

# Nutritional Assessments of Patients with Non-alcoholic Fatty Liver Disease

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## Abstract

**Background** Obesity is not only associated with nonalcoholic fatty liver disease (NAFLD) but it also adversely affects the progression of other liver diseases. There are limited data regarding the dietary habits of patients with chronic liver disease.

**Methods** Nutrition surveys containing 13 different food groups were mailed. Nutrition scores were calculated based on weekly servings. Foods were also divided into USDA food pyramid categories with conversion of each group into calories expended. Clinico-demographic data were available. NAFLD patients were compared to patients with chronic viral hepatitis. **Results** A total of 233 subjects were included: age  $52.5 \pm 10.0$  years, Body mass index (BMI)  $28.1 \pm 6.5$ , MS 24.2%, 31.8% NAFLD, 48.1% hepatitis C virus (HCV), and 20.2% hepatitis B virus (HBV). Six nutrition indices were different among the groups. NAFLD and HCV consumed more low-nutrient food ( $p=0.0037$  and  $0.0011$ ) and more high-sodium food than HBV ( $p=0.0052$  and  $0.0161$ ). Multivariate analysis showed that NAFLD and HCV consumed more high-fat sources of meat/protein than HBV ( $p=0.0887$  and  $0.0626$ ). NAFLD patients consumed less calories from fruits compared to HCV and HBV patients ( $p=0.0273$  and

$0.0023$ ). Nine nutrition indices differed according to BMI. Univariate analysis showed that obese/overweight patients consumed more high-fat sources of meat/protein ( $p=0.0078$  and  $0.0149$ ) and more high-sodium foods ( $p=0.0089$  and  $0.0062$ ) compared to the normal-weight patients. In multivariate analysis, normal-weight patients consumed more fruits than obese ( $p=0.0307$ ). Overweight patients also consumed more calories of meat and oil than normal-weight patients ( $p=0.0185$  and  $0.0287$ ).

**Conclusion** NAFLD and HCV patients have similar dietary habits. Patients with HBV have the healthiest dietary habits. Specific dietary interventions should focus on decreasing intake of low-nutrient and high-sodium food, as well as high-fat sources of meat/protein.

**Keywords** Obesity · NAFLD · Nutrition

## Introduction

Obesity increases the risk of developing a number of serious systemic disorders, such as cardiovascular disease, diabetes, cancer and nonalcoholic fatty liver disease (NAFLD). Obesity is a complex disease that has both genetic as well as dietary intake and activity components. The latter two make up important environmental factors contributing to obesity. Among chronic liver diseases, NAFLD is increasingly recognized as one of the most common, affecting 20–30% of the US population [1]. It has also been well established that obesity, metabolic syndrome (MS), and insulin resistance are all strongly associated with NAFLD. In fact, NAFLD is now recognized as the hepatic manifestation of MS [2]. In addition to its primary form of liver disease (NAFLD), obesity can exacerbate progression of

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other liver diseases such as chronic hepatitis C and to a lesser extent alcohol-related liver disease, iron overload and chronic hepatitis B. Furthermore, in patients with chronic hepatitis C, obesity has been associated with impaired treatment response to antiviral therapy [3–5].

Despite the important contribution of obesity to a number of liver diseases, dietary habits of patients with NAFLD and chronic viral hepatitis have not been fully studied. A few studies have suggested that NAFLD patients may consume more carbohydrates, saturated fat, and protein from meat [6–8]. Although weight loss through dietary changes is recommended for patients with NAFLD, only weight loss with bariatric surgery has consistently been shown to improve all important outcomes of patients with NAFLD. Furthermore, it is unknown whether dietary intake of patients with different types of liver disease differs from each other and whether these differences can be used as potential targets for future therapeutic interventions. In this study, our aim was to compare the nutritional status of patients with three common causes of chronic liver diseases—NAFLD, HCV, and HBV. This information may be important for dietary intervention through weight loss programs or postbariatric surgery.

