Original Article

Patient-Perceived Barriers to Lifestyle Interventions in Cirrhosis

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ABSTRACT

Background/Aims: Sarcopenia, muscle weakness, and physical frailty are independent predictors of mortality in cirrhosis. These adverse prognostic factors are potentially modifiable with lifestyle interventions, including adequate nutritional intake and physical activity. Our aim was to identify patient-perceived barriers and enablers to these interventions. **Patients and Methods:** Adult patients with cirrhosis were prospectively recruited from two tertiary care liver clinics. Patients were excluded if they had hepatocellular carcinoma beyond transplant criteria, other active malignancy, or advanced chronic disease. **Results:** A total of 127 patients (mean age: 60 ± 9 years, 58% males, and 48% with Child-Pugh-B/C (CP-B/C) disease) were included. Two-thirds of the patients had cirrhosis related to alcohol or hepatitis C. CP-B/C patients were more likely to take oral nutritional supplements (56% vs 29%) and less likely to consume animal protein daily (66% vs 85%) when compared to CP-A patients. Early satiety, altered taste, and difficulty in buying/preparing meals were more common in CP-B/C patients and even present in 20–30% of CP-A patients. Most patients reported adequate funds to purchase food. As quantified by the International Physical Activity Questionnaire-Short Form, 47% reported low activity levels, with no significant differences between groups. CP-B/C patients were more fatigued with exercise, however, overall Exercise Benefits/Barriers Scale scores were similar across groups. **Conclusions:** Barriers to nutritional intake and physical activity are common in cirrhosis and should be evaluated and treated in all patients. Asking simple screening questions in clinic and referring at-risk patients to expert multidisciplinary providers is a reasonable strategy to address these barriers. Future research should evaluate techniques to overcome modifiable barriers and enhance enablers.

Key Words: Exercise, fatigue, liver diseases, motor activity, nutrition therapy, surveys and questionnaires

Received: 05.05.2016, Accepted: 21.10.2016

How to cite this article: Ney M, Gramlich L, Mathiesen V, Bailey RJ, Haykowsky M, Ma M, *et al*. Patient-perceived barriers to lifestyle interventions in cirrhosis. Saudi J Gastroenterol 2017;23:97-104.

Liver cirrhosis is a chronic disease characterized by diffuse nodular hepatic fibrosis, portal hypertension, and progressive hepatic dysfunction.[1] Although worldwide prevalence numbers are unknown, estimates of up to 1% have been proposed for histological cirrhosis, the most common etiologies of which are alcohol, nonalcoholic fatty liver disease, and viral hepatitis.[2] In addition to damage to the involved organ, there are important extrahepatic consequences of cirrhosis, including significant reductions in muscle mass, muscle function, and exercise tolerance.[3] These muscle-related deteriorations are not only prevalent[3] but have also gained attention as being robust, independent, and perhaps most importantly, potentially modifiable predictors of morbidity and mortality in cirrhosis.[4,5]

In noncirrhotic healthy and clinical populations, nutritional therapy and regular physical activity have been associated

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Quick Response Code:

Website: www.saudijgastro.com

DOI: 10.4103/1319-3767.203357

with important health and survival benefits.[6,7] In patients with cirrhosis, there are fewer high-quality data available.[8] Existing studies do, however, supports the association between nutritional therapy and significant improvements in muscle mass.[9,10] Data is also accumulating that support the benefits of exercise in patients with cirrhosis. In a recent randomized controlled pilot trial of an 8-week supervised endurance training program, the exercise group was associated with significant improvements in peak oxygen uptake, muscle mass, and quality of life as well as significant reductions in fatigue as compared to a control group receiving usual care.[11] These benefits have been reproduced in additional studies.[12,13]

The existing literature suggests that nutrition and exercise hold promise as safe and effective interventions in cirrhosis, with the potential to impact both morbidity and mortality. To optimize the uptake of these nonpharmacological "lifestyle" based interventions, we targeted the second step outlined in the Theoretical Domains Framework for behaviour change.[14] The four steps outlined by the framework include determining the problem to be solved, identifying the barriers and enablers to be addressed, describing interventions to overcome barriers and enhance enablers, and, finally, measuring and understanding the impact of such interventions. Accordingly, in a cohort of outpatients with cirrhosis, we address steps one and two of the framework where we describe the self-reported nutritional intake and physical activity level of these patients and identify their perceived barriers and enablers to achieving adequate nutrition and exercise across Child-Pugh (CP) classes. This is an essential step prior to describing and understanding the impact of interventions.

