Analysis of the Influence of Lifestyle on Liver Dysfunction Based on NAHANES Database

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Research Article

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Abstract

Objective

To find out the influence of various factors in lifestyle on liver dysfunction, put forward reasonable suggestions on prevention of liver dysfunction.

Methods

Datasets from 2017 to March 2020 NHANES (National Health and Nutrition Examination Surveys) required for the analysis were downloaded from the NHANES website and R 4.1.1. Software was used for data analysis. Survey Design Logistic regression was used to analyze the influence of various factors on liver dysfunction and screen the risk factors.

Results

Hypertension, depression, and sedentary activity are risk factors for liver dysfunction, while reducing salt in diet and vigorous recreational activities were protective factors for liver dysfunction. The inflection points of blood pressure, BMI and sedentary activity were 98.33mmHg, 30.6kg/m2, 420min, respectively.

Conclusions

Blood pressure, BMI, mood and sedentary behavior are risk factors for liver dysfunction. We suggest that keeping MAP level at 70-98.33mmHg, controlling BMI < 30kg/m2, maintaining a positive attitude, and sedentary time less than 420 min per day are more conducive to reducing the risk of liver dysfunction.

1. Introduction

Liver is the largest substantial and digestive organ of the human body, with a variety of functions such as secretion, synthesis, metabolism and excretion. Various factors such as virus, pathology and chemical substances can affect the normal structure of liver parenchyma cells and tissue, causing liver dysfunction(1). With the growth of age, the structure and function of liver will change, including Alanine aminotransferase (ALT)(2), Volume(3), etc.

Different lifestyles affect liver function through a variety of factors, such as alcohol, drugs, and gut flora. Changes in gut microbiota can have a big impact on the liver, as gut bacteria and their by-products can enter the liver through the portal vein(4). Alcohol is the most common cause of liver damage. Nearly all people who consume alcohol for a long time develop fatty liver, but only a small proportion develop cirrhosis(5, 6), which leads to liver dysfunction. But there are also some people in the occurrence of liver dysfunction before the discovery of liver diseases, many factors in life may be the cause of disease, but lack of relevant research. Intestinal microbiota changes occur in many liver diseases, such as nonalcoholic fatty liver disease, cirrhosis, alcoholic cirrhosis, and cirrhosis with encephalopathy(7). In addition, different lifestyles can also affect liver function to varying degrees, but there is still a lack of research on this aspect. Therefore, this study was conducted to study working time, activity, mood, blood pressure, sleep time, smoking and other lifestyle factors, in order to find the influence of different life factors on liver dysfunction and provide reference for the prevention of liver dysfunction.

2. Methods

2.1 Study Sample
Datasets from 2017 to March 2020 NHANES (National Health and Nutrition Examination Surveys) required for the analysis were downloaded from the NHANES website and R 4.1.1. Software was used for data combined. The respondents included in this study were all over 20 years old, all accepted complete NHANES surveys, including Blood Pressure, Diabetes, Medical Conditions, Mental Health, Physical Activity, Use, Prescription, Medications, Sleep Disorders, Smoking, etc. After excluding respondents with incomplete survey data, a total of 11388 respondents were included in this study, including 5034 males and 6354 females. Characteristics of respondents are described in Table 1.

2.2 Classification of indicators

All indexes included in the study were converted into dichotomous variables. If the depression index occurred More than "More than half the days", the event was considered to have occurred. The time of sedentary activity is bounded by 8 hours. If the time exceeds 8 hours, the event is considered to occur. Mean arterial pressure (MAP) was used to reflect blood pressure to study the relationship between blood pressure and liver dysfunction. MAP=Diastolic blood pressure+1/3*Systolic blood pressure.

2.3 Diagnostic criteria for liver dysfunction

Biochemical indicators were used for diagnosis: (1) Alanine Aminotransferase (ALT) or Aspartate Aminotransferase (AST) > 1-3ULN; (2) Alkaline Phosphatase (ALP)> 1-2.5 ULN; (3) Bilirubin (BIL) > 1-1.5ULN. At least one criterion was met to consider the respondents to have liver dysfunction in this study.(8, 9).

2.4 Statistical analysis

Analyses were conducted using R 4.1.1. Survey Design Logistic regression was used to analyze the influence of various factors on liver dysfunction and screen the risk factors. The risk factors of liver dysfunction were stratified by sex, age, race and education level. Then the trend P test was carried out for several important factors. Smooth curve fitting was made for mean arterial pressure, body mass index (BMI) and sedentary activity time to find the inflection point of the curve.

3. Results

3.1 Analysis of the influence of various factors on liver dysfunction

After analyzing lifestyle-related factors in the NHANES database, we found that we found that hypertension (OR=1.851, [1.001,3.4222], P=0.0493), depression (mainly manifested as negative emotions) (Feeling down/Depressed/Hopeless, OR=1.606, [1.015,2.541], P=0.042; Feeling bad about yourself, OR=1.95, [1.292,2.942], P=0.001), overweight (OR=2.079, [1.197,3.611], P=0.009), mental illness (OR=1.609, [1.016,2.549], P=0.043 and sedentary activity (OR=2.164, [1.144,4.095], P=0.018) are risk factors for liver dysfunction, while reducing salt in diet (OR=0.319, [0.203,0.503], P=0.001) and vigorous recreational activities (OR=0.241, [0.123,0.469], P=0.001) were protective factors for liver dysfunction. The other indicators were not statistically significant. The analysis of the influence of various factors on liver dysfunction is shown in Table 2 and Figure 1.

3.2 The relationship between blood pressure and liver dysfunction

We divided MAP into four groups and conducted trend P test. The results are shown in Table 3. The Model 1 has been non-adjusted. The Model 2 adjusted gender, race, education level, age, Marital status and Ratio of family income to poverty. The Model 3 adjusted for factors other than weight and liver dysfunction. Then smooth curve fitting was performed for MAP and liver dysfunction, stratified by gender, age, race and education level respectively, and the results were shown in Figure 2. We found that the risk of liver dysfunction in men increased first and then decreased with MAP,
with an inflection point of 134.33mmHg, while that in females showed an overall upward trend after a fluctuation of 98.33mmHg. The total inflection point was 98.33mmHg.

In age group, we found that the curve of 20-40 years old group did not change much, and began to rise after 111mmHg, and the risk of liver dysfunction increased with it. In the 40-60 years old group, the curve reached the first inflection point at 95mmHg. In the 60-80 years old group, the risk of liver insufficiency was higher when blood pressure was greater than 92mmHg. In the group older than 80 years, the overall trend was downward, and the risk changed little after 100.33mmHg. The total inflection point was 98.33mmHg.

In racial subgroups, we find that the curve of non-Hispanic White is stable and begins to rise after 142.67mmHg, and the curve of Mexican American and Other Race remains at a high level around 98mmHg. Mexican American declined after 140mm. Non-Hispanic Black fluctuated and began to decline after 154.67 mmHg. The total inflection point was 98.33mmHg.

In the education level group, we find that the curve of less high school graduate group remains at the high risk level after 108.33mmHg, and the curve of high school graduate/GED or Equivalent group begins to rise after 118mmHg. While College graduate or above group increased at 92.67 mmHg. The total inflection point was 109.67 mmHg.

### 3.3 The relationship between BMI and liver dysfunction

We divided BMI into four groups and conducted trend P test. The results are shown in Table 4. The Model 1 has been non-adjusted. The Model 2 adjusted gender, race, education level, age, Marital status and Ratio of family income to poverty. The Model 3 adjusted for factors other than weight and liver dysfunction. Then smooth curve fitting was performed for BMI and liver dysfunction, stratified by gender, age, race and education level respectively, and the results were shown in Figure 3.

In the gender group, with the change of BMI, the risk of liver dysfunction did not change significantly in women, but significantly in men. The risk decreased first and then increased significantly after 34.5kg/m\(^2\). The total inflection point was 30.6 kg/m\(^2\).

In age groups, 20-40 years old formed a steady upward trend, and the inflection points of 40-60 years old and 60-80 years old were 30.7 kg/m\(^2\) and 25.8 kg/m\(^2\), respectively. However, at the same BMI, the risk was lower than that of 20-40 years old, and the risk of > 80 years old decreased significantly after 22.9 kg/m\(^2\). The total inflection point was 30.6 kg/m\(^2\).

In race groups, the curve of non-Hispanic White years old group and over other Race group increased steadily, but the risk of liver dysfunction in non-Hispanic White years old group was much lower than that in over other Race group. The risk of liver dysfunction in Non-Hispanic Black group began to increase after 22.4 kg/m\(^2\). The risk of liver dysfunction in Mexican American group increased significantly and reached the inflection point at 33.8 kg/m\(^2\). Its risk of liver dysfunction was much higher than the other three groups. The total inflection point was 30.6 kg/m\(^2\).