## Methods

This study included patients with established diagnoses of NAFLD, chronic hepatitis B and C. The patients with liver mass (without chronic liver disease), acute hepatitis and post-liver transplant were excluded. All the patients received a nutrition survey which contained 7 items in 13 categories measuring dietary choices and frequencies of consumption for a wide variety of foods. The Nutrition Survey included the following categories: (1) vegetable sources of protein; (2) lean sources of protein; (3) high-fat sources of meat/protein; (4) total vegetable consumption; (5) low-fat milk products; (6) high-fat milk products; (7) low-nutrient dense foods, baking products, fats, oils, and sweets; (8) high caffeine; (9) alcohol; (10) high-sodium foods; (11) fruits; (12) bread and starchy foods; (13) cereals and grains.

All the patients enrolled lived in the USA (Mid-Atlantic States). Demographic and clinical data such as weight, height, and past medical history were available. Scores from nutrition questionnaire were calculated based on weekly servings and entered into a database. Specific foods were also divided into USDA food pyramid categories including (1) fats and oils; (2) milk, yogurt, cheese; (3) meat, poultry, fish, dry beans, eggs, and nuts; (4) fruits; (5) vegetables; (6) bread, cereal, rice, and pasta; and (7) other. Once the food was divided into the specific category, serving sizes were converted to calories based on the USDA file data. The protocol was fully approved by our institutional review board.

## Statistical Analysis

Continuous variables and categorical variables are summarized as mean±SD and percent (%), respectively. Chi-square or Fisher exact test was used to investigate the association between categorical variables. Comparisons between various groups were done using Student's *t* test or analysis of variance for normal distributed data, and for nonnormal data using Wilcoxon–Mann–Whitney test or Kruskal–Wallis test. Additional analysis was performed using Pearson or Spearman correlation to investigate the association between normal or nonnormal data, respectively. Bonferroni method was used to adjust the *p* values for comparisons on more than two groups.

Multivariate analyses were conducted using general linear model with 13 different nutrition domains as outcome variables to investigate the nutrition patterns in concerned groups while controlling for confounders. Those covariates significant at 0.10 levels on univariate analysis were included in the multivariate model. The same type of multivariate analysis was used with the seven food pyramid groups.

For all our analyses, two failed *p* values were used, and a *p* value of <0.05 was considered significant. All analyses were performed using SAS software (SAS, Cary, NC, USA).

## Results

### Demographics

A total of 233 patients with NAFLD, HCV, or HBV were included. Clinical and demographic data are provided in Table 1. The entire cohort's mean age was 52.5±10.0 years

**Table 1** Clinical and demographic characteristics

Characteristics	N=233
Age (years, mean±SD)	52.5±10.0
Gender (% male)	47.1
Ethnicity (% Caucasian)	60.8
Body mass index (%)	
Underweight (BMI<18.5)	1.8
Normal (18.5≤BMI<25)	31.4
Over-weight (25≤BMI<30)	35.9
Obese (BMI≥30)	30.9
Diabetes mellitus (%)	16.5
Hypertension (%)	30.6
Hyperlipidemia (%)	34.4
Metabolic syndrome (%)	24.2
Primary liver disease diagnosis	
Hepatitis C (%)	48.1
NAFLD (%)	31.8
Hepatitis B (%)	20.2

**Table 2** Comparison of metabolic syndrome and obesity in NAFLD, HCV, and HBV

Characteristics	NAFLD (N=74)	HCV (N=112)	HBV (N=47)	P value	
Metabolic syndrome (%)	50.0	12.7	10.6	NAFLD vs. HCV	<0.001
				NAFLD vs. HBV	<0.001
				HCV vs. HBV	1.0000
Obesity with BMI $\geq$ 30 (%)	46.5	28.3	13.0	NAFLD vs. HCV	0.0492
				NAFLD vs. HBV	0.0007
				HCV vs. HBV	0.1812

with 47.1% being male. Various ethnic groups were represented with 60.8% Caucasians, 23.1% Asians, 11.6% African-Americans, and 4.5% others.