PATIENTS AND METHODS

Study population

This prospective study was conducted between August 2012 to February 2015 (with a 1-year hiatus in recruitment due to lack of research staff). Consecutive eligible outpatients with cirrhosis were recruited from two tertiary care liver clinics in Edmonton, Alberta, Canada. Inclusion criteria were a previous diagnosis of liver cirrhosis made by clinical, laboratory, radiology, or histology methods and age ≥18 years. Exclusion criteria were hepatocellular carcinoma beyond transplant listing criteria, other active malignancy, chronic obstructive pulmonary disease requiring home oxygen, chronic kidney disease requiring dialysis, and congestive heart failure with ejection fraction <50%. Local ethics approval was obtained prior to patient recruitment. As part of their outpatient liver care, over 90% of the patients had access to a registered dietician. However, neither physiotherapy or exercise counselling was included as part of routine clinical care.

Data collection

General descriptive and socioeconomic data were collected from all patients. Dietary practices were characterized with a Food Frequency Questionnaire (FFQ). Barriers and enablers to nutritional intake were assessed with a nutritional barriers and enablers questionnaire. The International Physical Activity Questionnaire-Short Form (IPAQ-SF) was used to quantify physical activity.[15] Data were reported as low versus moderate/high activity. Barriers and enablers to physical activity were assessed using the Exercise Benefits/Barriers Scale (EBBS).[16] A detailed description of the surveys and their interpretation is found in the supplementary methods.

Statistical analysis

Demographic data were described using means and standard deviations (SD), medians, and interquartile ranges (IQR) or proportions. All baseline and survey data were presented for the group as a whole as well as subdivided into patients with CP-A cirrhosis versus those with CP-B/C disease. CP-B/C patients were grouped together because these patients frequently have decompensated liver disease and are distinguished from CP-A patients who are classified as clinically compensated. A *t*-test or Chi-square test was used to make comparisons between CP-A vs CP-B/C patients. A P value of <0.05 was considered statistically significant. All statistical analyses were performed with the Statistical Package for the Social Sciences version 22 statistical software (SPSS, Inc., Chicago, IL).

RESULTS

Patient characteristics

A total of 140 eligible patients were invited to participate, and 127 patients consented and completed the study. The mean age of the study group was 60 ± 9 years, 58% were men, 90% were of Caucasian ethnicity, nearly half were married, and 52% were diagnosed with CP-A [Table 1]. Almost half of the patients had completed high school and 28% were employed at the time of the survey administration. The most common disease etiologies were alcohol (35%), hepatitis C (27%), and nonalcohol NASH/cryptogenic (21%). The proportion of CP-A patients did not differ significantly across liver disease etiologies. Significant differences were found between CP-A and CP-B/C patients for measures of disease severity, however, other baseline characteristics were similar between groups.

Dietary intake patterns

The food frequency questionnaire revealed a mean of 2.7 ± 0.9 meals per day, which was not significantly different across CP classes. CP-B/C patients consumed more snacks per day (2.5 ± 1.4 vs. 1.8 ± 1.1, $P = 0.004$), were more likely to take oral nutritional supplements (ONS) such as Ensure or Boost (56% vs. 29%, $P = 0.002$), and were less

