed intervention content and assessment methods based on the FITT principles for exercise therapy in patients with liver cirrhosis. Twelve studies were investigated concerning detailed intervention content and assessment methods related to exercise therapy.

Types of exercise therapy for patients with liver cirrhosis

In the mapping results of this scoping review, the most implemented types of exercise therapy for patients with liver cirrhosis were aerobic exercise and mixed programs combining aerobic exercise and resistance training. In addition, the patients with liver cirrhosis included in this scoping review were Child-Pugh A to B, with a relatively good hepatic reserve and a low risk of jaundice or variceal rupture. The American Association for the Study of Liver Diseases and European Association for the Study of the Liver reported in its Review of Exercise Therapy for Patients with Cirrhosis that, similar to this scoping review, patients with liver cirrhosis who underwent exercise therapy were more likely to be subjects with preserved hepatic reserve [9, 10]. Therefore, it is suggested that exercise therapy for patients with liver cirrhosis with relatively good hepatic reserve should include aerobic exercise as identified in this scoping review or a mixed program combining aerobic exercise and resistance training. On the other hand, the results of this scoping review revealed that there are very few reports on exercise therapy for patients with low liver reserve (Child-Pugh C) liver cirrhosis. This suggested the need for further research on the necessity of exercise therapy for these patients and the development of individualized and optimized approaches.

Previous literature reviews have recommended aerobic exercise or mixed aerobic and resistance training programs as exercise therapy for patients with liver cirrhosis [9, 18], and the results of this scoping review support these findings. The reported benefits of aerobic exercise include improvements in endurance, strength, and muscle mass [28, 29], making it effective for addressing sarcopenia as well [30]. Studies implementing aerobic exercise or mixed aerobic and resistance training programs for liver cirrhosis patients reported no worsening of cirrhosis, complications, or decompensation [11, 13], indicating the safety of these training modalities. Although resistance training for patients with liver cirrhosis has been reported to be safe and effective in previous RCTs [31], this is the only report, and no consensus has yet been reached on appropriate intensity settings. Furthermore, the results of this scoping review also provided a limited detailed description of the intensity setting. Therefore, further research is needed on the intensity of resistance training in resistance training programs for patients with cirrhosis.

Moreover, this scoping review also identified whether physicians, physical therapists, and other health care providers monitored or unmonitored patients with cirrhosis during exercise. In the articles adopted for this scoping review, there were three reports of monitored and eight reports of unmonitored exercise, and in any case, exercise could be performed without any adverse events such as worsening of liver function. However, conclusive evidence regarding the impact of exercise on liver function itself remains lacking. While previous studies on other chronic diseases suggest that exercise may help maintain or even improve organ function [32–34], similar evidence for cirrhosis is still insufficient. Further research is needed to clarify whether exercise can contribute to liver function preservation or improvement, particularly in long-term interventions. On the other hand, compliance rates for home physical therapy interventions for patients with cirrhosis have been reported to be only 14% [35] and 55% [36], indicating a low compliance rate for unmonitored exercise prescriptions for patients with cirrhosis. Other reports on compliance rates indicate that in cancer patients attending an outpatient clinic, an acceptability study of a moderate-intensity exercise program (6 to 12 weeks) showed that only 8.7% of the control group participated in a physical activity intervention at home [37]. Furthermore, regarding the participation rate of strength training, data from the Health Information National Trends Survey (HINTS) in the U.S. showed that regardless of gender or cancer type, less than 20% of both aerobic exercise and strength training recommendations were met [38], and patients with cirrhosis were reported to have low compliance rates, like those in previous studies. Aggravating disease conditions have been cited in previous studies as a factor in low compliance rates [39], and periodic checks and changes in exercise programs are recommended when exercises are prescribed to ensure compliance rates [9]. Previous studies indicate that patients with progressive liver disease often face limitations in exercise and tend to prefer supervised, personalized exercise programs [40, 41]. This preference may stem from disease-specific physiological constraints and anxiety about potential complications. Moreover, several barriers to the continuation of exercise therapy in patients with chronic diseases have been identified, including fatigue, muscle weakness, low motivation, and the