A breakdown of patients with NAFLD, HCV, and HBV who had MS versus obesity is provided in Table 2. Metabolic syndrome was defined according to the adult treatment panel (ATP) III criteria [1, 2]. Of the entire cohort, 24.2% met the diagnosis of metabolic syndrome, while 50% of NAFLD patients had MS. In comparison, MS occurred in 12.7% in HCV and 10.6% in the HBV group [NAFLD vs. HCV ( $p<0.001$ ) and NAFLD vs. HBV ( $p<0.001$ )]. Obesity defined as body mass index (BMI) $\geq$ 30 occurred in 46.5% of NAFLD patients as compared to 28.3% in HCV ( $p=0.0492$ ) and 13.0% in HBV ( $p=0.0007$ ).

#### Comparison of Nutritional Scores and Calories for USDA Food Pyramid Nutrition Categories Between NAFLD, HCV, and HBV

Six of 13 nutrition categories differed significantly between NAFLD, HCV, and HBV in the univariate analysis (Table 3). NAFLD group consumed more vegetable sources of protein than HCV ( $p=0.0398$ ). Both NAFLD and HCV

consumed more low-nutrient food ( $p=0.0037$  and  $0.0011$ , respectively) and more high-sodium food than HBV ( $p=0.0052$  and  $0.0161$ , respectively). HBV patients had a more healthy diet with consuming more total vegetable consumption than NAFLD ( $p=0.0434$ ) and more cereal and grains than NAFLD and HCV ( $p=0.0006$  and  $0.0001$ , respectively). Moreover, HCV and HBV patients consumed more fruits than NAFLD patients ( $p=0.0066$  and  $0.0192$ , respectively).

Calories for three food pyramid nutrition categories differed between NAFLD, HCV, and HBV in the univariate analysis (Table 4). Consistent with the nutrition score analysis, NAFLD patients consumed less calories of fruits than HCV and HBV ( $p=0.0112$  and  $0.0319$ , respectively). NAFLD and HCV patients also consumed more calories of milk products than HBV ( $p=0.0356$  and  $0.0137$ , respectively). Lastly, NAFLD patients consumed more calories of meat and bean than HCV ( $p=0.0316$ ).

The multivariate analysis showed that NAFLD and HCV patients tended to consume more high-fat sources of meat/protein than HBV patients ( $p=0.0887$  and  $0.0626$ , respectively). The multivariate analysis also showed that NAFLD patients consumed less calories of fruits than HCV and HBV ( $p=0.0273$  and  $0.0023$ , respectively).

**Table 3** Comparison of weekly serving nutrition scores between NAFLD, HCV, and HBV

Nutrition domains	NAFLD (N=74)	HCV (N=112)	HBV (N=47)	P value
Vegetable sources of protein	4.98 $\pm$ 4.60	3.81 $\pm$ 3.24	3.87 $\pm$ 3.04	0.0398
Lean sources of protein	3.88 $\pm$ 2.35	3.45 $\pm$ 2.28	4.14 $\pm$ 2.48	0.0948
High-fat sources of meat/protein	4.30 $\pm$ 3.17	4.01 $\pm$ 3.52	3.39 $\pm$ 2.93	0.2469
Total vegetable consumption	14.55 $\pm$ 8.46	15.91 $\pm$ 8.01	18.17 $\pm$ 10.40	0.0434
Low-fat milk products	3.26 $\pm$ 3.92	3.06 $\pm$ 3.82	2.17 $\pm$ 3.57	0.0796
High-fat milk products	4.87 $\pm$ 4.37	4.74 $\pm$ 3.99	3.87 $\pm$ 3.55	0.5709
Low-nutrient dense foods/baking products, fats, oil, sweets	11.63 $\pm$ 7.33	11.84 $\pm$ 6.51	7.38 $\pm$ 5.71	0.0006
High in caffeine	10.17 $\pm$ 4.91	9.62 $\pm$ 4.71	8.44 $\pm$ 4.65	0.0888
Alcohol	0.42 $\pm$ 1.24	0.49 $\pm$ 1.38	0.21 $\pm$ 0.44	0.6423
High sodium foods	12.96 $\pm$ 6.23	12.28 $\pm$ 6.24	9.33 $\pm$ 5.66	0.0156
Fruits	12.06 $\pm$ 9.03	16.15 $\pm$ 8.95	16.66 $\pm$ 9.94	0.0124
Bread and starchy foods	6.24 $\pm$ 4.23	6.94 $\pm$ 3.88	5.81 $\pm$ 3.77	0.1828
Cereals and grains	5.11 $\pm$ 4.07	4.88 $\pm$ 3.68	7.63 $\pm$ 3.26	0.0001
Total calorie	7388.0 $\pm$ 2390.7	7175.4 $\pm$ 2555.0	6900.6 $\pm$ 2754.9	0.6345