In the education level group, the less high school graduate group shows a downward trend as a whole, and the high school graduate/GED or Equivalent group drops after reaching the inflection point of 39.8 kg/m\(^2\). College graduate or above group starts to rise at 29.9 kg/m\(^2\). The total inflection point was 30.6 kg/m\(^2\).

### 3.4 The relationship between sedentary activity time and liver dysfunction
We divided sedentary activity time into four groups and conducted trend P test. The results are shown in Table 5. The Model 1 has been non-adjusted. The Model 2 adjusted gender, race, education level, age, Marital status and Ratio of family income to poverty. The Model 3 adjusted for factors other than weight and liver dysfunction. Then smooth curve fitting was performed for sedentary activity time and liver dysfunction, stratified by gender, age, race and education level respectively, and the results were shown in Figure 4.

In the gender group, the curve of male fluctuated greatly and reached the lowest point at 600min, while the curve of female rose at 75min and was generally stable. The risk of liver dysfunction in female was lower than that in male. The total inflection point was 451min.

In age groups, the changes of 20-40 years old group and 40-60 years old group were not obvious and reached the inflection point at 660min. The curve of the group over 80 years old gradually decreased and leveled off after 150min. The risk of liver dysfunction in the 60-80 years old group was significantly higher than that in the other three groups, and reached the inflection point at 240min. The total inflection point was 420min.

In the race groups, the curves of non-Hispanic White group changed significantly and increased after 150min, non-Hispanic Black group increased steadily from 90min, and Mexican American group decreased after reaching the inflection point at 300min. The Other Race group gradually rises. The total inflection point was 420min.

In the educational level group, high school graduate/GED or equivalent group and college graduate or above group gradually increase, the less High school graduate group began to decline after reaching the inflection point in 420min. The total inflection point was 420min.

4. Discussion

Heart diseases such as chronic heart failure can cause abnormal liver function(10-12), which is closely related to changes in hemodynamics(13-15). Changes in hemodynamics will also be reflected in changes in blood pressure. In our study, the total inflection point of gender, age, and race was 98.33mmHg, and the total inflection point of education level was 109.67mmHg. Under the condition of ensuring the normal perfusion of body organs, blood pressure less than the inflection point may have a smaller occurrence. The risk of liver dysfunction. Therefore, we consider that maintaining a MAP of 70-98.33mmHg in normal people is more conducive to reducing the risk of liver dysfunction.

Obesity is defined as BMI> 30 kg/m$^2$, while morbid obesity is defined as BMI> 40 kg/m$^2$ (16). BMI is an important indicator for evaluating human health, and it is also related to most diseases, including cardiovascular disease, reduced life expectancy, increased mortality, psychosocial problems, blood pressure, etc (17, 18). We found that BMI is related to the occurrence of liver dysfunction. Regardless of gender, age, race, and education level group, the total inflection point of BMI is 30.6 kg/m$^2$. This is consistent with the diagnostic criteria for obesity with BMI<30 kg/m$^2$. Therefore, a lower BMI can reduce the risk of liver dysfunction.

Sedentary behavior is independently associated with adverse health outcomes (19-21), including obesity, metabolic syndrome (METS), non-alcoholic fatty liver disease (NAFLD), and type 2 diabetes (22-26). KELLY et al. also found that sitting was associated with fatty liver disease (27). However, these studies did not give the relationship between sedentary time and liver dysfunction, nor did they give a specific time. In the sedentary activity study, I found that the total inflection point in the gender group was 451 minutes, and the total inflection point in age, race, and education level group was 420 minutes. Therefore, we believe that a sedentary time of less than 420 minutes a day can reduce the risk of liver dysfunction (not including sleep time).
In our study, several evaluation indicators of depression are risk factors for liver insufficiency, which is consistent with the results of several previous studies. Studies have shown that about 20-30% of patients with liver disease suffer from depression(28-30). The specific cause is not clear, but this may be related to alcoholism and drug use(31, 32). Our research also found that seeing a psychiatrist in the past month is a risk factor for liver insufficiency, but taking prescription drugs is a protective factor. The prescription drugs here are not only antidepressants, probably because these drugs improve the patient’s body condition.

In conclusion, blood pressure, BMI, mood and sedentary behavior are risk factors for liver dysfunction. We suggest that keeping MAP level at 70-98.33mmHg, controlling BMI < 30kg/m², maintaining a positive attitude, and sedentary time less than 420 min per day are more conducive to reducing the risk of liver dysfunction.

**Declarations**

**Ethics declarations**

**Ethics approval and consent to participate**

1. The data in this study comes from the NHANES database. After consulting the ethics committee of the PLA General Hospital, it is deemed that ethical procedures are not required.

2. **Accordance statement**

All authors of this article declare that all methods were carried out in accordance with relevant guidelines and regulations.

**Consent for publication**

Not applicable.

**Availability of data and materials**

The datasets generated during the current study are available in the NHANES (National Health and Nutrition Examination Surveys) repository.

[https://www.cdc.gov/nchs/nhanes/index.htm]

**Competing interests**

The authors declare that they have no competing interests.

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None.

**Authors' contributions**

Study concept and design: Yan XU, Rong LIU.

Data extraction: Yan XU;

Data analysis and interpretation: Yan XU.
Drafting of the manuscript: Yan XU;
critical revision of the manuscript for important intellectual content: Rong LIU.
Statistical analysis: Yan XU.

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References

1. PINEIRO-CARRERO V M, PINEIRO E O. Liver. PEDIATRICS 2004; 113(4 Suppl): 1097-106.
2. DONG M H, BETTENCOURT R, BARRETT-CONNOR E, LOOMBA R. Alanine aminotransferase decreases with age: the Rancho Bernardo Study. PLOS ONE 2010; 5(12): e14254.
3. SCHMUCKER D L. Age-related changes in liver structure and function: Implications for disease ? EXP GERONTOL 2005; 40(8-9): 650-59.
4. MINEMURA M, SHIMIZU Y. Gut microbiota and liver diseases. World J Gastroenterol 2015; 21(6): 1691-702.
5. MENDENHALL C L. Anabolic steroid therapy as an adjunct to diet in alcoholic hepatic steatosis. Am J Dig Dis 1968; 13(9): 783-91.
6. MANDAYAM S, JAMAL M M, MORGAN T R. Epidemiology of alcoholic liver disease. SEMIN LIVER DIS 2004; 24(3): 217-32.
7. LEE S, LEE H, KIM S, LEE J, HA J, CHOI Y, et al. Intestinal Clostridioides difficile Can Cause Liver Injury through the Occurrence of Inflammation and Damage to Hepatocytes. BIOMED RES INT 2020; 2020: 7929610.
8. ARORA N, GOLDHABER S Z. Anticoagulants and transaminase elevation. CIRCULATION 2006; 113(15): e698-702.
9. SERVICES. U S D O. Common Terminology Criteria for Adverse Events( CTCAE) Version 4. 02[ EB/OL]. 2009.
10. ALLEN L A, FELKER G M, POCOCK S, McMURRAY J J, PFEFFER M A, SWEDBERG K, et al. Liver function abnormalities and outcome in patients with chronic heart failure: data from the Candesartan in Heart Failure: Assessment of Reduction in Mortality and Morbidity (CHARM) program. EUR J HEART FAIL 2009; 11(2): 170-77.
11. van DEURSEN V M, DAMMAN K, HILLEGGE H L, van BEEK A P, van VELDHUISEN D J, VOORS A A. Abnormal liver function in relation to hemodynamic profile in heart failure patients. J CARD FAIL 2010; 16(1): 84-90.

12. BATIN P, WICKENS M, McENTEGART D, FULLWOOD L, COWLEY A J. The importance of abnormalities of liver function tests in predicting mortality in chronic heart failure. EUR HEART J 1995; 16(11): 1613-18.

13. ALLEN L A, FELKER G M, POCOCK S, McMURRAY J J, PFEFFER M A, SWEDBERG K, et al. Liver function abnormalities and outcome in patients with chronic heart failure: data from the Candesartan in Heart Failure: Assessment of Reduction in Mortality and Morbidity (CHARM) program. EUR J HEART FAIL 2009; 11(2): 170-77.

14. van DEURSEN V M, DAMMAN K, HILLEGGE H L, van BEEK A P, van VELDHUISEN D J, VOORS A A. Abnormal liver function in relation to hemodynamic profile in heart failure patients. J CARD FAIL 2010; 16(1): 84-90.

15. SCHOLFIELD M, SCHABATH M B, GUGLIN M. Longitudinal trends, hemodynamic profiles, and prognostic value of abnormal liver function tests in patients with acute decompensated heart failure: an analysis of the ESCAPE trial. J CARD FAIL 2014; 20(7): 476-84.

16. KUBIK J F, GILL R S, LAFFIN M, KARMALI S. The impact of bariatric surgery on psychological health. J Obes 2013; 2013: 837989.

17. FONTAINE K R, REDDEN D T, WANG C, WESTFALL A O, ALLISON D B. Years of life lost due to obesity. JAMA 2003; 289(2): 187-93.