Table 2 Mapping based on FITT for the included studies

Author (Years)	Monitored/ Unmonitored	FITT of intervention				Outcomes	Results
		Frequency	Intensity	Time	Type of exercise		
Q. Xiang (2024)[69]	Unmonitored	7 days/week for 12 weeks	(2)(3) 2000 steps/day and 60% of maximum heart rate	—	(1) BCAA orally group (2) Walking group (3) Walking and BCAA orally group	**Motor function**: Grip strength, Skeletal muscle mass index **Liver function**: Serological tests	**Motor function**: Grip strength and skeletal muscle mass index showed predominant improvement. No significant differences were observed between groups. **Liver function**: No significant differences were observed between groups
E. Sobhy (2024)[70]	Unmonitored	7 days/week for 4 weeks	—	20 min	(1) Standard care group (2) Standard care and BCAA orally group (3) Walking and resistance group (4) Walking and resistance and BCAA orally group	**Motor function**: Thickness of the quadriceps, Grip strength, Short physical performance battery test **Liver function**: MELD, Blood tests, Serological tests	**Motor function**: Thickness of the quadriceps, grip strength, and short physical performance battery test showed predominant improvement. No significant differences were observed between groups. **Liver function**: MELD showed predominant improvement. No significant differences were observed between groups.
L. Skladany(2024)[71]	Monitored	3 days/week for 12 weeks	—	15–20 min	(1) Walking and resistance group (2) Life guidance group	**Motor function**: LFI **Liver function**: CP, MELD, Ascites classification **Quality of life**: EQ-5D	**Motor function**: LFI showed predominant improvement in the exercise group. No significant differences were observed between groups. **Liver function**: Liver function parameters were not significantly different within and between groups. **Quality of life**: Quality of life measures were not significantly different within and between groups.
E. Román (2024)[66]	Unmonitored	3 days/ week for 12 months	—	20–60 min	(1) Cycle ergometry and resistance group (2) Usual care only group	**Motor function**: LFI, TUG, Gait speed, Body composition test **Liver function**: Blood tests, Serological tests **Quality of life**: SF-36	**Motor function**: The intervention group showed improvements in LFI, TUG, and gait speed, with significant differences between groups. **Liver function**: C-reactive protein decreased in the intervention group compared to the control group. **Quality of life**: The intervention group showed significant improvements in SF-36 physical function and physical role pre- and post-intervention.
P. Sirisunhirun (2022)[46]	Unmonitored	4 days/week for 12 weeks	(1) 60–80% of heart rate	40 min	(1) Walking and resistance group (2) Life guidance group	**Motor function**: 6MD, Thigh muscle mass, Anthropometric measurements **Liver function**: Blood tests, Transient elastography(liver and spleen stiffness), CP, MELD **Quality of life**: CLDQ	**Motor function**: No significant differences were observed within and between groups. **Liver function**: LS was significantly different within each group, but no statistically significant differences were found between the two groups. **Quality of life**: The home-based exercise training group showed significant improvement in CLDQ pre- and post-intervention, but no significant differences were found between groups.
D. Rossi (2022)[72]	Monitored	2 days/week for 12 weeks	(1) Borg Scale 12–14	30–50 min	(1) Walking(treadmill) group (2) Home exercise group	**Motor function**: FSS, Pimax, Pemax, Knee extensor strength, 6MD **Quality of life**: SF-36	**Motor function**: FSS, Pimax, Pemax, knee extensor strength, and 6MD showed significant differences within and between groups. **Quality of life**: SF-36 showed significant differences within and between groups.

Table 2 (continued)

