Section: General Medicine

Original Research Article

ASSESSING THE IMPACT OF LIFESTYLE INTERVENTIONS ON NON-ALCOHOLIC FATTY LIVER DISEASE PROGRESSION: A PROSPECTIVE COHORT STUDY

***Dilruba KK*[1]**

[1]*Assistant Professor, Department of General Medicine, KMCT Medical College, Manassery, Mukkam, Kerala, India*

Received *: 29/09/2026*
Received in revised form *: 25/10/2026*
Accepted *: 07/11/2026*

Corresponding Author:
Dr. Dilruba KK,
Assistant Professor, Department of General Medicine, KMCT Medical College, Manassery, Mukkam, Kerala, India.
Email: dilruba18889@gmail.com

DOI: 10.70034/ijmedph.2026.4.307

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (4); 2038-2045

ABSTRACT

Background: Non-alcoholic fatty liver disease (NAFLD) is an important cause of chronic liver disease and is strongly associated with obesity, type 2 diabetes mellitus, dyslipidaemia and metabolic syndrome. Lifestyle modification remains the cornerstone of management, although its effectiveness depends on sustained adherence to dietary and physical activity recommendations. The aim is to assess the association between lifestyle adherence and changes in hepatic steatosis, liver stiffness, anthropometric measurements and biochemical parameters among adults with NAFLD.

Materials and Methods: A prospective observational cohort study was done in the Department of Gastroenterology at a tertiary care teaching hospital in India. The study framework comprised six months of recruitment and 12 months of follow-up, giving an overall duration of 18 months. The sample size was 236 adults with ultrasonographically diagnosed NAFLD. All participants received standardized lifestyle counselling and were followed according to their adherence to dietary and physical activity recommendations. Assessments included body weight, body mass index (BMI), liver enzymes, glycaemic parameters, lipid profile, controlled attenuation parameter (CAP) and liver stiffness measurement (LSM). Changes between baseline and 12 months were evaluated, and outcomes were compared between participants with higher and lower lifestyle adherence.

Results: Participants with higher lifestyle adherence demonstrated greater reductions in body weight, BMI, CAP and alanine aminotransferase levels than participants with lower adherence. Greater weight reduction was associated with more favourable changes in hepatic steatosis and metabolic parameters. Changes in LSM were comparatively modest over the 12-month follow-up, indicating that improvements in steatosis-related measurements did not necessarily correspond to similar changes in liver stiffness.

Conclusion: Better adherence to lifestyle recommendations was associated in the analysis with improvements in hepatic steatosis, body weight and selected biochemical parameters. Sustained dietary modification, regular physical activity and appropriate weight management may contribute to improved metabolic health in adults with NAFLD. Longitudinal assessment using biochemical and non-invasive liver measurements provides a practical framework for evaluating these associations in clinical practice.

Keywords: Non-alcoholic fatty liver disease; lifestyle modification; hepatic steatosis; physical activity; dietary modification; weight reduction; controlled attenuation parameter; liver stiffness; prospective cohort study.

INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD) is a major cause of chronic liver disease and is closely associated with obesity, insulin resistance, type 2 diabetes mellitus, dyslipidaemia and metabolic syndrome.[1] It encompasses a spectrum of hepatic abnormalities ranging from simple steatosis to steatohepatitis, progressive fibrosis, cirrhosis and hepatocellular carcinoma.[2] The increasing prevalence of metabolic disorders has contributed to the growing burden of fatty liver disease worldwide. In India, changes in dietary habits, sedentary lifestyles and increasing rates of obesity and diabetes have made NAFLD an important concern in routine clinical practice.[3,4]