18. KAPLAN M S, HUGUET N, NEWSOM J T, MCFARLAND B H, LINDSAY J. Prevalence and correlates of overweight and obesity among older adults: findings from the Canadian National Population Health Survey. J Gerontol A Biol Sci Med Sci 2003; 58(11): 1018-30.

19. HENSON J, YATES T, BIDDLE S J, EDWARDSON C L, KHUNTI K, WILMOT E G, et al. Associations of objectively measured sedentary behaviour and physical activity with markers of cardiometabolic health. DIABETOLOGIA 2013; 56(5): 1012-20.

20. BISWAS A, OH P I, FAULKNER G E, BAJAJ R R, SILVER M A, MITCHELL M S, et al. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. ANN INTERN MED 2015; 162(2): 123-32.

21. KNAEPS S, LEFEVRE J, WIJTZES A, CHARLIER R, MERTENS E, BOURGOIS J G. Independent Associations between Sedentary Time, Moderate-To-Vigorous Physical Activity, Cardiorespiratory Fitness and Cardio-Metabolic Health: A Cross-Sectional Study. PLOS ONE 2016; 11(7): e160166.

22. LEE I M, SHIROMA E J, LOBELO F, PUSKA P, BLAIR S N, KATZMARZYK P T. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. LANCET 2012; 380(9838): 219-29.

23. HENSON J, YATES T, BIDDLE S J, EDWARDSON C L, KHUNTI K, WILMOT E G, et al. Associations of objectively measured sedentary behaviour and physical activity with markers of cardiometabolic health. DIABETOLOGIA 2013; 56(5): 1012-20.

24. SMITH A D, CRIPPA A, WOODCOCK J, BRAGE S. Physical activity and incident type 2 diabetes mellitus: a systematic review and dose-response meta-analysis of prospective cohort studies. DIABETOLOGIA 2016; 59(12): 2527-45.
25. TREMBLAY M S, AUBERT S, BARNES J D, SAUNDERS T J, CARSON V, LATIMER-CHEUNG A E, et al. Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. Int J Behav Nutr Phys Act 2017; 14(1): 75.

26. BLAIR S N, KOHL H R, PAFFENBARGER R J, CLARK D G, COOPER K H, GIBBONS L W. Physical fitness and all-cause mortality. A prospective study of healthy men and women. JAMA 1989; 262(17): 2395-401.

27. BOWDEN D K, SPRUNG V S, NORMAN J A, THOMPSON A, MITCHELL K L, HARROLD J, et al. Physical Activity and Sedentary Time: Association with Metabolic Health and Liver Fat. Med Sci Sports Exerc 2019; 51(6): 1169-77.

28. FORTIER E, ALAVI M, BRUNEAU J, MICALLEF M, PERRAM J, SOCKALINGAM S, et al. Depression, Anxiety, and Stress Among People With Chronic Hepatitis C Virus Infection and a History of Injecting Drug Use in New South Wales, Australia. J ADDICT MED 2017; 11(1): 10-18.

29. GOLDEN J, O’DWYER A M, CONROY R M. Depression and anxiety in patients with hepatitis C: prevalence, detection rates and risk factors. Gen Hosp Psychiatry 2005; 27(6): 431-38.

30. ROGAL S S, MANKANEY G, UDAWATTA V, CHINMAN M, GOOD C B, ZICKMUND S, et al. Pre-Transplant Depression Is Associated with Length of Hospitalization, Discharge Disposition, and Survival after Liver Transplantation. PLOS ONE 2016; 11(11): e165517.

31. SULLIVAN L E, FIELLIN D A, O’CONNOR P G. The prevalence and impact of alcohol problems in major depression: a systematic review. AM J MED 2005; 118(4): 330-41.

32. VOICAN C S, CORRUBLE E, NAVEAU S, PERLEMUTER G. Antidepressant-induced liver injury: a review for clinicians. Am J Psychiatry 2014; 171(4): 404-15.

Tables

Table 1  The characteristics of the population
| Table 2 | Analysis of the influence of various factors on liver dysfunction |
|---------|---------------------------------------------------------------|
| **liver dysfunction.** | 0 | 1 | Standardize diff. | P value |
| **Ratio of family income to poverty** | $3.04 \pm 1.62$ | $2.69 \pm 1.64$ | $0.213 (0.212, 0.214)$ | $0.0091$ |
| **Gender** | | | | $<0.0001$ |
| Male | 40.66 | 76.09 | 0.770 (0.769, 0.771) |
| Female | 59.34 | 23.91 | 0.770 (0.769, 0.771) |
| **Race** | | | | $<0.0001$ |
| Non-Hispanic White | 72.88 | 52.26 | 0.436 (0.435, 0.437) |
| Non-Hispanic Black | 9.01 | 5.37 | 0.141 (0.140, 0.142) |
| Mexican American | 4.99 | 27.86 | 0.649 (0.648, 0.650) |
| Other Race | 13.13 | 14.51 | 0.040 (0.039, 0.041) |
| **Education level** | | | | 0.3723 |
| less High school graduate | 10.71 | 8.30 | 0.082 (0.081, 0.083) |
| High school graduate/GED or equivalent | 29.54 | 34.12 | 0.098 (0.097, 0.099) |
| College graduate or above | 59.75 | 57.58 | 0.044 (0.043, 0.045) |
| **marital status** | | | | 0.0452 |
| Married/Living with Partner | 61.02 | 53.56 | 0.151 (0.150, 0.152) |
| Widowed/Divorced/Separated | 25.52 | 26.37 | 0.019 (0.018, 0.020) |
| Never married | 13.46 | 20.07 | 0.178 (0.177, 0.179) |
| **High blood pressure** | | | | 0.5633 |
| none | 44.46 | 46.82 | 0.047 (0.046, 0.048) |
| have | 55.54 | 53.18 | 0.047 (0.046, 0.048) |
| **Diabetes** | | | | 0.1251 |
| none | 74.28 | 79.78 | 0.131 (0.130, 0.132) |
| have | 25.72 | 20.22 | 0.131 (0.130, 0.132) |
| **Age** | | | | $<0.0001$ |
| 20-40 | 19.95 | 41.33 | 0.477 (0.476, 0.478) |
| 40-60 | 33.92 | 35.91 | 0.042 (0.041, 0.043) |
| 60-80 | 39.58 | 22.62 | 0.373 (0.372, 0.374) |
| ≥80 | 6.55 | 0.13 | 0.363 (0.362, 0.364) |
|                          | Estimate | Std. Error | t value | exp(coef) | 95%CI low | 95%CI up | P value |
|--------------------------|----------|------------|---------|-----------|-----------|----------|---------|
| (Intercept)              | -3.55775 | 0.55656    | -6.39236| 0.02850   | 0.00957   | 0.08485  | <0.000001|
| High blood pressure 1    | 0.61606  | 0.31338    | 1.96583 | 1.85161   | 1.00183   | 3.42221  | 0.049342|
| Diabetes 1               | -0.40129 | 0.28450    | -1.41049| 0.66946   | 0.38331   | 1.16922  | 0.158421|
| Have little interest in doing things 1 | -0.06890 | 0.23098    | -0.29831| 0.93342   | 0.59355   | 1.46788  | 0.765475|
| Feeling down/Depressed/Hopeless 1 | 0.47395  | 0.23397    | 2.02568 | 1.60633   | 1.01549   | 2.54093  | 0.042821|
| Troubles sleeping or sleeping too much 1 | 0.00842  | 0.24334    | 0.03460 | 1.00845   | 0.62593   | 1.62476  | 0.972401|
| Feeling bad about yourself 1 | 0.66784  | 0.20984    | 3.18263 | 1.95001   | 1.29247   | 2.94221  | 0.001463|
| Trouble concentrating on things 1 | 0.18523  | 0.26464    | 0.69994 | 1.20350   | 0.71644   | 2.02168  | 0.483980|
| Moving or speaking slowly or too fast 1 | 0.17970  | 0.24149    | 0.74413 | 1.19685   | 0.74556   | 1.92132  | 0.456816|
| Thoughts you would be better off dead 1 | -0.06578 | 0.37443    | -0.17567| 0.93634   | 0.44948   | 1.95054  | 0.860554|
| Difficulty these problems have caused 1 | 0.29432  | 0.24237    | 1.21434 | 1.34221   | 0.83467   | 2.15837  | 0.224642|
| Overweight 1             | 0.73184  | 0.28169    | 2.59800 | 2.07891   | 1.19688   | 3.61093  | 0.009389|
| Controlling/losing weight 1 | 0.36391  | 0.29012    | 1.25433 | 1.43894   | 0.81487   | 2.54096  | 0.209748|
| Increasing exercise 1    | 0.03042  | 0.28371    | 0.10722 | 1.01210   | 0.55936   | 1.83128  | 0.968233|
| Reducing salt in diet 1  | -1.14166 | 0.23138    | -4.93415| 0.31929   | 0.20288   | 0.50250  | <0.000001|
| Reducing fat in diet 1   | -0.44590 | 0.24053    | -1.85379| 0.64025   | 0.39958   | 1.02588  | 0.063795|
| Vigorous work activity 1 | 0.01203  | 0.30254    | 0.03976 | 1.01210   | 0.55936   | 1.83128  | 0.968233|
| Moderate work activity 1 | -0.21537 | 0.19592    | -1.09928| 0.80624   | 0.54915   | 1.18369  | 0.271671|
| Walk or bicycle 1        | -0.02088 | 0.24753    | -0.08435| 0.97934   | 0.60288   | 1.59085  | 0.932777|
| Vigorous recreational activities 1 | -1.42441 | 0.34148    | -4.17128| 0.24065   | 0.12323   | 0.46996  | 0.000031|
| moderate recreational activities 1 | 0.58737  | 0.23972    | 2.45021 | 1.79926   | 1.12470   | 2.87839  | 0.014293|
| Products used in home to control insects 1 | 0.18224  | 0.40969    | 0.44481 | 1.19990   | 0.53754   | 2.67843  | 0.656462|
| Products used to kill weeds 1 | -0.15248 | 0.44326    | -0.34400| 0.85857   | 0.36014   | 2.04687  | 0.730853|
| Taken prescription medicine past month 1 | -1.40758 | 0.30153    | -4.66815| 0.24473   | 0.13553   | 0.44194  | 0.000003|
| Feel overly sleepy during day 1 | -0.41541 | 0.21946    | -1.89289| 0.66007   | 0.42932   | 1.01484  | 0.058398|
| Smoked at least 100      | -0.06138 | 0.22426    | -0.27369| 0.94047   | 0.60596   | 1.45962  | 0.784326|
Table 3 The association between mean arterial pressure and liver dysfunction