Author (Years)	Monitored/ Unmonitored	FITT of intervention				Outcomes	Results
		Frequency	Intensity	Time	Type of exercise		
S. Mohta (2022)[73]	Unmonitored	7 days/week for 24 weeks	—	30–45 min	(1) Walking and resistance and BCAA orally group (2) Walking and resistance group	**Motor function**: 6MD, Gait speed, Lower limb strength, Body composition test **Liver function**: Blood tests, Serological tests, Ammonia levels, Serum myostatin levels, MELD **Quality of life**: CLDQ	**Motor Function**: No significant differences were observed within and between groups. **Liver function**: No significant differences were observed within and between groups. **Quality of life**: CLDQ was not significantly different within and between groups.
J. C. Lai (2021)[35]	Unmonitored	3 days/week for 12 weeks	(1) Resistance training sets the load by the type of band.	30 min	(1) Walking and resistance group (2) Motor guidance group	**Motor function**: LFI **Quality of life**: CLDQ	**Motor Function**: LFI was not significantly different within and between groups. **Quality of life**: CLDQ was not significantly different within and between groups.
M. Hernández-Conde (2021)[74]	Unmonitored	3 days/week for 12 weeks	5,000 to 10,000 steps a day	30 min	(1) Walking and resistance and BCAA orally exercise and nutrition group (2) Walking and resistance group	**Motor function**: LFI, Body composition test **Liver function**: Blood tests, Serological tests	**Motor function**: LFI showed significant differences within and between groups. **Liver function**: No significant differences were observed within and between groups.
C. M. Morkane (2020)[75]	Monitored	5 days/week for 6 weeks	80% of work rate at VO_2 at AT (moderate) and 50% of the difference between VO_2 peak and VO_2 at AT (severe)	40 min	(1) Cycle ergometry exercise group (2) Usual care only group	**Motor function**: CPET	**Motor function**: The exercise group showed improvement in peak VO_2.
H. W. Chen (2020)[76]	Unmonitored	5 days/week for 12 weeks	(1) Walking adds 500 steps to the normal number of steps each week.	30 min	(1) Walking and resistance group (2) Dietary intervention group	**Motor function**: 6MD, CPET, Body composition test **Quality of life**: Sickness impact profile (SIP)	**Motor function**: 6MD showed significant differences within and between groups. **Quality of life**: The exercise group showed significant improvement in the SIP questionnaire's ambulation and eating sections pre- and post-intervention.

Table 2 (continued)

Author (Years)	Monitored/ Unmonitored	FITT of intervention				Outcomes	Results
		Frequency	Intensity	Time	Type of exercise		
L. Aamann (2020)[31]	Monitored	36 trials for 12 weeks	(1) Load capacity to perform 15 cycles at moderate intensity.	—	(1) Resistance exercise group (2) Relaxation program group	**Motor function**: Isokinetic knee extension peak torque, Cross-sectional area [CSA] of the quadriceps muscle, Body composition test, 6MD	**Motor function**: The exercise group showed significant improvement in isokinetic knee extension peak torque and CSA within and between groups. The exercise group also showed significant improvement in 6MD pre- and post-intervention.
						Liver function: Blood tests, MELD, Ammonia Metabolism/ Glutamine Challenge	**Liver function**: No significant differences were observed within and between groups.
						Quality of life: SF-36	**Quality of life**: The exercise group showed significant improvements in SF-36 vitality and mental health pre- and post-intervention.
C. Kruger (2018)[36]	Unmonitored	3 days/week for 8 weeks	—	—	(1) Cycle ergometry exercise group (2) Usual care only group	**Motor function**: peak VO2, 6MD	**Motor function**: The exercise group showed significant improvement in peak VO_2 pre- and post-intervention. 6MD showed significant differences between groups.
						Liver function: Blood tests, MELD	**Liver function**: No significant differences were observed within and between groups.
						Quality of life: CLDQ, EQ-VAS	**Quality of life**: CLDQ and EQ-VAS showed no significant differences within and between groups.
A. Hiraoka (2017)[77]	Unmonitored	7 days/week for 12 weeks	(1) The normal number of steps plus 2000 steps	—	(1) Walking group	**Motor function**: Body composition test, Lower limb strength, Grip strength	**Motor function**: Motor function showed predominant improvement pre- and post-intervention.
						Liver function: Serological tests	**Liver function**: No changes were observed pre- and post-intervention.
A. Berzigotti (2016)[79]	Monitored	1 days/week for 16 weeks	(1) Borg Scale 10–12	60 min	(1) Aerobic and resistance group	**Motor function**: Maximal oxygen uptake	**Motor function**: The exercise group showed improvement in maximal oxygen uptake.
						Liver function: Blood tests, Serological tests	**Liver function**: No changes were observed pre- and post-intervention.
						Quality of life: CLDQ	**Quality of life**: The exercise group showed improvement in CLDQ.
E. Román (2016)[11]	Monitored	3 days/week for 12 weeks	—	60 min	(1) Cycle ergometry and resistance exercise group (2) Usual care only group	**Motor function**: TUG, CPET, Body composition test	**Motor function**: TUG showed predominant improvement pre- and post-intervention. No significant differences were observed between groups.
L. Zenith (2014)[12]	Monitored	3 days/week for 8 weeks	(1) 60–70% of maximum heart rate	30 min	(1) Cycle ergometry exercise group (2) Motor guidance group	**Motor function**: Peak VO2, Muscle mass and thigh circumference, 6MD	**Motor function**: Peak VO_2 and 6MD showed significant differences within and between groups.
						Liver function: Blood tests, Serological tests, MELD, CP	**Liver function**: No significant differences were observed within and between groups.
						Quality of life: CLDQ, EQ-VAS	**Quality of life**: The activity and fatigue subscores of the CLDQ and EQ-VAS showed significant differences within and between groups.