Table 1: Baseline characteristics of included patients

Variable	Patients (*n*=127)	CP-A (*n*=66)	CP-B/C (*n*=61)	*P* comparing CP-A vs. CP-B/C
Age (years)	60±9.4	61±9.5	59±9.2	0.22
Male	73 (57.5%)	39 (59.1%)	34 (55.7%)	0.72
Married	73 (57.5%)	37 (56.1%)	36 (59%)	0.86
Living alone	30 (23.6%)	17 (25.8%)	13 (21.3%)	0.68
Employment				
Employed	36 (28.3%)	24 (36.4%)	12 (19.7%)	0.06
Social assistance/disability	43 (33.9%)	17 (25.8%)	26 (42.6%)	
Retired/Pension plan	48 (37.8%)	25 (37.9%)	23 (37.7%)	
Education				
<High school	19 (15%)	9 (13.6%)	10 (16.4%)	0.87
High school	46 (36.2%)	25 (37.9%)	21 (34.4%)	
>High school	62 (48.8%)	32 (48.5%)	30 (49.2%)	
Cirrhosis etiology				
Alcohol	45 (35.4%)	21 (31.8%)	24 (39.3%)	0.54
HCV	34 (26.8%)	18 (27.3%)	16 (26.2%)	
HBV	3 (2.4%)	3 (4.5%)	0 (0%)	
PBC/PSC/AIH	16 (12.6%)	8 (12.1%)	8 (13.1%)	
NASH/Cryptogenic	26 (20.5%)	15 (22.7%)	11 (18%)	
Disease severity				
CP-A	66 (52%)	-	-	-
CP-B	34 (26.8%)	-	-	-
CP-C	27 (21.3%)	-	-	-
MELD	12±5.3	8.9±2.5	15±5.5	<0.001
Laboratory parameters				
Hemoglobin (g/L)	124±21	132±18	116±21	<0.001
WBC (× 109/L)	5.3±2.6	5.3±2.4	5.4±2.7	0.98
Platelets (× 109/L)	116±64	126±65	104±62	0.05
Albumin (g/L)	36±6	39±4.1	32±5.7	<0.001
Sodium (mmol/L)	138±4	139±2.9	136±4.6	<0.001
Creatinine (μmol/L)	89±48	79±29	101±61	0.01
Bilirubin (μmol/L)	32±42	19±12	47±56	<0.001
INR	1.3±0.4	1.1±0.1	1.5±0.4	<0.001

Data represented as mean ± standard deviation or proportion, AIH: Autoimmune hepatitis, CP-A: Child-Pugh class A, CP-B: Child-Pugh class B, CP-C: Child-Pugh class C, HBV: Hepatitis B virus, HCV: Hepatitis C virus, INR: International normalized ratio, MELD: Model for end-stage liver disease, NASH: Nonalcoholic steatohepatitis, PBC: Primary biliary cholangitis, PSC: Primary sclerosing cholangitis, WBC: White blood cells

likely to consume meat-based protein on a daily basis (66% vs. 85%, $P = 0.01$) when compared to CP-A patients. The consumption of foods from the other food groups were similar between groups [Table 2]. It was common for patients of all disease severities to take vitamins and minerals (84%).

Barriers and enablers to nutrition

Barriers to nutritional intake were present even in CP-A patients. Only 77% of CP-A patients could finish an entire meal and 68% reported a good appetite [Table 3]. All barriers were more common in patients with advanced cirrhosis. The most common symptomatic barriers in the CP-B/C groups were low energy (46%), pain/illness (34%), nausea/vomiting (34%), and ascites (31%). Only 56% of those in the CP-B/C group had a good appetite and 53% could eat an entire meal. CP-B/C patients were less likely to report that "food tastes good" (61% vs. 80%, $P = 0.02$). Food access was more of a struggle for CP-B/C patients reporting that it was significantly more challenging to purchase food (31% vs. 14%, $P = 0.02$), travel to grocery stores, and prepare meals (46% versus 26%, $P = 0.02$). Patients without a spouse ($n = 54$) were at higher risk for each of these food access barriers (data not shown).

With regard to enablers to nutritional intake, almost 90% of all patients reported that they were comfortable reading nutrition labels on food packaging, restricting dietary salt intake, and having enough money to purchase food.

Physical activity status

Only 15% of patients reported performing any vigorous physical activity for any duration. Moderate physical

Table 2: Selected Food Frequency Questionnaire responses in CP-A versus CP-B/C patients

Variable	All patients (*n*=127)	CP-A (*n*=66)	CP-B/C (*n*=61)	*P* comparing CP-A and CP B/C patients
Meals/day	2.71±0.93	2.62±0.75	2.81±1.09	0.26
Snacks/day	2.13±1.3	1.83±1.08	2.46±1.35	0.004
Takes vitamins and minerals	107 (84.3%)	58 (87.9%)	49 (80.3%)	0.33
Takes oral nutritional supplements	53 (41.7%)	19 (28.8%)	34 (55.7%)	0.002
≥1 serving dairy/day	113 (89%)	58 (87.9%)	55 (90.2%)	0.78
≥2 servings legumes or eggs/day	111 (87.4%)	58 (87.9%)	53 (86.9%)	1
Eat meat, fish or poultry every day	96 (75.6%)	56 (84.8%)	40 (65.6%)	0.01
≥2 serving fruits or vegetables/day	100 (78.7%)	49 (74.2%)	51 (83.6%)	0.29
≥1 serving of grains every day	114 (90%)	59 (89%)	55 (90%)	0.89
View themselves as having moderate to major nutritional problems	36 (28.3%)	14 (22.2%)	22 (36.1%)	0.11