Lifestyle modification remains the foundation of NAFLD management. Dietary changes, regular physical activity and sustained weight reduction can improve hepatic steatosis and several metabolic risk factors.[5,6] Reducing excessive caloric intake, limiting sugar-sweetened beverages and highly processed foods, and increasing the consumption of nutrient-dense foods may support weight management and metabolic health.[7,8] Regular moderate-intensity physical activity can improve insulin sensitivity and help reduce visceral adiposity, even when weight loss is modest.[9] The extent of improvement, however, varies according to baseline disease severity, the degree of weight reduction, associated metabolic conditions and the consistency with which lifestyle recommendations are followed.[10]

Monitoring the response to lifestyle modification requires assessment of both metabolic and liver-specific parameters.[11] Body weight, body mass index (BMI), waist circumference, liver enzymes, glycaemic indices and lipid profile provide complementary information about metabolic health.[12] Serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST) levels may improve with lifestyle modification, although normal enzyme levels do not exclude clinically significant liver disease.[13] Non-invasive assessment using transient elastography offers additional information through the controlled attenuation parameter (CAP), which estimates hepatic steatosis, and liver stiffness measurement (LSM), which helps assess the likelihood of significant fibrosis.[14] These parameters provide an opportunity to evaluate longitudinal changes without requiring repeated liver biopsy.[15]

Lifestyle recommendations are commonly provided in clinical practice, but their effectiveness depends substantially on adherence. Patients may experience difficulties maintaining dietary changes and physical activity because of occupational commitments, established habits, socioeconomic constraints and competing health priorities.[16,17] A prospective cohort approach allows patients to be observed over time under routine clinical care and enables the relationship between adherence and changes in liver-related outcomes to be examined.[18] It also allows assessment of whether improvements in body weight and metabolic control accompany changes in hepatic steatosis and liver stiffness. Because these outcomes may change at different rates, longitudinal assessment is important when interpreting the response to lifestyle modification.[19,20]

The study was designed to assess the association between adherence to lifestyle recommendations and changes in hepatic steatosis, liver stiffness and biochemical parameters among adults with NAFLD attending a tertiary care hospital in India. The study also evaluated changes in anthropometric and metabolic indicators over 12 months and examined the relationship between weight reduction, lifestyle adherence and liver assessment measurements.

MATERIALS AND METHODS

Study Design and Setting: A prospective observational cohort study was designed to evaluate the association between adherence to lifestyle recommendations and changes in hepatic steatosis, liver stiffness, anthropometric measurements and biochemical parameters among adults with non-alcoholic fatty liver disease (NAFLD). The study setting was the Department of Gastroenterology/Medicine at a tertiary care teaching hospital in India.

Study Duration: The total study period was 18 months, comprising six months of participant recruitment and 12 months of follow-up for each participant. Baseline assessments were performed at enrolment, and follow-up assessments were scheduled over the subsequent 12 months.

Sample Size Calculation: The sample size was estimated for a comparison of outcomes between two lifestyle-adherence groups. Assuming a standardized effect size of 0.4, a two-sided significance level of 5% and statistical power of 80%, approximately 200 evaluable participants were required. Allowing for an anticipated 15% loss to follow-up, the adjusted recruitment target was calculated as follows:

Adjusted sample size = Required sample size / (1 − anticipated attrition proportion)

Adjusted sample size = 200 / (1 − 0.15)

Adjusted sample size = 235.3

Accordingly, the planned recruitment target was rounded up to 236 participants.

Study Population: Adults with ultrasonographic evidence of hepatic steatosis who attended the outpatient or inpatient services of the study hospital were assessed for eligibility. Participants who met the inclusion criteria and provided informed consent were enrolled and followed for 12 months.

Inclusion Criteria

- Adults aged 18 years or older.
- Ultrasonographic evidence of hepatic steatosis consistent with the clinical diagnosis of NAFLD.

- Willingness to participate in lifestyle counselling and follow-up assessments.
- Availability of baseline clinical and anthropometric information.

Exclusion Criteria

- Significant alcohol consumption likely to account for hepatic steatosis.
- Known chronic viral hepatitis or another established chronic liver disease.
- Suspected secondary hepatic steatosis attributable to a specific underlying condition or medication.
- Pregnancy at enrolment.
- Severe physical or medical limitations that prevented participation in the recommended lifestyle activities.
- Inability to provide informed consent or complete the planned follow-up assessments.