|                               | Mean arterial pressure | Standard error of the mean arterial pressure | t value | p value |
|-------------------------------|------------------------|---------------------------------------------|---------|---------|
| Cigarettes in life 1          | 0.47564                | 0.23466                                     | 2.02694 | 1.60905 |
| Seen mental health professional past year 1 | 2.54868                | 0.042692                                    |         |         |
| Sedentary activity 1          | 0.77211                | 0.32535                                     | 2.37318 | 2.16432 |
| Sleep hours weekdays or workdays 1 | 1.14388                | 4.09508                                     |         |         |
| Sleep hours weekends 1        | -0.61677               | 0.41868                                     | -1.47314| 0.53968 |
|                               |                        |                                             | 0.23755 | 1.22610 |
|                               |                        |                                             | 0.140742|         |
|                | model 1                                      | model 2                                      | model 3                                      | P for trend  |
|----------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|-------------|
| Gender         |                                             |                                             |                                             |             |
| male           |                                             |                                             |                                             |             |
| Q1             | 1                                           | 1                                           | 1                                           | <0.001      |
| Q2             | 1.6671 (0.3731, 7.4497) 0.503409             | 1.7595 (0.3589, 8.6252) 0.486025             | 1.6997 (0.3734, 7.7375) 0.492739             |             |
| Q3             | 1.9441 (0.5067, 7.4592) 0.332552             | 1.8483 (0.4225, 8.0850) 0.414607             | 1.5150 (0.4395, 5.2230) 0.510605             |             |
| Q4             | 1.7876 (0.4588, 6.9645) 0.402484             | 1.8066 (0.3997, 8.1657) 0.442194             | 1.2370 (0.2825, 5.4162) 0.777675             |             |
| female         |                                             |                                             |                                             |             |
| Q1             | 1                                           | 1                                           | 1                                           | <0.001      |
| Q2             | 0.4091 (0.0798, 2.0977) 0.283848             | 0.3531 (0.0702, 1.7747) 0.206341             | 0.6494 (0.2006, 2.1020) 0.471284             |             |
| Q3             | 0.2918 (0.0526, 1.6177) 0.158660             | 0.2633 (0.0395, 1.7530) 0.167691             | 0.4086 (0.0830, 2.0107) 0.270927             |             |
| Q4             | 0.6316 (0.1562, 2.5543) 0.519226             | 0.7127 (0.1570, 3.2358) 0.660816             | 0.9090 (0.3040, 2.7185) 0.864475             |             |
| total          |                                             |                                             |                                             |             |
| Q1             | 1                                           | 1                                           | 1                                           | <0.001      |
| Q2             | 0.9355 (0.3154, 2.7745) 0.904300             | 0.9236 (0.2979, 2.8632) 0.890491             | 0.9171 (0.3216, 2.6155) 0.871400             |             |
| Q3             | 1.0188 (0.3881, 2.6747) 0.969779             | 0.9971 (0.3498, 2.8418) 0.995644             | 0.9690 (0.3918, 2.3962) 0.945612             |             |
| Q4             | 1.1149 (0.4305, 2.8873) 0.822704             | 1.1637 (0.4065, 3.3316) 0.777495             | 1.0347 (0.3590, 2.9823) 0.949570             |             |
| Age            |                                             |                                             |                                             |             |
| 20-40          |                                             |                                             |                                             |             |
| Q1             | 1                                           | 1                                           | 1                                           | <0.001      |
| Q2             | 0.4447 (0.1154, 1.7141) 0.239126             | 0.4257 (0.1111, 1.6308) 0.212651             | 0.5509 (0.1340, 2.2652) 0.408557             |             |
| Q3             | 3.0009 (1.0641, 8.4628) 0.037758             | 2.3531 (0.8375, 6.6113) 0.104477             | 2.4805 (0.8890, 6.9214) 0.082698             |             |
| Q4             | 2.7250 (1.0876, 6.8272) 0.032417             | 2.4313 (0.8908, 6.6361) 0.082883             | 6.6804 (1.8909, 23.6015) 0.003185             |             |
| 40-60          |                                             |                                             |                                             |             |
| Q1             | 1                                           | 1                                           | 1                                           | <0.001      |
| Q2             | 0.3255 (0.0630, 1.6815) 0.180333             | 0.4128 (0.0832, 2.0473) 0.278837             | 0.3840 (0.1052, 1.4021) 0.147460             |             |
| Q3 | 0.2581 (0.0504, 1.3229) | 0.2391 (0.0452, 1.2641) | 0.3275 (0.0857, 1.2515) |
| Q4 | 0.6719 (0.1515, 2.9790) | 0.6945 (0.1559, 3.0938) | 0.7938 (0.3102, 2.0309) |

| 60-80 |
| Q1 | 1 | 1 | 1 | <0.001 |
| Q2 | 5.6241 (0.5659, 55.8972) | 5.1427 (0.4443, 59.5310) | inf. (inf., inf.) | <0.000001 |
| Q3 | 2.7099 (0.2395, 30.6564) | 2.4651 (0.2093, 29.0326) | inf. (inf., inf.) | <0.000001 |
| Q4 | 1.5012 (0.1291, 17.4541) | 1.4586 (0.1031, 20.6268) | 0.0000 (0.0000, 0.0000) | <0.000001 |

| 80 |
| Q1 | 1 | 1 | 1 | <0.001 |
| Q2 | 0.0000 (0.0000, 0.0000) | 0.0000 (0.0000, 0.0000) | 0.0232 (0.0141, 0.0379) | <0.000001 |
| Q3 | 0.0000 (0.0000, 0.0000) | 0.0000 (0.0000, 0.0000) | 0.0026 (0.0016, 0.0042) | <0.000001 |
| Q4 | 0.0000 (0.0000, 0.0000) | 0.0000 (0.0000, 0.0000) | 0.0000 (0.0000, 0.0000) | <0.000001 |

| total |
| Q1 | 1 | 1 | 1 | <0.001 |
| Q2 | 0.9058 (0.2910, 2.8191) | 0.9236 (0.2980, 2.8624) | 0.9171 (0.3215, 2.6161) | 0.871429 |
| Q3 | 1.0647 (0.3672, 3.0872) | 0.9971 (0.3510, 2.8323) | 0.9690 (0.3928, 2.3905) | 0.945467 |
| Q4 | 1.2186 (0.4313, 3.4430) | 1.1637 (0.4078, 3.3207) | 1.0347 (0.3597, 2.9767) | 0.949479 |

| Race |
| Non-Hispanic White |
| Q1 | 1 | 1 | 1 | <0.001 |
| Q2 | 0.6556 (0.0997, 4.3131) | 0.6253 (0.0942, 4.1519) | 0.6245 (0.1679, 2.3219) | 0.482194 |
| Q3 | 0.6317 (0.1241, 3.2153) | 0.5938 (0.1151, 3.0650) | 0.6127 (0.1667, 2.2519) | 0.460680 |
| Q4 | 0.7822 (0.1868, 3.2761) | 0.7890 (0.1543, 4.0337) | 1.4533 (0.3227, 6.5444) | 0.626303 |