Data represented as mean ± standard deviation or proportion, CP-A: Child-Pugh class A, CP-B: Child-Pugh class B, CP-C: Child-Pugh class C

Table 3: Barriers to nutrition in CP-A versus CP-B/C patients

Variable	CP-A patients who report agree or strongly agree (*n*=66)	CP-B/C patients who report agree or strongly agree (*n*=61)	*P* comparing CP-A vs. CP-B/C
Appetite			
My appetite is good	68.2%	55.7%	0.15
I feel hungry	50%	41%	0.31
I am able to eat an entire meal	77.3%	52.5%	0.003
I eat fruits and vegetables	93.9%	93.4%	0.91
I eat dairy products	87.9%	90.2%	0.68
I eat proteins	90.9%	90.2%	0.89
I eat grains	89.4%	90.2%	0.89
I eat enough to maintain my weight	87.9%	62.3%	0.001
Symptoms			
I experience nausea/vomiting	16.7%	34.4%	0.02
I experience diarrhea that interferes with eating	6.1%	24%	0.06
I have low energy that interferes with eating	28.8%	45.6%	0.07
I have fluid in my abdomen that interferes with eating	10.6%	31%	<0.001
I have pain/illness that interferes with eating	15.2%	34.4%	0.01
I have difficulty swallowing that interferes with eating	4.6%	11.5%	0.15
Food enjoyment			
Food tastes good	80.3%	60.7%	0.02
My taste has remained the same	66.7%	57.4%	0.28
My interest in food remains the same	77.3%	66.7%	0.19
Nutrition comprehension			
I understand how to read labels and restrict salt	87.9%	93.4%	0.29
I avoid foods as I am not sure how they will affect my liver disease	39.4%	27.9%	0.17
Food access			
I have enough money to buy food	90.9%	85.3%	0.33
I find it difficult to buy food	13.6%	31.2%	0.02
I have good support with buying/cooking food	71.2%	70.5%	0.93
I find it difficult to shop and prepare meals	25.8%	45.9%	0.02

CP-A: Child-Pugh class A, CP-B: Child-Pugh class B, CP-C: Child-Pugh class C

activities were reported by 34% of patients and 77% reported walking >10 minutes per day. Total combined patient activity was measured in metabolic equivalent of task (MET)-minutes/week with a median level of 693 (IQR: 1748). One MET is equal to energy expenditure of sitting quietly at rest. Less than 600 MET-minutes per week is considered a "low" physical activity level. When stratified according to the IPAQ scoring guide, 47%, 38%, and

15% of patients had low, moderate, and high activity levels, respectively. The mean MELD score in the low activity group was 13 ± 5.7 compared to 11.2 ± 4.9 ($P = 0.06$) when the moderate and high activity groups were combined [Figure 1].

Barriers and enablers to physical activity

Perceived barriers and enablers to exercise are presented in Table 4 (also Supplementary Table 1). When the mean scores of barriers were compared, two were prevalent for CP-B/C vs CP-A patients – "Exercise tires me" ($P = 0.04$) and "I am fatigued by exercise" ($P = 0.002$).

On the enablers side, the majority of patients reported that they agreed or strongly agreed with the health-benefits of exercise, including its effects on muscle strength and function, protection against cardiovascular disease, improved disposition, and mental alertness. The only significant difference was that less CP-B/C patients reported improved feelings of well-being from exercise (79% versus 92%, $P = 0.03$). Only 2% of the patients felt that exercise took too much time from their family responsibilities and exercise was too costly for only 9% of patients. The cumulative scores for both the benefits and barriers scales were nearly identical between CP-A and CP-B/C patients. Patients in the low activity group had a lower combined EBBS score than patients in the moderate/high activity group, $P = 0.008$ [Figure 1], suggesting a more positive attitude toward exercise in the moderate/high activity group.