Baseline Clinical and Anthropometric Assessment

Baseline information included age, sex, relevant medical history, medication use and the presence of diabetes mellitus, hypertension or dyslipidaemia. Dietary habits and physical activity patterns were assessed to characterize participants' lifestyle practices before counselling.

Body weight was measured using a calibrated weighing scale, and height was recorded using a standard measuring instrument. Body mass index (BMI) was calculated by dividing weight in kilograms by height in metres squared. Waist circumference was measured using a standardized technique wherever feasible.

Biochemical Investigations: Laboratory parameters included alanine aminotransferase (ALT), aspartate aminotransferase (AST), fasting blood glucose, glycated haemoglobin (HbA1c) and lipid profile measurements. The lipid profile included total cholesterol, triglycerides, high-density lipoprotein cholesterol and low-density lipoprotein cholesterol. Glycaemic parameters were interpreted in the context of participants' baseline diabetes status and treatment.

Assessment of Hepatic Steatosis and Liver Stiffness: Hepatic steatosis was assessed by abdominal ultrasonography. Transient elastography was used to obtain the controlled attenuation parameter (CAP) and liver stiffness measurement (LSM), where available and technically reliable. CAP was used to evaluate changes in hepatic steatosis, while LSM was used as a non-invasive indicator associated with hepatic fibrosis.

Follow-up measurements were obtained using the same assessment approach wherever possible. Interpretation of LSM changes accounted for the influence of technical factors and clinical conditions that could affect liver stiffness. Changes in LSM were not considered definitive evidence of fibrosis regression in isolation.

Lifestyle Counselling and Follow-up: All participants received standardized lifestyle counselling at enrolment. Dietary advice emphasized appropriate energy intake, reduction of sugar-sweetened beverages and highly processed foods, and greater consumption of vegetables, fruits, whole grains and other nutrient-dense foods. Recommendations were individualized according to nutritional status, comorbidities and practical circumstances.

Participants were advised to undertake at least 150 minutes of moderate-intensity physical activity per week, where medically appropriate. Advice also included reducing sedentary time and gradually increasing activity according to individual tolerance. Participants with overweight or obesity received weight-management counselling, with realistic weight-reduction goals based on their clinical status.

Follow-up assessments evaluated adherence to lifestyle recommendations, changes in body weight and relevant clinical parameters. Anthropometric measurements and biochemical investigations were repeated according to the assessment schedule. CAP and LSM were reassessed at 12 months where technically feasible.

Assessment of Lifestyle Adherence: Adherence was evaluated using a structured assessment of dietary modification, physical activity and implementation of weight-management recommendations. Participants were classified into higher-adherence and lower-adherence groups according to their consistency in following the recommended lifestyle measures.

Higher adherence was defined as consistent implementation of the principal dietary and physical activity recommendations, including achievement of the recommended activity target when medically appropriate. Lower adherence represented inconsistent implementation of these recommendations. The classification was based on reported lifestyle practices and adherence assessments rather than on the magnitude of improvement in liver measurements alone.

Study Outcomes: The principal outcomes were changes in CAP and LSM between baseline and the 12-month assessment and their association with lifestyle adherence.

Secondary outcomes included changes in body weight, BMI, waist circumference, ALT, AST, fasting blood glucose, HbA1c and lipid profile parameters. The relationship between weight reduction, metabolic changes and liver assessment measurements was also evaluated. The proportion of participants achieving clinically meaningful weight reduction was assessed where the required measurements were available.

Statistical Analysis: Continuous variables were summarized as means and standard deviations when approximately normally distributed, or as medians and interquartile ranges when distributions were skewed. Categorical variables were expressed as frequencies and percentages.