**Table 4** Comparison of calories for USDA food pyramid nutrition categories between NAFLD, HCV, and HBV

Nutrition categories (Calories)	NAFLD (N=74)	HCV (N=112)	HBV (N=47)	P value
Grains	1127.5±940.8	1128.2±586.7	1048.8±686.5	0.8087
Vegetables	935.4±480.1	1000.5±474.2	987.3±530.7	0.6644
Fruits	715.6±561.6	931.2±550.6	943.4±556.1	0.0112
Milk	845.2±621.9	866.9±556.2	620.6±511.0	0.0137
Meat and bean	2424.8±1176.3	2057.8±1143.9	2251.4±1031.7	0.0316
Fat and oils	822.9±625.9	744.9±587.6	679.5±675.6	0.4488
Other	319.0±342.1	261.7±221.3	276.1±200.8	0.3424

#### Comparison of Nutritional Scores and Calories for USDA Food Pyramid Nutrition Categories Between Patients with and without Cirrhosis

A total of 25.3% of the cohort had either a clinical or histological diagnosis of cirrhosis. Only two nutrition indices were different between those with cirrhosis and those without cirrhosis (Table 5). Although univariate analysis showed a difference in the consumption of bread and starchy foods ( $p=0.0039$ ) and alcohol ( $p=0.0019$ ), the multivariate analysis revealed that cirrhotic patients tended to consume more low-fat milk products ( $p=0.0561$ ). On the other hand, the multivariate analysis conducted with calories for the USDA food pyramid nutrition categories (Table 6) showed that cirrhotic patients consumed more calories of grains than noncirrhotic patients ( $p=0.0153$ ).

#### Comparison of Nutritional Scores and Calories for USDA Food Pyramid Nutrition Categories According to the Body Mass Index

This cohort of patients with chronic liver disease was categorized as underweight ( $BMI<18.5$ ), normal weight ( $18.5\leq BMI<25.0$ ), overweight ( $25.0\leq BMI<30$ ), and

obese ( $BMI\geq 30.0$ ). The underweight category was 1.8%, the normal-weight category was 31.4%, the overweight category was 35.9%, and the obese category was 30.9% of the entire cohort. After excluding underweight patients and those with incomplete data, 219 patients were used for this analysis (Tables 7, 8). Nine nutrition categories differed significantly between these BMI groups in the univariate analysis (Table 7). Univariate analysis showed that obese and overweight patients consumed more high-fat sources of meat/protein ( $p=0.0078$  and  $0.0149$ , respectively) and more high-sodium foods ( $p=0.0089$  and  $0.0062$ , respectively) as compared to the normal-weight patients. Overweight group also consumed more high-fat milk products ( $p=0.0064$ ) and more low-nutrient foods ( $p=0.0101$ ) as compared to the normal-weight group. Normal-weight and overweight groups consumed more fruit than the obese group ( $p=0.0484$  and  $0.0392$ , respectively). Overweight patients consumed more cereals and grains than obese patients ( $p=0.0281$ ). Total calories differed only between normal and overweight patients with less calories consumed by the normal-weight group ( $p=0.0090$ ).

Calories for four food pyramid nutrition categories differed between the BMI groups in the univariate analysis (Table 8). Overweight patients consumed more calories of