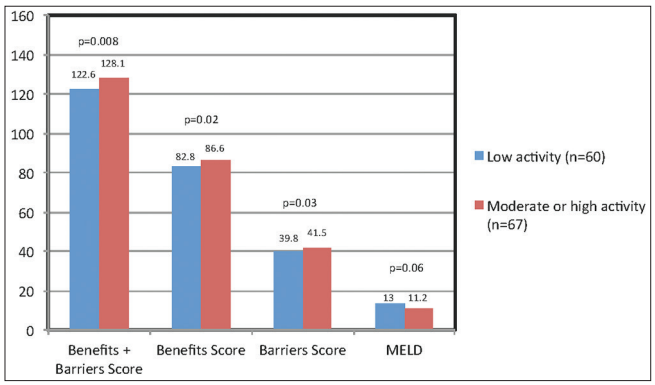

Figure 1: Mean Exercise Benefits/Barriers Scale (EBBS) score and model for end-stage liver disease (MELD) score stratified by activity level. Higher activity levels were associated with greater EBBS scores

DISCUSSION

This prospective study is the first to address the benefits and barriers of lifestyle interventions in cirrhosis. The main study findings are threefold. First, although the majority of patients consume foods from each food group, concordant with the published literature, patients with CP-B/C cirrhosis are less likely to consume meat-based protein on a daily basis than CP-A patients. Second, significant and potentially modifiable barriers exist to nutritional intake in cirrhosis, notable even in those patients with CP-A disease, but most marked in patients with CP-B/C disease. Third, although EBBS scores are similar to those reported for the general population, self-reported physical activity levels in patients with cirrhosis are low, with fatigue noted as the major barrier.

Since it is probable that many barriers to nutritional intake may be lessened by routine access to a dietician, we chose to focus on a cohort of patients in which the majority had received dietary counselling. This allowed us to determine the barriers that remained despite counselling. In accordance with this education, 90% of our patients reported a high level of comfort with label reading and 84% reported taking vitamin/mineral supplements. Furthermore, over half of the CP B/C patients consumed ONS and they also ate more snacks/day than CP-A patients. The high intake of ONS is likely a marker of the challenges these patients face with more traditional food intake. The majority of patients ate foods

Table 4: Selected questions from EBBS reported as mean±SD scores or percentage of patients responding either agree/strongly agree with comparison *P* values

Variable	CP-A mean (SD) score (*n*=66)	CP-B/C mean (SD) score (*n*=61)	*P* comparing mean score in CP-A vs. CP-B/C patients	CP-A patients who report agree or strongly agree (*n*=66)	CP-B/C patients who report agree or strongly agree (*n*=61)	*P* comparing percentage of patients who agree/strongly agree versus not
Exercise tires me	2.35±0.75	2.05±0.83	0.04	60.6%	70.5%	0.25
I am fatigued by exercise	2.42±0.75	2.00±0.80	0.002	51.5%	72.1%	0.02
Exercise takes too much time from my family responsibilities	3.38±0.52	3.25±0.51	0.15	1.5%	3.3%	0.52
It costs too much to exercise	3.24±0.70	3.21±0.64	0.81	9.1%	8.2%	0.86
I have improved feelings of well being from exercise	3.00±0.46	2.93±0.70	0.53	92.4%	78.7%	0.03
Benefits score	84.5±8.73	85.1±9.49	0.73	-	-	-
Barriers score	40.7±4.78	40.7±4.29	0.95	-	-	-

CP-A: Child-Pugh class A, CP-B: Child-Pugh class B, CP-C: Child-Pugh class C, EBBS: Exercise Benefits/Barriers Scale, SD: Standard deviation

from each of the four food groups, with the exception of lower daily meat intake in patients with CP-B/C disease. The latter finding is in accordance with previously reported data[17] and with findings from our local data in 630 liver transplant listed patients with cirrhosis, where we demonstrated that only 24% of patients met protein intake targets.[18]

The barriers to nutritional intake were not surprisingly more common in patients with advanced cirrhosis.[19] Symptoms such as poor appetite, nausea, pain, ascites control, and altered taste represent potential challenges to meeting nutritional targets. In a cohort of patients with Hepatitis C, Musialik *et al*. demonstrated that umami and salty tastes were impaired when compared to a healthy population, whereas sweet flavor perception was heightened.[20] Because umami is most associated with the palatability of proteins, the progressive derangement of umami sensitivity in patients with worsening liver disease becomes a possible explanation for decreased protein intake.[20] The finances to buy food were surprisingly reported as being adequate in most of our patients with cirrhosis, but shopping and meal preparation were recognized as being more common barriers to nutritional intake in patients with CP-B/C disease and in patients who were unmarried.