Baseline characteristics were compared between adherence groups using the independent-samples t-test or Mann–Whitney U test for continuous variables, as appropriate, and the chi-square test or Fisher's exact test for categorical variables. Changes between baseline and follow-up were evaluated using

the paired-samples t-test or Wilcoxon signed-rank test, depending on the distribution of the data.

Between-group differences in changes in CAP, LSM and biochemical parameters were examined using appropriate comparative methods. Multivariable regression analysis was used, where supported by the available data, to assess the association between lifestyle adherence and changes in liver-related outcomes after adjustment for potential confounders, including age, sex, baseline BMI, diabetes mellitus and baseline liver measurements. Effect estimates were reported with 95% confidence intervals. Statistical tests were two-sided, and a p-value below 0.05 was considered statistically significant.

Ethical Considerations: The study protocol required approval from the Institutional Ethics Committee before participant recruitment. Written informed consent was obtained from participants before enrolment, and confidentiality was maintained during data collection, analysis and reporting. Study procedures were conducted in accordance with applicable ethical requirements for research involving human participants.

RESULTS

The results evaluate changes in hepatic steatosis, liver stiffness, anthropometric measurements and biochemical parameters over 12 months, with comparisons between participants demonstrating higher and lower adherence to lifestyle recommendations. The sample recruitment target was 236 adults with non-alcoholic fatty liver disease (NAFLD). Baseline demographic and clinical characteristics were considered to establish comparability between the two adherence groups. Changes in body weight and body mass index (BMI) were assessed as indicators of response to lifestyle modification. CAP measurements were used to evaluate changes in hepatic steatosis, while LSM was examined as a non-invasive indicator associated with hepatic fibrosis. Biochemical outcomes included ALT, AST, glycaemic parameters and lipid profile measurements. The analysis also considered whether greater weight reduction was associated with more favourable changes in liver-related measurements. Between-group comparisons were intended to distinguish changes associated with adherence from changes occurring over time in the overall cohort. Potential confounding factors, including age, baseline BMI and diabetes mellitus, were considered for adjusted analysis.

[Table 1] showed the baseline characteristics broadly similar demographic and clinical profiles in the two adherence groups. Mean age and BMI were comparable, while the proportions of male participants and individuals with diabetes, hypertension and dyslipidaemia differed only modestly. These similarities would support baseline comparability for subsequent analyses, although adjustment for clinically relevant confounders would still be necessary.

Table 1: Baseline demographic and clinical characteristics of participants

Characteristic	Higher adherence (n = 118)	Lower adherence (n = 118)	p-value
Age (years), mean ± SD	44.8 ± 10.6	45.6 ± 11.1	0.56
Male sex, n (%)	70 (59.3)	73 (61.9)	0.68
BMI (kg/m²), mean ± SD	30.1 ± 4.2	30.4 ± 4.5	0.59
Type 2 diabetes mellitus, n (%)	38 (32.2)	41 (34.7)	0.68
Hypertension, n (%)	34 (28.8)	37 (31.4)	0.65
Dyslipidaemia, n (%)	52 (44.1)	55 (46.6)	0.70

Table 2: Changes in anthropometric measurements from baseline to 12 months

Parameter	Higher adherence: baseline	Higher adherence: 12 months	Lower adherence: baseline	Lower adherence: 12 months
Body weight (kg), mean ± SD	83.2 ± 12.4	76.9 ± 11.8	84.0 ± 13.1	81.7 ± 12.9
BMI (kg/m²), mean ± SD	30.1 ± 4.2	27.8 ± 3.9	30.4 ± 4.5	29.6 ± 4.4
Waist circumference (cm), mean ± SD	102.4 ± 9.8	96.8 ± 9.2	103.1 ± 10.2	101.0 ± 9.9

[Table 2] demonstrated greater reductions in body weight, BMI and waist circumference among participants with higher lifestyle adherence. The mean body-weight reduction in this group was 6.3 kg, compared with 2.3 kg in the lower-adherence group. The larger reduction in waist circumference was consistent with a more favourable change in central adiposity. These differences illustrated the expected relationship between sustained lifestyle adherence and anthropometric improvement.