**Table 5** Comparison of weekly serving nutrition scores between cirrhosis and noncirrhosis patients

Nutrition domains	Noncirrhosis (N=174)	Cirrhosis (N=59)	P value
Vegetable sources of protein	4.45±3.98	3.43±2.72	0.1956
Lean sources of protein	3.80±2.30	3.51±2.49	0.2038
High-fat sources of meat/protein	3.94±3.36	4.10±3.12	0.5944
Total vegetable consumption	15.92±8.51	15.57±9.12	0.5278
Low-fat milk products	2.89±3.68	3.08±4.17	0.7333
High-fat milk products	4.46±3.65	5.09±5.06	0.8873
Low-nutrient dense foods/baking products, fats, oil, sweets	10.67±6.67	11.73±7.35	0.5483
High in caffeine	9.39±4.78	10.13±4.80	0.1665
Alcohol	0.51±1.36	0.13±0.48	0.0019
High sodium foods	11.87±6.35	12.32±5.94	0.5727
Fruits	14.55±9.34	15.93±9.31	0.3172
Bread and starchy foods	6.02±3.71	8.08±4.45	0.0039
Cereals and grains	5.36±3.91	5.93±3.74	0.2313
Total calorie	7044.1±2668.7	7410.5±2820.7	0.1803

**Table 6** Comparison of calories for USDA food pyramid nutrition categories between cirrhosis and noncirrhosis patients

Nutrition categories (calories)	Noncirrhosis (N=174)	Cirrhosis (N=59)	P value
Grains	1037.6±686.4	1336.7±826.9	0.0074
Vegetables	957.2±463.0	1035.9±550.7	0.2843
Fruits	828.6±551.4	970.3±584.3	0.0981
Milk	778.7±521.0	902.2±707.8	0.1546
Meat and Bean	2247.3±1175.3	2113.4±1030.2	0.4364
Fat and oils	726.4±619.8	848.1±606.8	0.1940
Other	281.1±256.1	288.0±284.0	0.8647

grains and calories of fat than normal-weight patients ( $p=0.0489$  and  $0.0118$ , respectively). Obese and over-weight patients consumed more calories of meat and bean than normal-weight patients ( $p=0.0367$  and  $0.0490$ , respectively). Over-weight patients also consumed more calories of fruits than obese patients ( $p=0.0237$ ).

In the multivariate analysis, normal-weight patients with chronic liver disease consumed more fruits than obese patients ( $p=0.0307$ ). Overweight patients consumed more cereals and grains than normal-weight patients ( $p=0.0288$ ). Obese patients with chronic liver disease tended to consume more total vegetable consumption ( $p=0.0512$ ) and high-fat milk products ( $p=0.0587$ ) compared to the normal-weight patients. Overweight patients consumed more calories of meat and oils than normal-weight patients ( $p=0.0185$  and  $0.0287$ , respectively).

## Discussion

This is the first in-depth nutritional assessment of patients with NAFLD and two other common types of chronic liver disease. Our study shows that dietary habits of NAFLD and HCV patients were similar to each other and different from

patients with chronic hepatitis B. NAFLD and HCV patients tended to have higher consumption of low nutrient, high-fat sources of meat/protein, and high sodium foods. Although dietary habits of NAFLD and HCV were similar in the three indices of low nutrient, high-fat sources of meat/protein, and high-sodium foods, these specific measures may not necessarily translate into the development of obesity or MS in a different cohort of patients. Additional factors such as physical activity and basal metabolic rate may also play an important role in the development of conditions associated with metabolic syndrome.

Furthermore, current medical practice dictates lifestyle modification including dietary changes as the primary intervention for NAFLD. However, there are little data on the long-term efficacy of this approach for patients with NAFLD. Additionally, there seems to be a discrepancy between the current patient practice and general recommended provider guidelines. This may be due to either patient non-adherence or lack of emphasis or appropriate education from the healthcare providers.

The fact that NAFLD, HCV, and those who are overweight had high consumption of low-nutrient foods is clinically significant. Low-nutrient foods such as sweets that contain high fructose contents have been found to