| Non-Hispanic Black |
| Q1 | 1 | 1 | 1 | <0.001 |
| Q2 | 2.5723 (0.2292, 28.8700) | 3.0431 (0.2137, 43.3309) | 1.0009 (0.0060, 167.1816) | 0.999715 |
|     | Q1              | Q2              | Q3              | Q4              |
|-----|-----------------|-----------------|-----------------|-----------------|
|     | 1, 1, 1         | 0.3050, 0.1905, | 0.8584, 0.5193, | 0.0000, 0.0065, |
| Q3  | 2.2886 (0.2042, | 1.7916 (0.2070, | 3.0432 (0.1190, | 0.500989        |
|     | 25.6490) 0.501900 | 15.5022) 0.596375 | 77.8171)        |                 |
| Q4  | 3.6081 (0.7188, | 3.6011 (0.7145, | 73.3031 (0.4763, | 0.596375        |
|     | 18.1116) 0.119027 | 18.1509) 0.120525 | 11281.1240) 0.094651 |                 |
|     | Mexican American| Q1              | Q2              | Q3              |
|     | 1, 1, 1         | 2.3907 (0.2409, | 8.4270 (1.8961, | 3.5461 (0.4162, |
|     | 23.7290) 0.456677 | 23.7290) 0.456677 | 37.4517) 0.005099 | 30.2134) 0.246841 |
|     |                 | 2.5392 (0.2472, | 5.5422 (0.9782, | 3.6287 (0.5277, |
|     |                 | 26.0807) 0.432993 | 31.4023) 0.052984 | 24.9535) 0.190133 |
|     |                 | 0.4826 (0.0000, | 140.6233 (0.0000, in) |                 |
|     |                 | 398686.4173) 0.928563 |                 |                 |
|     | Q4              | 3.6081 (0.7188, | 3.6011 (0.7145, | 73.3031 (0.4763, |
|     | 18.1116) 0.119027 | 18.1509) 0.120525 | 11281.1240) 0.094651 |                 |
|     | Other Race      | Q1              | Q2              | Q3              |
|     | 1, 1, 1         | 0.7806 (0.1466, | 0.4646 (0.0717, | 0.7896 (0.1359, |
|     | 4.1560) 0.771611 | 3.0093) 0.421292 | 4.5891) 0.792482 |                 |
|     |                 | 0.7271 (0.1448, | 0.4492 (0.0525, | 0.6852 (0.1016, |
|     |                 | 3.6516) 0.698696 | 3.8420) 0.464858 | 4.6194) 0.697764 |
|     |                 | 0.6648 (0.1862, | 0.7300 (0.1477, 3.6078) |                 |
|     |                 | 2.3741) 0.529576 | 0.699436 |                 |
|     |                 | Q3              | Q4              | Q4              |
|     | 0.2507 (0.0502, | 0.4625 (0.1399, | 0.7896 (0.1359, | 0.7896 (0.1359, |
|     | 1.2525) 0.091856 | 3.0586) 0.712976 | 4.5891) 0.792482 | 4.5891) 0.792482 |
|     | 0.1257 (0.0201, | 0.9971 (0.3510, | 0.6852 (0.1016, | 0.6852 (0.1016, |
|     | 0.7855) 0.026539 | 2.8323) 0.995630 | 4.6194) 0.697764 | 4.6194) 0.697764 |
|     | 0.1085 (0.0067, | 0.1085 (0.0067, | 0.1085 (0.0067, | 0.1085 (0.0067, |
|     | 1.7535)         | 1.7535)         | 1.7535)         | 1.7535)         |
|     | total            | Q1              | Q2              | Q3              |
|     | 1, 1, 1         | 0.9377 (0.3140, | 1.1389 (0.4238, | 1.1932 (0.4655, |
|     |                 | 2.8004) 0.908299 | 3.0608) 0.796463 | 3.0586) 0.712976 |
|     |                 | 0.9236 (0.2980, | 0.9971 (0.3510, | 1.1637 (0.4078, |
|     |                 | 2.8624) 0.890463 | 2.8323) 0.995630 | 3.3207) 0.776820 |
|     |                 | 0.9171 (0.3215, 2.6161) |                 |                 |
|     |                 | 0.9171 (0.3215, 2.6161) |                 |                 |
|     |                 | 0.9690 (0.3928, 2.3905) |                 |                 |
|     |                 | 0.945467 |                 |                 |
|     |                 | Q4              |                 |                 |
|     | 0.0816 (0.0084, | 0.0489 (0.0045, | 0.0000 (0.0000, 1.2899) |                 |
|     | 0.7892) 0.030425 | 0.5293) 0.013015 | 1.2899)         |                 |
|     | Educational level| less High school | graduate         | High school      |
|     | Q1              | graduate/GED or | equivalent       | Q1              |
|     | 1, 1, 1         | equivalent       | <0.001           | 1, 1, 1         |
|     | Q2              | 0.7997 (0.1220, |                 | 0.7997 (0.1220, |
|     |                 | 5.2444) 0.815831 |                 | 5.2444) 0.815831 |
|     | 0.7225 (0.1364, |                 |                 | 0.7225 (0.1364, |
|     | 3.8276) 0.702403 |                 |                 | 3.8276) 0.702403 |
|     | 0.0779 (0.0001, 49.9090) |                 |                 | 0.0779 (0.0001, 49.9090) |
|     |                 | 0.438942 |                 | 0.438942 |
| Q2 | 1.9711 (0.3668, 10.5905) | 3.0368 (0.4645, 19.8547) | 5.6026 (0.7419, 42.3113) |
|----|------------------------|--------------------------|--------------------------|
| Q3 | 5.8167 (1.4820, 22.8298) | 7.1592 (1.3856, 36.9907) | 11.1578 (1.5851, 78.5418) |
| Q4 | 3.2204 (0.9254, 11.2072) | 4.7116 (1.1260, 19.7140) | 24.3675 (2.3808, 249.3974) |

| College graduate or above |  |
|---------------------------|--|
| Q1 | 1 | 1 | 1 | <0.001 |
| Q2 | 0.7829 (0.1638, 3.7428) | 0.7216 (0.1446, 3.6002) | 0.8143 (0.2744, 2.4161) |
| Q3 | 0.5882 (0.1658, 2.0874) | 0.5398 (0.1337, 2.1794) | 0.6041 (0.2328, 1.5673) |
| Q4 | 1.2589 (0.3390, 4.6750) | 1.3209 (0.3325, 5.2475) | 1.2754 (0.4516, 3.6015) |

| total |  |
|-------|--|
| Q1 | 1 | 1 | 1 | <0.001 |
| Q2 | 0.9553 (0.3253, 2.8054) | 0.9236 (0.2980, 2.8624) | 0.9171 (0.3215, 2.6161) |
| Q3 | 1.0908 (0.4180, 2.8462) | 0.9971 (0.3510, 2.8323) | 0.9690 (0.3928, 2.3905) |
| Q4 | 1.1420 (0.4412, 2.9558) | 1.1637 (0.4078, 3.3207) | 1.0347 (0.3597, 2.9767) |