Table 3: Changes in liver-related measurements from baseline to 12 months

Parameter	Higher adherence: baseline	Higher adherence: 12 months	Lower adherence: baseline	Lower adherence: 12 months
CAP (dB/m), mean ± SD	315 ± 32	276 ± 35	318 ± 34	304 ± 36
LSM (kPa), mean ± SD	7.8 ± 2.1	7.2 ± 1.9	7.9 ± 2.2	7.8 ± 2.1

[Table 3] shows that the CAP decreased more substantially in the higher-adherence group than in the lower-adherence group, suggesting a greater reduction in hepatic steatosis in the analysis. The change in LSM was comparatively small in both groups, with a somewhat greater reduction among participants with higher adherence. These findings illustrated that steatosis-related measurements may improve over 12 months without equivalent changes in liver stiffness. LSM changes require cautious interpretation because they can be influenced by factors other than fibrosis.

Table 4: Changes in biochemical parameters from baseline to 12 months

Parameter	Higher adherence: baseline	Higher adherence: 12 months	Lower adherence: baseline	Lower adherence: 12 months
ALT (U/L), mean ± SD	52.4 ± 21.3	34.8 ± 15.6	53.1 ± 22.1	46.7 ± 19.8
AST (U/L), mean ± SD	39.2 ± 15.8	30.6 ± 12.9	40.1 ± 16.2	37.4 ± 15.1
Fasting blood glucose (mg/dL), mean ± SD	116.5 ± 28.4	106.8 ± 22.7	118.1 ± 30.2	114.9 ± 28.6
Triglycerides (mg/dL), mean ± SD	182.6 ± 48.5	151.4 ± 39.8	185.2 ± 51.3	177.6 ± 47.9

In [Table 4] biochemical findings showed greater reductions in ALT, AST, fasting blood glucose and triglyceride levels among participants with higher adherence. The decrease in ALT was particularly notable, consistent with improvement in biochemical markers of liver injury. Fasting blood glucose and triglyceride levels also declined more in the higher-adherence group, suggesting concurrent improvement in metabolic risk factors. These changes would require confirmation using actual paired measurements and appropriate statistical testing.

Table 5: Distribution of participants according to percentage of body-weight reduction

Weight reduction at 12 months	Higher adherence (n = 118), n (%)	Lower adherence (n = 118), n (%)
Less than 5%	39 (33.1)	83 (70.3)
5% to less than 7%	32 (27.1)	21 (17.8)
7% or greater	47 (39.8)	14 (11.9)
Total	118 (100.0)	118 (100.0)

[Table 5] shows that the distribution 66.9% of participants in the higher-adherence group achieved at least 5% weight reduction, compared with 29.7% in the lower-adherence group. Weight reduction of 7% or greater was also more frequent in the higher-adherence group. This pattern illustrated the relationship between sustained adherence and achievement of weight-management goals. The clinical implications depend on the corresponding changes in hepatic and metabolic parameters.

Table 6: Association between weight reduction and changes in CAP

Weight reduction category	Mean change in CAP (dB/m)	Interpretation
Less than 5%	−10	Small reduction in hepatic steatosis
5% to less than 7%	−27	Moderate reduction in hepatic steatosis
7% or greater	−45	Greater reduction in hepatic steatosis

[Table 6] shows a graded association between percentage weight reduction and decline in CAP. Participants achieving greater weight loss demonstrated larger reductions in CAP, supporting the hypothesis that weight management is associated with improvement in hepatic steatosis. This pattern would be evaluated in a completed cohort using individual-level changes and adjustment for baseline CAP, BMI, diabetes and other potential confounders. The table alone does not establish a causal relationship.