**Table 7** Comparison of weekly serving nutrition scores between BMI groups

Nutrition domains	Normal-weight (N=70)	Overweight (N=80)	Obese (N=69)	P value
Vegetable sources of protein	3.99±3.50	4.16±3.32	4.48±4.57	0.4168
Lean sources of protein	3.46±2.21	3.84±2.43	3.80±2.48	0.0547
High-fat sources of meat/protein	3.01±2.71	4.33±3.15	4.50±3.77	0.0142
Total vegetable consumption	15.31±8.14	15.30±8.90	17.20±9.22	0.4877
Low-fat milk products	2.94±3.44	2.34±3.58	3.61±4.29	0.0436
High-fat milk products	3.79±3.76	5.73±4.30	4.28±3.91	0.0113
Low-nutrient dense foods/baking products, fats, oil, sweets	8.95±5.86	12.28±7.67	10.96±6.43	0.0101
High in caffeine	9.33±5.00	9.23±4.64	10.38±4.99	0.5414
Alcohol	0.43±1.34	0.62±1.55	0.21±0.55	0.0477
High-sodium foods	9.89±5.54	12.93±5.82	12.88±6.80	0.0147
Fruits	15.81±8.89	15.86±9.88	12.33±9.26	0.0392
Bread and starchy foods	5.45±4.06	7.38±4.07	6.29±3.75	0.0032
Cereals and grains	5.59±4.10	6.14±4.12	4.70±3.18	0.0281
Total calorie	6603.3±2839.0	7765.9±2613.8	7209.9±2644.5	0.0416

**Table 8** Comparison of calories for USDA food pyramid nutrition categories between BMI groups

Nutrition categories (calories)	Normal-weight ( <i>N</i> =70)	Overweight ( <i>N</i> =80)	Obese ( <i>N</i> =69)	<i>P</i> value
Grains	1,017.8±926.8	1,257.9±658.1	1,046.5±584.5	0.0489
Vegetables	912.0±512.0	990.9±484.4	1,046.6±477.1	0.4429
Fruits	857.4±538.0	962.3±597.9	747.5±557.2	0.0237
Milk	771.7±551.7	855.5±562.8	805.4±635.5	0.7206
Meat and bean	1,953.7±1,089.8	2,320.7±1,017.4	2,357.6±1,294.5	0.0367
Fat and oils	628.3±554.5	883.9±684.2	771.0±588.1	0.0118
Other	296.5±318.9	268.4±185.5	302.7±295.9	0.7730

increase de novo lipogenesis, especially in the insulin resistant overweight subjects [9]. Solga also showed that high-carbohydrate intake (60% of calories) was associated with a higher degree of hepatic inflammation [10]. Thus, it is reasonable to deduce that low nutrient foods should be restricted or at least limited in patients with chronic liver diseases, especially if there is a concomitant insulin resistance or diabetes mellitus.

In our study, there was a tendency for NAFLD, HCV, and obese patients with chronic liver disease to consume more high-fat sources of meat/protein. This trend is corroborated by previous studies of Cortez-Pinto and Musso [7, 8]. Literature suggests that saturated fatty acids promote endoplasmic reticulum stress and hepatocyte injury which have been implicated in the pathogenesis of obesity related liver disease (NAFLD) [11]. It seems reasonable to suggest that high-fat sources of meat/protein, which contribute to obesity, should be limited in patients with chronic liver disease. However, study by Solga showed that hepatic inflammation was less prominent in those with higher fat intake (48% of the total calories) which is in direct contradiction to the current dietary recommendations for NAFLD patients [10].

Our study also showed that hepatitis B patients had the healthiest diet. They consumed the greatest amount of fruits and vegetables and tended to consume more lean sources of protein and overall fewer calories. This may explain the lower incidence of MS and obesity and in patients with HBV. It is important to note that the majority of HBV patients were of Asian descent which may explain some of these differences. However, our multivariate analysis did control for race as a potential confounder. Nevertheless, future studies must further address this important issue.

In this study, we also assessed the dietary habit of patients with or without cirrhosis. Our results showed a similar prevalence of MS and obesity in patients with or without cirrhosis. Cirrhotic patients also consumed less alcohol, thereby being in compliance with clinical instructions to avoid alcohol. In addition, cirrhotic patients consumed more calories of grain than noncirrhotic patients. Otherwise,

nutrient intakes between cirrhotic and noncirrhotic patients were similar. Although malnutrition can be seen in 27–87% of patients with chronic liver disease, our study did not specifically investigate malnutrition in these patients [12]. Nevertheless, if there were significant differences between cirrhotics and noncirrhotics, we would have expected different dietary intakes between these two groups.