How can we use the nutritional information gathered in this study to inform change in practice? In our experience, the routine involvement of a dietician has been an essential enabler of improved education and nutritional intake, both of which are less likely to happen in a busy solo hepatologist clinic.[21] The current study has identified significant and potentially modifiable barriers to intake, particularly in patients with more advanced dysfunction but to our surprise even in patients with early stage cirrhosis. We would propose that nutritional intake patterns and barriers be routinely addressed at clinic visits (see Table 5 for potential clinic encounter questions).[22] If the palatability of animal-based protein is noted to be an issue, vegetarian protein alternatives (legumes, dairy) to achieving targets can be provided. ONS should be liberally recommended, particularly as a late-evening snack in patients with more advanced liver dysfunction. Socioeconomic status and certain factors such as education, occupational class, and household income have been clearly linked with healthy food choices in other studies.[23] Because these are potentially modifiable with social work support, our data would support directed questioning about shopping and meal preparation, particularly for patients with more advanced disease and for those without a spouse.

Physical activity levels were low in this cohort of patients and are in keeping with the low peak oxygen uptake identified in patients with cirrhosis.[3,11] The median physical activity level reported in our study cohort [693 (IQR: 1748) MET-minutes/week], much lower than the 1743 MET-minutes/week seen in a cohort of 187 dialysis patients from China,[24] highlights a large and potentially modifiable physical activity deficit. Despite the low physical activity levels, overall EBBS scores were similar to healthy controls,[16] suggesting that perceived barriers and enablers to exercise were similar to patients without chronic disease. Patients in the lowest activity category did have significantly lower EBBS scores than those of their higher activity counterparts, indicating greater perceived barriers and fewer perceived enablers. While many of the barriers investigated by the EBBS did not represent a major deterrent to activity, three statements, "exercise tires me," "I am fatigued by exercise," and "exercise is hard work for me" were the most frequently reported barriers to activity at 65%, 61%, and 58% respectively. The same three questions from the EBBS have been previously found to be the most prevalent in persons with physical disabilities or chronic health conditions.[25] Though it is well-known that fatigue poses a particular challenge for patients with chronic liver disease, effective strategies for combating fatigue are less well understood.[26]

What can be done to improve physical activity levels in our patients with cirrhosis? The lack of guidelines related to physical activity in cirrhosis and initial perceptions that exercise may be unsafe in cirrhosis[27] are an important barrier that make it less likely that physicians will promote

Table 5: Examples of screening questions that can be asked in clinical practice

Potential screening questions
Canadian Nutrition Screening Tool - positive if both questions answered YES
Have you lost weight in the past 6 months without trying to lose this weight?
Have you been eating less than usual for more than a week?
Have you noticed a reduction in your muscle size or strength in the last 6 months?
Are there any symptoms that make it challenging for you to take in as many calories as you did before?
Has the taste of food changed?
Do you feel full faster?
Do you have pain, nausea, vomiting or ascites that make it difficult for you to eat?
Are you still able to prepare meals during the day, or do you have someone at home to help prepare meals?
Are you able to get groceries yourself or do you have someone to help you with this?
Has the taste of meat changed or diminished for you?
Do you perform regular exercise, such as walking or going to the gym?
How many days per week?
How long does each exercise session last?
What type of exercise do you perform?
At what intensity (0 - nothing to 10 - maximum)?
If you do not exercise, what limits you from doing so?

it to their patients. The mitigation of this barrier will require further evidence of the benefits of exercise and integration of the existing data into practice guidelines. At a minimum, patients should be asked simple screening questions about physical activity in order to create awareness about the subject [Table 5]. Cardiac rehabilitation programs for coronary artery disease patients have significantly impacted both cardiac and all cause mortality through the combination of exercise programs and patient lifestyle education that focus on enhancing enablers and reducing barriers.[28] It is not too far of a stretch to hypothesize that similar results could be accomplished in the cirrhosis population. Similar to the importance of a dietician, we would propose the routine involvement of an expert in physical therapy would be an ideal component to a well-rounded multidisciplinary cirrhosis care team.