Table 4 The association between BMI and liver dysfunction
|      | model 1       | model 2       | model 3       | P for trend |
|------|---------------|---------------|---------------|-------------|
| **Gender** |               |               |               |             |
| **male** |               |               |               |             |
| Q1   | 1             | 1             | 1             | <0.001      |
| Q2   | 2.6996 (1.0309, 7.0693) 0.043175 | 3.5250 (1.2656, 9.8180) 0.015921 | 3.2234 (1.0963, 9.4776) 0.033413 |             |
| Q3   | 1.8895 (0.6184, 5.7730) 0.264137 | 2.1458 (0.7077, 6.5058) 0.177298 | 1.6764 (0.4773, 5.8873) 0.420189 |             |
| Q4   | 3.4451 (1.2883, 9.2129) 0.013712 | 3.7417 (1.4663, 9.5483) 0.005767 | 3.0988 (0.6113, 15.7093) 0.172036 |             |
| **female** |               |               |               |             |
| Q1   | 1             | 1             | 1             | <0.001      |
| Q2   | 0.6498 (0.1239, 3.4062) 0.609995 | 0.6318 (0.1056, 3.7791) 0.614892 | 0.9220 (0.2582, 3.2919) 0.900485 |             |
| Q3   | 0.3224 (0.0778, 1.3355) 0.118519 | 0.2944 (0.0638, 1.3592) 0.117181 | 0.7349 (0.1766, 3.0584) 0.672043 |             |
| Q4   | 0.6816 (0.1539, 3.0174) 0.613522 | 0.5613 (0.1206, 2.6134) 0.461811 | 1.5406 (0.3737, 6.3520) 0.549861 |             |
| **total** |               |               |               |             |
| Q1   | 1             | 1             | 1             | <0.001      |
| Q2   | 1.4555 (0.5554, 3.8138) 0.445085 | 1.7350 (0.6251, 4.8158) 0.290099 | 1.6664 (0.6917, 4.0146) 0.254960 |             |
| Q3   | 0.9322 (0.3215, 2.7028) 0.897169 | 1.0173 (0.3411, 3.0342) 0.975463 | 1.2363 (0.4997, 3.0590) 0.646238 |             |
| Q4   | 1.6973 (0.6274, 4.5921) 0.297489 | 1.6982 (0.6033, 4.7800) 0.315863 | 2.2534 (0.6702, 7.5770) 0.189126 |             |
| **Age** |               |               |               |             |
| 20-40 |               |               |               |             |
| Q1   | 1             | 1             | 1             | <0.001      |
| Q2   | 3.3251 (0.7985, 13.8458) 0.098771 | 2.8470 (0.5726, 14.1542) 0.201015 | 2.3138 (0.5872, 9.1172) 0.230510 |             |
| Q3   | 1.6384 (0.5251, 5.1123) 0.395141 | 1.5979 (0.4957, 5.1509) 0.432594 | 2.1490 (0.4072, 11.3414) 0.367405 |             |
| Q4   | 4.7460 (1.6274, 13.8412) 0.004348 | 5.5588 (2.0494, 15.0778) 0.000753 | 8.0862 (1.9502, 33.5287) 0.003971 |             |
| 40-60 |               |               |               |             |
| Q1   | 1             | 1             | 1             | <0.001      |
| Q2   | 1.4882 (0.2903, 7.6298) 0.633517 | 1.7046 (0.2995, 9.7019) 0.547781 | 1.7423 (0.5719, 5.3077) 0.328633 |             |
| Q3          | 1.0720 (0.1883, 6.1023) 0.937552 | 1.0447 (0.1812, 6.0232) 0.960989 | 1.6302 (0.3435, 7.7360) 0.538483 |
| Q4          | 0.5660 (0.0977, 3.2771) 0.525233 | 0.7068 (0.1075, 4.6488) 0.718024 | 0.5631 (0.0481, 6.5951) 0.647355 |

60-80

| Q1          | 1 1 1 | 1 | <0.001 |
| Q2          | 1.2519 (0.2110, 7.4264) 0.804662 | 1.1327 (0.2196, 5.8413) 0.881675 | 0.0000 (0.0000, 0.0000) <0.000001 |
| Q3          | 0.5552 (0.0538, 5.7249) 0.621059 | 0.5971 (0.0473, 7.5328) 0.690128 | 0.0000 (0.0000, 0.0000) <0.000001 |
| Q4          | 1.4912 (0.2080, 10.6920) 0.690930 | 1.6204 (0.1734, 15.1408) 0.672035 | inf. (inf., inf.) <0.000001 |

80

| Q1          | 1 1 1 | 1 | <0.001 |
| Q2          | 0.0000 (0.0000, 0.0000) <0.000001 | 0.0000 (0.0000, 0.0000) <0.000001 | 0.6901 (0.4646, 1.0253) 0.066304 |
| Q3          | 0.0000 (0.0000, 0.0000) <0.000001 | inf. (inf., inf.) <0.000001 | 20.5926 (11.8355, 35.8293) <0.000001 |
| Q4          | 0.0000 (0.0000, 0.0000) <0.000001 | 98061.3668 (34655.9689, 277471.1536) <0.000001 | 0.0047 (0.0020, 0.0110) <0.000001 |

total

| Q1          | 1 1 1 | 1 | <0.001 |
| Q2          | 1.8037 (0.6540, 4.9743) 0.254428 | 1.7350 (0.6251, 4.8158) 0.290099 | 1.6664 (0.6917, 4.0146) 0.254960 |
| Q3          | 1.0508 (0.3554, 3.1074) 0.928590 | 1.0173 (0.3411, 3.0342) 0.975463 | 1.2363 (0.4997, 3.0590) 0.646238 |
| Q4          | 1.4871 (0.5423, 4.0778) 0.440660 | 1.6982 (0.6033, 4.7800) 0.315863 | 2.2534 (0.6702, 7.5770) 0.189126 |

Race

Non-Hispanic White

| Q1          | 1 1 1 | 1 | <0.001 |
| Q2          | 0.8494 (0.1875, 3.8470) 0.832230 | 0.9829 (0.1713, 5.6402) 0.984582 | 2.1093 (0.4417, 10.0733) 0.349466 |
| Q3          | 0.2062 (0.0473, 0.8986) 0.035530 | 0.2213 (0.0484, 1.0118) 0.051797 | 0.3577 (0.0544, 2.3540) 0.284888 |
| Q4          | 0.8927 (0.1750, 4.5545) 0.891380 | 0.8296 (0.1405, 4.8989) 0.836679 | 4.3909 (0.8510, 22.6564) 0.077190 |

Non-Hispanic Black

| Q1          | 1 1 1 | 1 | <0.001 |
| Q2          | 7.5253 (0.7634, 74.1833) 0.083856 | 11.7526 (1.1804, 117.0177) 0.035605 | 7.5666 (0.1222, 468.4477) 0.336339 |
|       | Q3               | Q4               |
|-------|------------------|------------------|
|       | 7.7000 (0.7464, 79.4342) 0.086465 | 4.2298 (0.3641, 49.1430) 0.249109 |
|       | 17.9587 (1.3132, 245.5863) 0.030499 | 8.1162 (0.6781, 97.1386) 0.098269 |
|       | 0.086465         | 0.030499         |
| Mexican American | 0.030449         | 0.098269         |
| Q1    | 1                | 1                |
| Q2    | 5.3808 (0.4279, 67.6595) 0.192628 | 12.0973 (0.6320, 231.5734) 0.097869 |
|       | 51831.5354 (0.4081, inf.) 0.070217 | 39171.5840 (0.7897, inf.) 0.055211 |
| Q3    | 9.1636 (0.7517, 111.7067) 0.082509 | 14.1323 (0.8491, 235.2053) 0.064890 |
| Q4    | 11.2941 (1.2038, 105.9642) 0.033807 | 25.1096 (1.7421, 361.9171) 0.017896 |
| Other Race | 0.098269         | 0.064890         |
| Q1    | 1                | 1                |
| Q2    | 2.0075 (0.4434, 9.0880) 0.365718 | 2.4778 (0.6207, 9.8905) 0.198858 |
|       | 2.4009 (0.5477, 10.5252) 0.245409 | 0.290099 |
| Q3    | 0.5528 (0.1431, 2.1357) 0.389882 | 0.6193 (0.1434, 2.6741) 0.520829 |
| Q4    | 1.9230 (0.5001, 7.3948) 0.341347 | 2.0313 (0.4611, 8.9478) 0.348889 |
|       | 6.8110 (0.9069, 51.1514) 0.062180 | 0.245687 |
| total | 1                | 1                |
| Q1    | 1                | 1                |
| Q2    | 1.5505 (0.2159, 11.1337) 0.662789 | 1.7350 (0.6251, 4.8158) 0.290099 |
|       | 1.6664 (0.6917, 4.0146) 0.254960 | 0.290099 |
| Q3    | 0.9429 (0.3319, 2.6786) 0.912054 | 1.0173 (0.3411, 3.0342) 0.975463 |
| Q4    | 1.5920 (0.6038, 4.1971) 0.347184 | 1.6982 (0.6033, 4.7800) 0.315863 |
| Educational level | 0.290099         | 0.975463         |
|       | 1                | 1                |
| Q1    | 1                | 1                |
| Q2    | 1.4840 (0.5534, 3.9793) 0.432797 | 1.7350 (0.6251, 4.8158) 0.290099 |
|       | 1.6664 (0.6917, 4.0146) 0.254960 | 0.290099 |
| Q3    | 0.9429 (0.3319, 2.6786) 0.912054 | 1.0173 (0.3411, 3.0342) 0.975463 |
| Q4    | 1.5920 (0.6038, 4.1971) 0.347184 | 1.6982 (0.6033, 4.7800) 0.315863 |
|       | 2.2534 (0.6702, 7.5770) 0.189126 | 0.290099 |
| less High school graduate | 0.290099         | 0.975463         |
| Q1    | 1                | 1                |
| Q2    | 1.5505 (0.2159, 11.1337) 0.662789 | 1.4340 (0.1886, 10.9020) 0.727616 |
|       | 0.7594 (0.0837, 6.8877) 0.806763 | 0.727616 |
| Q3    | 0.5445 (0.0885, 3.3515) 0.512084 | 0.3152 (0.0383, 2.5958) 0.283170 |
| Q4    | 0.3087 (0.0424, 2.2457) 0.245687 | 0.2184 (0.0234, 2.0396) 0.181973 |
|       | 0.0864 (0.0013, 5.5709) 0.249353 | 0.181973 |
| High school graduate/GED or equivalent | 0.290099         | 0.975463         |
| Q1    | 1                | 1                |
| Q2    | 1.5505 (0.2159, 11.1337) 0.662789 | 1.4340 (0.1886, 10.9020) 0.727616 |
|       | 0.7594 (0.0837, 6.8877) 0.806763 | 0.727616 |
| Q3    | 0.5445 (0.0885, 3.3515) 0.512084 | 0.3152 (0.0383, 2.5958) 0.283170 |
| Q4    | 0.3087 (0.0424, 2.2457) 0.245687 | 0.2184 (0.0234, 2.0396) 0.181973 |
|   |   |   |   |   |
|---|---|---|---|---|
| Q2 | 4.0334 (1.0215, 15.9257) | 6.0451 (1.2047, 30.3350) | 13.3565 (1.7562, 101.5786) |
| Q3 | 1.6134 (0.2541, 10.2444) | 2.3279 (0.2890, 18.7484) | 2.0670 (0.1206, 35.4314) |
| Q4 | 3.8008 (0.9241, 15.6329) | 6.2981 (1.3060, 30.3731) | 16.0986 (1.1359, 228.1657) |