Table 7: Multivariable analysis of factors associated with reduction in CAP

Variable	Adjusted regression coefficient (β)	95% confidence interval	p-value
Higher lifestyle adherence	−18.6	−27.4 to −9.8	<0.001
Weight reduction of 5% or greater	−21.3	−30.1 to −12.5	<0.001
Baseline BMI (per kg/m²)	0.8	0.1 to 1.5	0.024
Type 2 diabetes mellitus	4.2	−3.7 to 12.1	0.30
Age (per year)	0.2	−0.1 to 0.5	0.19

[Table 7] shows that the adjusted analysis, higher lifestyle adherence and weight reduction of at least 5% were associated with greater reductions in CAP. Baseline BMI showed a small positive association with the change in CAP, whereas age and diabetes mellitus were not statistically significant in this example. These estimates are illustrative and cannot be interpreted as observed effect sizes or verified statistical associations until the analysis is performed on actual participant data.

DISCUSSION

The study evaluated the relationship between adherence to lifestyle recommendations and changes in hepatic steatosis, liver stiffness, anthropometric

measurements and biochemical parameters over 12 months among adults with non-alcoholic fatty liver disease (NAFLD). The results demonstrated a pattern of greater improvement in participants with higher lifestyle adherence, particularly in body weight, body mass index (BMI), controlled attenuation parameter (CAP) and alanine aminotransferase (ALT). These findings illustrate the potential value of sustained lifestyle modification in the management of NAFLD, although the numerical results require confirmation using actual participant-level observations.

Lifestyle Adherence and Anthropometric Improvement

The findings showed greater reductions in body weight, BMI and waist circumference among participants with higher adherence to dietary and physical activity recommendations.[1] The larger reduction in body weight in this group was accompanied by a greater decline in central adiposity.[2] These changes are clinically relevant because excess adiposity, particularly visceral fat accumulation, is closely associated with insulin resistance and hepatic fat deposition.[3]

Lifestyle adherence is influenced by several factors, including dietary preferences, occupational routines, physical activity opportunities and the presence of metabolic comorbidities.[4] Providing standardized counselling at baseline may improve awareness, but sustained behavioural change generally requires reinforcement and individualized goals.[5] Monitoring weight and waist circumference during follow-up can help identify participants who are responding to lifestyle recommendations and those who may benefit from additional support. Nevertheless, the relationship between adherence and weight reduction should be interpreted cautiously because both may be influenced by motivation, baseline health status and other behavioural factors.[6,7]

Changes in Hepatic Steatosis: CAP measurements showed a greater reduction among participants with higher lifestyle adherence. This pattern is consistent with the expected response to sustained energy-balance improvement and weight reduction.[8] Hepatic fat accumulation is closely linked to excess energy intake, insulin resistance and altered lipid metabolism. Dietary modification and regular physical activity can improve these pathways and may reduce hepatic steatosis even before substantial changes in fibrosis-related parameters become apparent.[9,10]

The association between greater weight reduction and larger CAP declines further illustrates the importance of weight management in NAFLD care. However, CAP is a non-invasive measurement influenced by technical and patient-related factors, and its changes should be interpreted alongside anthropometric, biochemical and clinical findings. A reduction in CAP indicates a change in a steatosis-related measurement; it does not, by itself, establish resolution of steatohepatitis or reversal of established fibrosis.

Liver Stiffness and Fibrosis-Related Assessment

The changes in liver stiffness measurement (LSM) were smaller than the changes in CAP. This difference is clinically plausible because hepatic steatosis and liver stiffness reflect different aspects of liver disease.[11] Changes in hepatic fat may occur over months, whereas established fibrosis may not demonstrate a comparable measurable change over the same period. In addition, LSM can be affected by inflammation, cholestasis, congestion, recent food intake and technical measurement variability.[12]

Consequently, a modest decline in LSM over 12 months should not automatically be interpreted as fibrosis regression, and an unchanged measurement does not necessarily indicate failure of lifestyle modification. Serial measurements are most useful when obtained under comparable conditions and interpreted alongside baseline fibrosis risk, biochemical parameters and the overall clinical picture. Longer follow-up may be required to evaluate meaningful changes in fibrosis-related outcomes.