Several limitations of our study require mention. First, the sample size was moderate. Second, there was no healthy control group included in our study. Third, as it has previously been evaluated,[29-31] and as it would have extended the survey duration considerably, we did not collect detailed data on anthropometrics or calorie and protein intake in this population. Consequently, it was not possible to directly examine the relationship between our identified barriers, nutritional status, or quantitative macronutrient intake. Fourth, while the majority of patients had already received dietary counselling by the time they participated in the study, our clinics did not provide routine access to a physical therapist. It is probable that results in a cohort without dietician intervention or with access to a physical therapist would demonstrate different barriers. Fifth, although validated in many studies, when compared to direct measurements of physical activity by objective tools, the IPAQ-SF is biased to overestimate physical activity.[32] In our patient population, where physical activity levels are already very low, direct measurement would have likely led to even lower actual activity levels. Finally, as we chose to include only outpatients with cirrhosis, the results of our analysis cannot be extended to hospitalized patients with cirrhosis. Moreover, given the modest sample size, there would be insufficient power to perform statistical comparisons using three groups (CP-A/B/C).

CONCLUSIONS

To conclude, by evaluating barriers and enablers to lifestyle measures in cirrhosis, this study has addressed steps one and two in the Theoretical Domains Framework for implementing behaviour change. The cirrhosis patient population self-reported quantifiable issues with achieving daily adequate nutrition and exercise levels. Significant barriers remain regarding adoption of nutritional and physical activity interventions in patients with cirrhosis, especially as disease severity worsens but even in compensated patients. A unique feature of this study is that the barriers to nutritional interventions occur despite the patients having regular access to a registered dietician.

Ideally, clinicians should incorporate brief questions regarding a patient's nutritional intake and physical activity practices into their daily clinical encounters with patients [Table 5]. Recognizing that clinic time-limitations prevent detailed nutrition and exercise assessments,[33] we propose that clinicians begin monitoring their patients and creating a dialogue. As nutrition and exercise interventions are assessed for impact on quality of life, symptom burden, transplant wait list, MELD, and longevity, then it will be the health care system's responsibility to instill the necessary changes. In turn, this will shift to a more patient-focused care model by embracing a multidisciplinary chronic disease management approach with access to dietician, physical therapy, and social work resources. Research evaluating lifestyle interventions should consider and integrate possible solutions to overcoming modifiable barriers and enhancing enablers and sensible appreciation of the limitations of pharmacotherapies for some patient populations.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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Supplementary

Supplementary Table 1: All questions from the EBBS reported as mean±SD scores or percentage of patients responding either agree/strongly agree with comparison *P* values*