Table 2 (continued)

Author (Years)	Monitored/ Unmonitored	FITT of intervention: Frequency	Intensity	Time	Type of exercise	Outcomes	Results
E. Román (2014)[79]	Monitored	3 days/week for 12 weeks	(1) 60% of maximum heart rate	—	(1) Cycle ergometry & Walking Exercise group (2) Nutrition guidance Control group	**Motor function**: 6MD, 2-minute step test **Liver function**: Blood tests, Serological tests, MELD, CP **Quality of life**: SF-36	**Motor function**: 6MD and the 2-minute step test showed predominant improvement pre- and post-intervention. No significant differences were observed between groups. **Liver function**: No significant differences were observed within and between groups. **Quality of life**: The general health, vitality, and social function subscores of SF-36 showed significant differences within and between groups.

Abbreviations: LFI, Liver Frailty Index; FSS, Fatigue Severity Scale; Pimax, maximum inspiratory pressure; Pemax, maximum expiratory pressure; peak VO2, peak oxygen uptake; 6MD, 6-minute walking distance; CPET, Cardiopulmonary exercise testing; TUG, Timed-Up-and-Go test; CP, Child-Pugh class; MELD, Model for End-Stage Liver Disease score; EQ-5D, EuroQOl-5D; SF-36, Short-Form 36-Item Health Survey; CLDQ, Chronic Liver Disease Questionnaire; SIP, Sickness Impact Profile questionnaire; EQ-VAS, EQ-visual analog scale.

challenge of attending medical appointments [42]. Taking these factors into account, exercise prescriptions that include regular monitoring and tailored guidance from healthcare professionals may enhance adherence to exercise. Additionally, careful thought is required regarding the setting in which exercise therapy is provided. While hospitals offer a controlled environment with expert supervision, home-based or community rehabilitation programs necessitate a greater focus on self-management by patients. Thus, strategies such as motivational interviewing and technology-assisted monitoring (e.g., mobile apps or wearable devices) could play a vital role in fostering long-term adherence to exercise therapy [43, 44]. Future research should explore the effectiveness of these strategies. In conclusion, when prescribing exercise to patients with liver cirrhosis, it is necessary to periodically check the pathophysiology of the disease and the exercise program, as well as to make appropriate changes in the exercise program.

FITT principles for patients with liver cirrhosis

In the mapping results of this scoping review, the most frequently reported intervention schedules monitored and unmonitored, were three or more sessions per week for 12 weeks. Previous studies [9] recommended exercise programs based on FITT principles for progressive liver diseases, including liver cirrhosis, suggesting exercises like those for chronic disease. The recommended frequency of aerobic exercise was reported as at least four sessions per week, with each session lasting approximately 40 min, aiming for a total of 150 min per week. The mapping results of this scoping review align with these recommendations, suggesting that patients with liver cirrhosis may benefit from high-frequency exercise.

Regarding intensity settings, aerobic exercise (i.e. walking, treadmill, ergometer.) has been reported to a moderate level of load intensity was used the Borg Scale in a 10-point scale, the mapping results of this scoping review found limited reports using the Borg Scale for intensity setting, with heart rate being the more commonly used measure. Furthermore, in the case of aerobic exercise prescription under supervision, the intensity setting was often based on heart rate using the cardiopulmonary exercise test (CPX), while in the case of unmonitored (home exercise program), the prescribed number of steps and Borg Scale were often reported, indicating that the intensity setting differed depending on whether the patient was monitored or not. Though previous research on aerobic exercise prescription for sarcopenia reported that heart rate-based intensity setting is the most used [45], similar results may apply to patients with liver cirrhosis.