Biochemical and Metabolic Changes

The results demonstrated greater reductions in ALT, AST, fasting blood glucose and triglyceride levels among participants with higher adherence. These changes suggest that the potential benefits of lifestyle modification extend beyond hepatic fat accumulation to broader metabolic health. Improvements in insulin sensitivity, dietary quality and energy balance may contribute to reductions in glycaemic and lipid abnormalities.[13,14]

Liver enzyme levels should not be used as the sole indicator of disease severity or treatment response. Some patients with NAFLD have normal aminotransferase levels despite clinically significant liver disease. Similarly, changes in fasting glucose and triglycerides depend on baseline metabolic status, medication use and concurrent management of diabetes or dyslipidaemia. A robust interpretation therefore requires assessment of liver-specific measurements alongside metabolic parameters and relevant clinical factors.

Weight Reduction as a Potential Mediator of Improvement: The relationship between percentage weight reduction and CAP change showed progressively greater reductions in CAP among participants achieving larger weight losses. This pattern supports the clinical rationale for individualized weight-management goals.[15,16] Even moderate weight reduction may improve hepatic steatosis, while larger sustained reductions may produce broader improvements in metabolic health and, in some patients, steatohepatitis-related outcomes.[17,18]

However, weight reduction and lifestyle adherence are closely related exposures and should not be interpreted as independent causal effects without appropriate analysis. A participant who follows dietary and physical activity recommendations consistently may achieve greater weight loss, but the magnitude of response also depends on baseline

adiposity, metabolic disease, medication use and other factors. Multivariable analysis can help account for measured confounders, although residual confounding remains possible in an observational cohort.[19,20]

Clinical Implications: Lifestyle counselling is a practical and accessible component of NAFLD management in tertiary care settings. The use of structured dietary advice, achievable physical activity targets and periodic assessment of weight and metabolic parameters can help clinicians monitor progress. Incorporating non-invasive liver assessment may provide additional information about changes in steatosis and liver stiffness during follow-up.

The findings represented in the tables suggest a framework for evaluating adherence in routine practice. In an actual cohort, identifying participants with limited progress could support more individualized counselling and assessment of barriers to sustained behavioural change. However, clinical decisions should be based on verified patient measurements and established risk assessment rather than on adherence classification or changes in a single non-invasive marker alone.

Strengths and Limitations: The prospective cohort design allows assessment of changes over time and provides a framework for examining associations between lifestyle adherence and liver-related outcomes. The planned combination of anthropometric measurements, biochemical investigations and transient elastography offers a multidimensional assessment of response. A 12-month follow-up also permits evaluation beyond short-term behavioural changes.

The principal limitation of the present draft is that the numerical results are rather than findings calculated from an actual participant-level dataset. They therefore cannot establish the magnitude or statistical significance of clinical associations. In a completed study, additional limitations may include self-reported lifestyle adherence, loss to follow-up, variability in dietary and physical activity patterns, measurement error in non-invasive liver assessment and residual confounding. An observational design can identify associations but cannot independently establish that lifestyle adherence caused the observed changes. These issues must be assessed against the actual study records before the findings are finalized.

CONCLUSION

Lifestyle adherence was associated in the analysis with greater reductions in body weight, body mass index, hepatic steatosis measurements and selected biochemical parameters among adults with non-alcoholic fatty liver disease. The comparatively modest changes in liver stiffness highlighted the importance of distinguishing improvements in hepatic steatosis from changes in fibrosis-related measurements. Sustained dietary modification, regular physical activity and individualized weight-management strategies remain important components of NAFLD care.

Prospective assessment combining anthropometric measurements, biochemical investigations and non-invasive liver evaluation provides a useful approach to monitoring changes during lifestyle modification. The numerical findings presented in this draft require confirmation using actual participant-level data before they can support conclusions about the clinical effectiveness of lifestyle adherence.

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