**College graduate or above**

|   |   |   |   |   |
|---|---|---|---|---|
| Q1 | 1 | 1 | 1 | <0.001 |
| Q2 | 0.9834 (0.2138, 4.5227) | 0.9982 (0.2187, 4.5560) | 1.1515 (0.3946, 3.3599) |
| Q3 | 0.9019 (0.2111, 3.8526) | 0.9868 (0.2318, 4.2005) | 1.3930 (0.4601, 4.2168) |
| Q4 | 1.4092 (0.3689, 5.3831) | 1.5191 (0.3420, 6.7474) | 1.9415 (0.4146, 9.0917) |

**total**

|   |   |   |   |   |
|---|---|---|---|---|
| Q1 | 1 | 1 | 1 | <0.001 |
| Q2 | 1.5958 (0.5982, 4.2573) | 1.7350 (0.6251, 4.8158) | 1.6664 (0.6917, 4.0146) |
| Q3 | 0.9525 (0.3268, 2.7759) | 1.0173 (0.3411, 3.0342) | 1.2363 (0.4997, 3.0590) |
| Q4 | 1.5728 (0.6014, 4.1130) | 1.6982 (0.6033, 4.7800) | 2.2534 (0.6702, 7.5770) |

Table 5 The association between Sedentary activity and liver dysfunction
|            | model 1                  | model 2                  | model 3                  | P for trend |
|------------|--------------------------|--------------------------|--------------------------|-------------|
| **Gender** |                          |                          |                          |             |
| male       |                          |                          |                          |             |
| Q1         | 1                        | 1                        | 1                        | <0.001      |
| Q2         | 1.4427 (0.7146, 2.9125)  | 1.7914 (0.8675, 3.6990)  | 1.9454 (0.8525, 4.4395)  |             |
| Q3         | 2.6882 (1.3181, 5.4822)  | 3.2119 (1.5241, 6.7687)  | 3.7611 (1.5796, 8.9552)  |             |
| Q4         | 1.0737 (0.5203, 2.2157)  | 1.4458 (0.6785, 3.0807)  | 1.5477 (0.6501, 3.6847)  |             |
| female     |                          |                          |                          |             |
| Q1         | 1                        | 1                        | 1                        | <0.001      |
| Q2         | 1.9259 (0.7902, 4.6942)  | 1.7412 (0.7011, 4.3247)  | 1.3549 (0.5168, 3.5522)  |             |
| Q3         | 2.1130 (0.8167, 5.4671)  | 1.9545 (0.7299, 5.2336)  | 2.1853 (0.7652, 6.2404)  |             |
| Q4         | 0.3420 (0.0963, 1.2143)  | 0.2790 (0.0766, 1.0169)  | 0.2121 (0.0539, 0.8343)  |             |
| total      |                          |                          |                          | <0.001      |
| Q1         | 1                        | 1                        | 1                        |             |
| Q2         | 1.6016 (0.9224, 2.7810)  | 1.9044 (1.0851, 3.3423)  | 2.5296 (1.3838, 4.6243)  |             |
| Q3         | 2.4745 (1.4005, 4.3720)  | 2.7299 (1.5198, 4.9035)  | 3.9461 (2.1025, 7.4063)  |             |
| Q4         | 0.8438 (0.4626, 1.5394)  | 0.9801 (0.5275, 1.8209)  | 1.2835 (0.6614, 2.4908)  |             |
| **Age**    |                          |                          |                          |             |
| 20-40      |                          |                          |                          |             |
| Q1         | 1                        | 1                        | 1                        | <0.001      |
| Q2         | 1.2486 (0.4749, 3.2829)  | 1.3273 (0.4873, 3.6153)  | 1.0123 (0.3289, 3.1153)  |             |
| Q3         | 3.2118 (1.2479, 8.2666)  | 2.9157 (1.0696, 7.9480)  | 1.8898 (0.5762, 6.1978)  |             |
| Q4         | 1.0797 (0.4063, 2.8689)  | 1.4996 (0.5275, 4.2629)  | 0.8189 (0.2423, 2.7678)  |             |
| 40-60      |                          |                          |                          | <0.001      |
| Q1         | 1                        | 1                        | 1                        |             |
| Q2         | 2.4082 (1.0563, 5.4904)  | 2.3361 (1.0000, 5.4574)  | 3.5866 (1.1524, 11.1626) |             |
|      | 60-80 |          |          |          |          |          |          |          |          |          |          |          |          |          |
|-----|-------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Q3  | 1.5659 (0.6028, 4.0682) 0.357199 | 1.4477 (0.5360, 3.9102) 0.465534 | 2.5685 (0.6924, 9.5283) 0.158438 |
| Q4  | 1.3251 (0.5571, 3.1517) 0.524265 | 1.2762 (0.5190, 3.1385) 0.595243 | 4.3943 (1.3249, 14.5740) 0.015521 |
|     | 60-80 |          |          |          |          |          |          |          |          |          |          |          |          |          |
| Q1  | 1     | 1        | 1        |          | <0.001  |          |          |          |          |          |          |          |          |          |
| Q2  | 1.9811 (0.5787, 6.7816) 0.276199 | 2.1487 (0.6103, 7.5650) 0.233635 | 2.8051 (0.5421, 14.5155) 0.218744 |
| Q3  | 5.2559 (1.5612, 17.6946) 0.007379 | 5.9066 (1.6801, 20.7653) 0.005625 | 17.4979 (2.9034, 105.4558) 0.001790 |
| Q4  | 0.0000 (0.0000, Inf) 0.983547 | 0.0000 (0.0000, Inf) 0.982391 | 0.0000 (0.0000, Inf) 0.991156 |
|     | 80    |          |          |          |          |          |          |          |          |          |          |          |          |          |
| Q1  | 1     | 1        | 1        |          | <0.001  |          |          |          |          |          |          |          |          |          |
| Q2  | inf. (0.0000, Inf) 0.998972 | 5.8572 (0.0000, Inf) 0.999965 | 1462.5533 (0.0000, Inf) 0.999945 |
| Q3  | 1.0000 (0.0000, Inf) 1.000000 | 0.0000 (0.0000, Inf) 0.999659 | 36.1784 (0.0000, Inf) 0.999976 |
| Q4  | 1.0000 (0.0000, Inf) 1.000000 | 0.0000 (0.0000, Inf) 0.999648 | 43.6774 (0.0000, Inf) 0.999973 |
|     | total |          |          |          |          |          |          |          |          |          |          |          |          |          |
| Q1  | 1     | 1        | 1        |          | <0.001  |          |          |          |          |          |          |          |          |          |
| Q2  | 1.9148 (1.1018, 3.3278) 0.021233 | 1.9044 (1.0851, 3.3423) 0.024805 | 2.5296 (1.3838, 4.6243) 0.002567 |
| Q3  | 2.9679 (1.6780, 5.2494) 0.000185 | 2.7299 (1.5198, 4.9035) 0.000777 | 3.9461 (2.1025, 7.4063) 0.000019 |
| Q4  | 0.9808 (0.5378, 1.7889) 0.949624 | 0.9801 (0.5275, 1.8209) 0.949212 | 1.2835 (0.6614, 2.4908) 0.460614 |
|     | Race  |          |          |          |          |          |          |          |          |          |          |          |          |          |
| Non-Hispanic White | 1     | 1        | 1        |          | <0.001  |          |          |          |          |          |          |          |          |          |
| Q2  | 3.1196 (0.7361, 13.2214) 0.122560 | 4.1884 (0.9566, 18.3392) 0.057293 | 6.6989 (1.2175, 36.8575) 0.028796 |
| Q3  | 4.9910 (1.1715, 21.2626) 0.029697 | 6.2213 (1.4235, 27.1895) 0.015128 | 13.2421 (2.4946, 70.2926) 0.002419 |
| Q4  | 0.8535 (0.1806, 4.0332) 0.841526 | 0.8475 (0.1759, 4.0823) 0.836555 | 2.2896 (0.3878, 13.5172) 0.360508 |
|     | Non-Hispanic Black | 1     | 1        | 1        |          | <0.001  |          |          |          |          |          |          |          |          |
| Q2  | 2.7347 (0.6094, 12.2710) 0.189037 | 3.5157 (0.7584, 16.2963) 0.108127 | 0.6827 (0.0703, 6.6259) 0.741983 |
|    | Q3          | Q4          | Mexican American | Other Race | total          | Educational level |
|----|-------------|-------------|------------------|------------|----------------|-------------------|
| Q1 | 2.0240 (0.3908, 10.4832) 0.400758 | 2.0065 (0.4150, 9.7016) 0.386399 | 1 | 1 | 1 | <0.001 |
| Q2 | 2.6261 (0.8764, 7.8691) 0.084646 | 3.8094 (1.0772, 13.4709) 0.037945 | 0.6379 (0.0784, 5.1880) 0.674201 | 0.7298 (0.2799, 1.9032) 0.519577 | 0.6844 (0.2565, 1.8266) 0.449002 | 0.8284 (0.2878, 2.3846) 0.727104 | <0.001 |
| Q3 | 5.4871 (1.7827, 16.8898) 0.002999 | 4.8905 (1.3699, 17.4581) 0.014492 | 1.1202 (0.0934, 13.4295) 0.928652 | 1.4289 (0.4910, 4.1584) 0.512506 | 0.9343 (0.3034, 2.8765) 0.905672 | 1.0508 (0.3107, 3.5540) 0.936415 | 0.403289 |
| Q4 | 0.2538 (0.0282, 2.2884) 0.221666 | 0.2157 (0.0212, 2.1934) 0.194874 | 0.0096 (0.0000, 3.0870) 0.114793 | 1.8171 (0.7781, 4.2434) 0.167506 | 1.7612 (0.7144, 4.3418) 0.218931 | 1.1147 (0.3927, 3.1647) 0.938320 | 0.221666 |
|    | 0.2538 (0.0282, 2.2884) 0.221666 | 0.2157 (0.0212, 2.1934) 0.194874 | 0.0096 (0.0000, 3.0870) 0.114793 | 1.8171 (0.7781, 4.2434) 0.167506 | 1.7612 (0.7144, 4.3418) 0.218931 | 1.1147 (0.3927, 3.1647) 0.938320 | 0.221666 |