Variable	CP-A mean (SD) score (*n*=66)	CP-B/C mean (SD) score (*n*=61)	*P* comparing mean score in CP-A vs. CP-B/C patients	CP-A patients who report agree or strongly agree (*n*=66)	CP-B/C patients who report agree or strongly agree (*n*=61)	*P* comparing percentage of patients who agree/strongly agree versus not
I enjoy exercise	2.86±0.78	2.92±0.82	0.70	68.2%	72.1%	0.63
Exercise decreases feelings of stress and tension for me	2.82±0.58	2.95±0.72	0.25	75.8%	75.4%	0.96
Exercise improves my mental health	2.92±0.56	3.00±0.75	0.52	80.3%	82%	0.81
Exercise takes too much of my time	2.94±0.70	3.05±0.53	0.32	24.2%	11.5%	0.06
I will prevent heart attacks by exercising	3.17±0.57	3.05±0.67	0.29	90.9%	83.6%	0.22
Exercise tires me	2.35±0.75	2.05±0.83	0.04	60.6%	70.5%	0.25
Exercise increases my muscle strength	3.18±0.63	3.18±0.59	0.99	90.9%	93.4%	0.6
Exercise gives me a sense of personal accomplishment	2.95±0.59	3.02±0.70	0.59	83.3%	83.6%	0.97
Places for me to exercise are too far away	2.77±0.76	2.98±0.76	0.12	27.3%	16.4%	0.14
Exercising makes me feel relaxed	2.80±0.56	2.85±0.57	0.62	75.8%	78.7%	0.7
Exercising lets me have contact with friends and persons I enjoy	2.42±0.73	2.57±0.76	0.26	43.9%	54.1%	0.26
I am too embarrassed to exercise	3.27±0.65	3.36±0.58	0.42	10.6%	4.9%	0.24
Exercising will keep me from having high blood pressure	3.06±0.49	2.98±0.62	0.44	90.9%	80.3%	0.09
It costs too much to exercise	3.24±0.70	3.21±0.64	0.81	9.1%	8.2%	0.86
Exercising increases my level of physical fitness	3.21±0.41	3.20±0.51	0.85	100%	95.1%	0.07
Exercise facilities do not have convenient schedules for me	2.98±0.62	3.11±0.52	0.21	13.6%	8.2%	0.33
My muscle tone is improved with exercise	3.12±0.51	3.10±0.51	0.80	92.4%	95.1%	0.54
Exercising improves functioning of my cardiovascular system	3.14±0.46	3.16±0.55	0.76	98.5%	95.1%	0.28
I am fatigued by exercise	2.42±0.75	2.00±0.80	0.002	51.5%	72.1%	0.02
I have improved feelings of well being from exercise	3.00±0.46	2.93±0.70	0.53	92.4%	78.7%	0.03
My spouse (or significant other) does not encourage exercising	2.83±0.78	3.08±0.69	0.06	36.4%	13.1%	0.002
Exercise increases my stamina	3.05±0.51	3.00±0.48	0.61	92.4%	91.8%	0.9
Exercise improves my flexibility	2.98±0.54	3.08±0.49	0.29	84.9%	95.1%	0.06
Exercise takes too much time from family relationships	3.30±0.58	3.26±0.58	0.69	6.1%	3.2%	0.46
My disposition is improved with exercise	3.00±0.43	2.92±0.56	0.35	90.9%	83.6%	0.22
Exercising helps me sleep better at night	2.89±0.68	2.92±0.71	0.85	74.2%	73.8%	0.95
I will live longer if I exercise	3.00±0.53	3.11±0.69	0.29	86.4%	81.2%	0.5
I think people in exercise clothes look funny	3.12±0.62	3.15±0.65	0.82	13.6%	14.8%	0.86
Exercise helps me decrease fatigue	2.73±0.57	2.61±0.71	0.29	69.7%	63.9%	0.49
Exercising is a good way for me to meet new people	2.52±0.61	2.62±0.69	0.35	48.5%	60.7%	0.17
My physical endurance is improved by exercising	3.03±0.39	3.00±0.58	0.73	93.9%	90.2%	0.43
Exercising improves my self-concept	2.88±0.45	3.00±0.48	0.15	83.3%	88.5%	0.41
My family members do not encourage me to exercise	2.95±0.81	2.92±0.76	0.80	25.8%	19.7%	0.42
Exercising increases my mental alertness	2.98±0.41	3.03±0.45	0.53	90.9%	91.8%	0.86
Exercise allows me to carry out normal activities without becoming tired	2.83±0.51	2.67±0.75	0.16	77.3%	67.2%	0.21
Exercise improves the quality of my work	2.80±0.53	2.74±0.58	0.51	77.3%	67.2%	0.21
Exercise takes too much time from my family responsibilities	3.38±0.52	3.25±0.51	0.15	1.5%	3.3%	0.52
Exercise is good entertainment for me	2.67±0.64	2.70±0.72	0.75	63.6%	68.9%	0.54
Exercising increases my acceptance by others	2.47±0.64	2.59±0.69	0.31	48.5%	57.4%	0.32
Exercise is hard work for me	2.26±0.87	2.23±0.90	0.86	59.1%	55.7%	0.71
Exercise improves overall body functioning for me	3.02±0.37	3.13±0.50	0.14	93.9%	93.4%	0.91

Contd...

Supplementary Table 1: Contd...

Variable	CP-A mean (SD) score (*n*=66)	CP-B/C mean (SD) score (*n*=61)	*P* value comparing mean score in CP-A vs. CP-B/C patients	CP-A patients who report agree or strongly agree (*n*=66)	CP-B/C patients who report agree or strongly agree (*n*=61)	*P* comparing percentage of patients who agree/strongly agree versus not
There are too few places for me to exercise	2.91±0.67	3.03±0.63	0.29	15.2%	11.5%	0.55
Exercise improves the way my body looks	3.00±0.43	3.02±0.62	0.86	93.9	85.3	0.11
Benefits score	84.5±8.73	85.1±9.49	0.73	-	-	-
Barriers score	40.7±4.78	40.7±4.29	0.95	-	-	-

*Score range for benefits score is from 29 to 116 and score range for barriers score is from 14 to 56. Barrier parameters are highlighted in grey. Individual questions are scored from 1 to 4 with 1 = strongly disagree and 4 = strongly agree. Higher scores for benefit scale indicate greater perceived benefits and higher scores for barriers score indicate fewer barriers as it is scored in reverse as per EBBS scoring guide