On the other hand, this scoping review found few reports detailing specific resistance training intensity settings for patients with liver cirrhosis. Among the included studies, some employed moderate-intensity resistance training (e.g., 40–60% 1RM or a Borg scale of 11–13), and these studies reported no major adverse events, suggesting that such intensities may be feasible for this population [31, 46]. However, a review focusing on sarcopenic older adults provided more comprehensive information on intensity settings using repetition maximum (RM) and the Borg Scale [45, 47]. This review of previous studies recommended resistance training for sarcopenia with the following parameters: 3 days per week frequency, intensity ranging from 20 to 79% of 1RM, a Borg scale of 6 to 14 (somewhat hard), and 20 ~ 75 min [45]. Furthermore, in age-related sarcopenia, muscle training is effective at high intensities (i.e. 80% 1RM) and reasonably effective at low intensities (≦50% 1RM) [47]. Furthermore, studies on other chronic diseases, such as chronic kidney disease and heart failure, have reported that moderate-intensity resistance training (typically 40–60% 1RM) is generally safe and beneficial in improving muscle strength and physical function [48, 49]. Given these findings, it may be reasonable to suggest that resistance training for patients with liver cirrhosis could follow similar intensity recommendations. However, due to the potential risks associated with cirrhosis, including bleeding tendencies and fatigue accumulation, a cautious approach is warranted. Further research is needed to establish optimal intensity settings specific to this population.

Patients with liver cirrhosis have impaired liver function, which leads to protein catabolism and synthesis failure, resulting in increased proteolysis and energy consumption. As a result, glycogen in the liver is chronically depleted, and the substrate for glycogenesis is obtained by degrading muscle proteins, resulting in sarcopenia due to abnormal glucose and protein metabolism [50]. While resistance training in patients with liver cirrhosis has been reported to increase muscle mass and promote muscle protein synthesis, patients with liver cirrhosis have abnormal glucose and protein metabolism, and exercise may contribute to protein catabolism [50]. In addition, patients with liver cirrhosis may have cachexia [51], cachexia is a complex metabolic syndrome characterized by muscle loss with or without fat loss owing to an underlying disease and its therapeutic process [52]. Therefore, previous studies have mentioned the need to take into account the worsening of the disease state and to pay attention to the load setting in resistance training for patients with cirrhosis [39]. Recently, low-load, high-frequency training using resistance bands or body weight has been reported to be effective in preventing muscle atrophy and promoting muscle hypertrophy in healthy subject [53]. Accordingly, in resistance training for patients with liver cirrhosis, setting intensity individually and prescribing exercises starting, while ensuring safety, is considered desirable.

Assessments used for patients with liver cirrhosis

In the mapping results of this scoping review, the most commonly used assessments before and after implementing exercise programs for patients with liver cirrhosis were the 6MD and the Chronic Liver Disease Questionnaire (CLDQ). Furthermore, MELD was the most used method for liver function evaluation. MELD is a score evaluation using blood biochemical test data and indicates hepatic reserve capacity; the higher the score, the poorer the prognosis [54, 55]. This scoping review showed that most patients did not show any change in liver function pre and post-rehabilitation. These results suggested that rehabilitation of patients with liver cirrhosis can be performed safely without adversely affecting liver function. On the other hand, however, no certain findings were obtained regarding the effects of exercise on liver function, suggesting the need for further studies on the effects of rehabilitation on liver function.

The evaluation items in the rehabilitation field include evaluation methods that indicate the quality of healthy life of the subject, such as physical and mental functions and structures, activities, and participation, in the functional classification based on the International Classification of Functioning, Disability, and Health [56, 57]. The results of this scoping review revealed that the 6MD is most commonly used to assess physical function and structure in patients with cirrhosis, and the CLDQ is most frequently used to evaluate the quality of health life.

The 6MD is a simple method for assessing endurance [58]. On the other hand, this scoping review also included an assessment of endurance using the CPX. CPX can evaluate oxygen uptake, an objective index of exercise tolerance, as a measured value, and specific components of exercise tolerance, such as ventilatory capacity, circulatory capacity, and muscle metabolic capacity. However, it has also been pointed out that it is not an evaluation tool that can be implemented in all facilities, as it requires expensive equipment and skilled staff [59]. In contrast, 6MD can be performed at most facilities because it does not require special equipment and is easy to perform [58]. Furthermore, the validity of the assessment in children, the elderly [60], and patients with cardiac or respiratory disease has been reported [61, 62], and it may be a useful endurance measure in assessing endurance in patients with cirrhosis.