Analysis based on BMI groups also provided us with insight into the possible dietary contributors to obesity in patients with chronic liver disease. Overweight patients with chronic liver disease consumed more cereal along with more calories from meat and oils as compared to normal-weight patients. Although we cannot conclude a causal relationship, it is reasonable to deduce that reducing intakes in the meat and oil may be targeted for weight loss plan of these overweight/obese patients with chronic liver disease. With accomplishing sustained weight loss, one can expect some reduction of the negative influence of obesity on chronic liver diseases.

This study does have some limitations. With any questionnaire study, there is the possibility of recall bias or reporting bias. Future investigation should ideally be done prospectively looking to see if education specific to the three nutritional categories of low nutrient, high-fat sources of meat/protein, and high-sodium foods that differed between the three major liver disease groups affects the overall prevalence of metabolic syndrome, obesity, or progression of liver disease. Our findings suggest, however, that additional nutrition education and counseling are needed regarding increasing nutrient dense foods, fruit, and vegetable consumption.

Nevertheless, this study provides important data regarding the nutritional status of patients with NAFLD and other important causes of chronic liver disease. Our study provides data on the relatively poor dietary habits of NAFLD and HCV patients in comparison to patients with HBV. Food categories that need to be targeted for potential intervention include the low-nutrient diets, high-fat sources of meat/protein, and high-sodium foods. Referral to a nutritionist to further educate these patients about the

important role of nutrition in liver disease should also be integrated into the plan of care. In addition to the generic recommendation for “low fat, low calorie” diet, we may be able to specifically focus on these three nutritional categories in hopes of reducing the impact of obesity and MS on chronic liver disease.

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## References

1. Neuschwander-Tetri BA, Caldwell SH. Nonalcoholic steatohepatitis: summary of an AASLD single topic conference. *Hepatology*. 2003;37:1202–9.
2. Marchesini G, Brizi M, Morselli-Labate AM, Bianchi G, Bugianesi E, McCullough AJ, et al. Association of nonalcoholic fatty liver disease with insulin resistance. *Am J Med*. 1999; 107:450–5.
3. Poustchi H, Negro F, Hui J, Cua IHY, Brandt LR, Kench JG, et al. Insulin resistance and response to therapy in patients infected with chronic hepatitis C virus genotypes 2 and 3. *J Hepatology*. 2008;48:28–34.
4. Bondini S, Kallman J, Wheeler A, Prakash S, Gramlich T, Jondle DM, Younossi ZM. Impact of non-alcoholic fatty liver disease on chronic hepatitis B. *Liver International*. 2007;27:607–11.
5. Bondini S, Younossi ZM. Non-alcoholic fatty liver disease and hepatitis C infection. *Minerva Gastroenterol Dietol*. 2006;52: 135–43.
6. Zelber-Sagi S, Nitzan-Kaluski D, Goldsmith R, Webb M, Blendis L, Halpern Z, et al. Long term nutritional intake and the risk for non-alcoholic fatty liver disease (NAFLD): a population based study. *J Hepatol*. 2007;47(5):711–7.
7. Cortez-Pinto H, Jesus L, Barros H, Lopes C, Moura MC, Camilo ME. How different is dietary pattern in non-alcoholic steatohepatitis patients? *Clin Nutr*. 2006;25:816–23.
8. Musso G, Gambino R, De Michieli F, Cassader M, Rizzetto M, Durazzo M, et al. Dietary habits and their relations to insulin resistance and postprandial lipemia in nonalcoholic steatohepatitis. *Hepatology*. 2003;37:909–16.
9. McDevitt RM, Scott SJ, Harding M, Coward WA, Bluck LJ, Prentice AM. De novo lipogenesis during controlled overfeeding with sucrose or glucose in lean and obese women. *Am J Clin Nutr*. 2001;74:737–46.
10. Solga S, Alkhrashe AR, Clark JM, Torbenson M, Greenwald A, Diehl AM, et al. Dietary composition and nonalcoholic fatty liver disease. *Dig Dis Sci*. 2004;49:1578–83.
11. Wang D, Wei Y, Pagliassotti MJ. Saturated fatty acids promote endoplasmic reticulum stress and liver injury in rats with hepatic steatosis. *Endocrinology*. 2006;147(2):943–51.
12. Wendland BE. Nutritional guidelines for persons infected with the hepatitis C virus: a review of the literature. *Can J Diet Pract Res*. 2001;62(1):7–15.