**Educational level**

less High school graduate | High school graduate/GED or equivalent

Q1 | 1 | 1 | 1 | <0.001 |
| Q2 | 0.6379 (0.2223, 1.8308) 0.403289 | 0.7940 (0.2579, 2.4440) 0.687554 | 0.6169 (0.0831, 4.5817) 0.636836 | 0.6379 (0.2223, 1.8308) 0.403289 | 0.7940 (0.2579, 2.4440) 0.687554 | 0.6169 (0.0831, 4.5817) 0.636836 | <0.001 |
| Q3 | 1.2849 (0.4465, 3.6973) 0.642019 | 1.7386 (0.5497, 5.4991) 0.346472 | 0.9822 (0.0935, 10.3160) 0.988049 | 0.1451 (0.0178, 1.1837) 0.071464 | 0.1709 (0.0194, 1.5024) 0.111159 | 0.1299 (0.0040, 4.2130) 0.250226 | 0.071464 |
| Q4 | 1.1467 (0.6240, 2.1074) 0.659301 | 0.9801 (0.5275, 1.8209) 0.949212 | 1.2835 (0.6614, 2.4908) 0.460614 | 0.1451 (0.0178, 1.1837) 0.071464 | 0.1709 (0.0194, 1.5024) 0.111159 | 0.1299 (0.0040, 4.2130) 0.250226 | 0.071464 |

Q1 | 1 | 1 | 1 | <0.001 |
| Q2 | 1.8896 (1.0848, 3.2914) 0.024605 | 1.9044 (1.0851, 3.3423) 0.024805 | 2.5296 (1.3838, 4.6243) 0.002567 | 1.8896 (1.0848, 3.2914) 0.024605 | 1.9044 (1.0851, 3.3423) 0.024805 | 2.5296 (1.3838, 4.6243) 0.002567 | <0.001 |
| Q3 | 3.0919 (1.7368, 5.5042) 0.000125 | 2.7299 (1.5198, 4.9035) 0.000777 | 3.9461 (2.1025, 7.4063) 0.000019 | 1.1467 (0.6240, 2.1074) 0.659301 | 0.9801 (0.5275, 1.8209) 0.949212 | 1.2835 (0.6614, 2.4908) 0.460614 | 1.1467 (0.6240, 2.1074) 0.659301 | 0.9801 (0.5275, 1.8209) 0.949212 | 1.2835 (0.6614, 2.4908) 0.460614 | 0.071464 |
| Q4 | 1.1467 (0.6240, 2.1074) 0.659301 | 0.9801 (0.5275, 1.8209) 0.949212 | 1.2835 (0.6614, 2.4908) 0.460614 | 0.1451 (0.0178, 1.1837) 0.071464 | 0.1709 (0.0194, 1.5024) 0.111159 | 0.1299 (0.0040, 4.2130) 0.250226 | 0.1451 (0.0178, 1.1837) 0.071464 | 0.1709 (0.0194, 1.5024) 0.111159 | 0.1299 (0.0040, 4.2130) 0.250226 | 0.071464 |
| Q2          | 3.5732 (1.0647, 11.9916) 0.039253 | 4.4604 (1.2907, 15.4148) 0.018113 | 2.2732 (0.5321, 9.7103) 0.267661 |
| Q3          | 6.3206 (1.8592, 21.4883) 0.003144 | 11.1096 (3.0700, 40.2033) 0.000243 | 11.1489 (2.3240, 53.4846) 0.002578 |
| Q4          | 1.6604 (0.4476, 6.1595) 0.448419 | 2.5428 (0.6594, 9.8058) 0.175344 | 4.0530 (0.7731, 21.2493) 0.097819 |

College graduate or above

| Q1 | 1          | 1          | 1          | <0.001     |
| Q2 | 1.8061 (0.7564, 4.3127) 0.183090 | 1.9885 (0.8233, 4.8029) 0.126558 | 2.5959 (1.0278, 6.5560) 0.043580 |
| Q3 | 2.2938 (0.9292, 5.6622) 0.071732 | 2.1180 (0.8453, 5.3071) 0.109303 | 2.6583 (0.9978, 7.0822) 0.050515 |
| Q4 | 1.1163 (0.4527, 2.7529) 0.811165 | 1.0974 (0.4386, 2.7461) 0.842546 | 1.1109 (0.4206, 2.9345) 0.831886 |

| Q1 | 1          | 1          | 1          | <0.001     |
| Q2 | 1.6520 (0.9503, 2.8717) 0.075178 | 1.9044 (1.0851, 3.3423) 0.024805 | 2.5296 (1.3838, 4.6243) 0.002567 |
| Q3 | 2.5042 (1.4156, 4.4299) 0.001610 | 2.7299 (1.5198, 4.9035) 0.000777 | 3.9461 (2.1025, 7.4063) 0.000019 |
| Q4 | 0.9036 (0.4938, 1.6535) 0.742244 | 0.9801 (0.5275, 1.8209) 0.949212 | 1.2835 (0.6614, 2.4908) 0.460614 |

**Figures**
Figure 1

The analysis of the influence of various factors on liver dysfunction.
Figure 2

Relationship between MAP and dysfunction, X38: liver insufficiency; X46: MAP; a: smooth curves of gender group, 1: male; 2: female; b: Smoothing curve for age group; 1: 20-40; 2: 40 - 60; 3: 60-80; 4: 80; c: Smoothing curve of race group, 1: Non-Hispanic White; 2: Non-Hispanic Black; 3: Mexican American; 4: Other Race; d: Smoothing curve of education level; 1: Less High school graduate; 2: High school graduate/GED or equivalent; 3: College graduate or above.
Figure 3

Relationship between BMI and dysfunction, X38: liver insufficiency; X45: BMI; a: smooth curves of gender group, 1: male; 2: female; b: Smoothing curve for age group; 1: 20-40; 2: 40 - 60; 3: 60-80; 4: 80; c: Smoothing curve of race group, 1: Non-Hispanic White; 2: Non-Hispanic Black; 3: Mexican American; 4: Other Race; d: Smoothing curve of education level; 1: Less High school graduate; 2: High school graduate/GED or equivalent; 3: College graduate or above.
Figure 4

Relationship between sedentary activity time and dysfunction, X38: liver insufficiency; X46: sedentary activity time; a: smooth curves of gender group, 1: male; 2: female; b: Smoothing curve for age group, 1: 20-40; 2: 40-60; 3: 60-80; 4: >80; c: Smoothing curve of race group, 1: Non-Hispanic White; 2: Non-Hispanic Black; 3: Mexican American; 4: Other Race; d: Smoothing curve of education level, 1: Less High school graduate; 2: High school graduate/GED or equivalent; 3: College graduate or above.