The CLDQ is a 29-item self-administered health-related QOL instrument [63]. It includes items in the domains of fatigue, activity, emotional function, abdominal symptoms, systemic symptoms, and worry, which are rated on a 7-point Likert scale. Higher scores indicate a better health-related QOL. Patients with liver cirrhosis have been reported to experience decreased endurance and overall fatigue [64], making these symptoms likely targets for treatment. In addition, clinical and epidemiological studies of patients with cirrhosis have indicated the importance of health-related QOL instruments [65]. Therefore, it was considered reasonable to use the 6MD to evaluate endurance as a physical function and the CLDQ as a health-related QOL instrument for patients with cirrhosis. However, reports demonstrating significant improvements in endurance or QOL evaluations were limited, and controlled reports on exercise intensity settings were scarce. Consequently, whether exercise therapy for patients with liver cirrhosis contributes to the improvement of endurance and QOL remains unclear. Future studies aiming to establish exercise therapy for patients with liver cirrhosis will need to consider intensity settings tailored to individual patients. Recent studies have also reported on the long-term effects of rehabilitation interventions, including improvements in liver function, physical function, and survival rates [66–68]. However, these findings remain limited, and further research is necessary to clarify the long-term efficacy of exercise therapy for patients with liver cirrhosis, particularly its impact on disease progression and overall survival.

Study limitations

This scoping review had some limitations. First, only original human studies published in English were included, while editorials, commentaries, conference abstracts, letters, reviews, and case reports were excluded. Although this may have resulted in incomplete data, the risk of data duplication was minimized.

Furthermore, the included studies exhibited considerable heterogeneity in study design, intervention protocols, and outcome measures, making direct comparisons challenging. Additionally, some studies lacked detailed methodological descriptions, potentially affecting the reliability of their findings. The small sample sizes in some studies may have limited the generalizability of the findings.

In terms of the review process, the search strategy focused on three electronic databases (PubMed, Web of Science, and Scopus), which improved the comprehensiveness of the review but also posed a limitation due to the exclusion of other potential sources of information, such as gray literature. Consequently, the risk of publication bias remains a concern. Additionally, the long-term effects of these exercise interventions remain unclear, as this scoping review primarily focused on short-term and pre- and post-intervention outcomes. Future research should explore whether the benefits of exercise therapy for patients with liver cirrhosis are sustained over extended periods and whether long-term exercise therapy influences survival rates, disease progression, and overall health outcomes.

Finally, this scoping review lacked quality assessment, limiting our ability to comment on the effectiveness of the interventions. Therefore, conducting a systematic review in the future that incorporates a quality assessment and provides a detailed evaluation of the interventions' effectiveness and causal relationships is essential.

Conclusions

For the establishment of effective exercise therapy for patients with liver cirrhosis, future research should concentrate on tailoring intensity settings according to individual patient needs. Additionally, a more detailed analysis of the effectiveness of interventions across different outcome measures is necessary to determine the most effective interventions for specific outcomes, given the findings of this scoping review that a wide variety of outcome measures are used to assess the effectiveness of rehabilitation interventions for patients with liver cirrhosis. Furthermore, standardized reporting of intervention details and assessment methods is crucial for improving the quality and comparability of studies in this field.

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Author contributions

All authors contributed to the study's conception and design. YH, MK, DI, and TK conducted the literature search, data extraction, analysis, and interpretation. YH wrote the first draft of the manuscript. MK, HK, and TK critically revised the manuscript. ST supervised the overall study design and methodology. TT provided critical supervision during data interpretation and manuscript preparation. Both ST and TT critically revised the entire study. All authors reviewed and approved the final version of the manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

TK received lecture fees from ASKA Pharmaceutical Co., Ltd., Taisho Pharmaceutical Co., Ltd., Kowa Company, Ltd., AbbVie GK., Eisai Co., Ltd., Novo Nordisk Pharma Ltd., Janssen Pharmaceutical K.K., Otsuka Pharmaceutical Co., Ltd., EA Pharma Co., Ltd. ST received lecture fees from Otsuka, Abbvie, Asuka, Daiichi Sankyo, Chiome Bioscience, Takeda, Jansen, and Gilead. He also received research grants from Rho to, Asuka, Mochida, Fuji, Stemrim, Abotto, Tsumura, Kiowa, Toso, Touwa, Shionogi, Nihonseibutsu, and scholarship grants from Otsuka, Nihonkayaku, Abbvie, Dainipponsumito, Asahikasei, Pharma, Takeda.

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