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Investigating the Two-Way Interaction Effect of Diet and Lifestyle Factors on Liver Fat Levels: A Controlled Spectroscopic Analysis

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Abstract

Background: Changes in normal liver lipid levels indicate various diseases closely related to dietary and lifestyle factors. Magnetic resonance spectroscopy (MRS) is a reliable, advanced, and noninvasive method for estimating these levels. This study aimed to evaluate the interaction effect of diet and lifestyle factors on liver lipid levels, as measured by MRS, among female students.

Methods and Results: This cross-sectional study included 29 female students from the Department of Radiological Sciences who underwent MRS to evaluate liver lipid levels and correlate these levels with lifestyle factors assessed by a questionnaire.

SPSS two-way ANCOVA was applied to the acquired data. Diet and exercise had a significant interaction effect on the liver lipid levels after adjusting for gender and age (P=0.036). The interaction between diet and other factors such as caffeinated drinks, family history, smoking, and body mass index (BMI) with lipid levels did not reach significant levels (P>0.05).

Conclusion: The results obtained support the strong interaction effect of diet and exercise on liver fat levels. Adopting a healthy lifestyle characterized by healthy food choices and regular exercise may help maintain normal liver fat levels and reduce the risk of hepatic steatosis and non-alcoholic fatty liver disease in young women. **(International Journal of Biomedicine. 2024;14(4):649-653.)**

Keywords: magnetic resonance spectroscopy • lifestyle factors • non-alcoholic hepatic steatosis • fatty liver disease

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Abbreviations

BMI, body mass index; **HS**, hepatic steatosis; **LFC**, liver fat content; **MRS**, magnetic resonance spectroscopy; **NAFLD**, non-alcoholic fatty liver disease.

Introduction

The liver is the largest visceral organ and gland in the body.[1] It plays a central role in lipid metabolism,[2] and measuring liver lipid content in humans is important. According to liver histology, a "normal" lipid level is one in which a liver biopsy shows macroscopic fatty changes in less than 5% of hepatocytes.[3] Changes in normal liver lipid levels indicate various diseases closely related to dietary and lifestyle factors.[4,5]

High consumption of carbohydrates, fats, protein, soft drinks, alcohol, and coffee are risk factors for increased liver fat levels.[6] Low intake of vitamins D, E, and C is also associated with the development of non-alcoholic fatty liver disease (NAFLD).[7]

The number of individuals suffering from NAFLD is increasing worldwide, leading to a search for non-invasive tools to investigate liver fat.[8] Liver enzyme routine biochemical testing is the standard test for liver fat level.

Ultrasound, MRI, liver biopsy, and MRS are other ways of estimating fat levels.[9]

MRS is an advanced and non-invasive technique adjunct to MRI measurements.[10] MRS is part of the nuclear magnetic resonance (NMR) technique that expresses the measurement result as a spectrum, where the metabolite frequency in PPM units is displayed on the X-axis and its amplitude is on the Y-axis (unitless). MRS has the potential to become an alternative procedure for liver biopsy to avoid complications such as bleeding and infection.[8] MRS procedures can detect hepatic steatosis (HS) early and provide accurate grading, leading to proper management.

The liver fat spectroscopy procedure is single voxel spectroscopy (SVS). The SVS consists of three main sequences: CHESS, STEAM, and PRESS. A chemical shift selective (CHESS) sequence is used to suppress water signals from the spectrum; it is essential because the water signal is higher than the fat signal. Stimulated echo acquisition mode (STEAM) consists of three selective 90° pulses with orthogonal gradients. Point-resolved spectroscopy (PRESS) is based on the spin-echo sequence where a 90° pulse is followed by two 180° pulses with three orthogonal gradients.[11-14]

The way of life in Saudi Arabia has changed recently, especially among the 18- to 25-year-old age groups, which has increased the consumption of fatty products and caffeinated drinks among young Saudi adults. Focusing on health education and awareness of the close relationship between lifestyle, fast-fat diet, and HS should attract the attention of young Saudi women, with greater emphasis on their future health.

This study aimed to evaluate the interaction effect of diet and lifestyle factors on liver lipid levels, as measured by MRS, among students in the radiological sciences department.

Material and Methods

This study was conducted to investigate the association between lifestyle (diet, caffeinated drinks, smoking, family history, exercise, and MBI) estimated from a questionnaire with liver fat levels estimated by MRS. Twenty-nine healthy female students from the Department of Radiological Sciences of the College of Health and Rehabilitation Sciences at Princess Nourah bint Abdulrahman University (Riyadh, Saudi Arabia), aged 18 to 25, participated in this study. The MRS was conducted using a 1.5 Tesla Philips scanner with a TE time of 30 ms and TR of 200 ms. The resulting liver spectrum is shown in Figure 1. As noted on the spectrum, the liver fat peak is shown at 1.03 PPM frequency.

The questionnaire included[15] questions about lifestyle factors such as weekly fast-food consumption (food with carbs, sugar, and saturated fat), caffeinated drinks, smoking, family history, exercise, and body mass index). These factors are known to affect liver fat levels. The collected data were managed confidentially and tabulated in an Excel sheet for all participants, after which the required statistical tests were applied.

Two-way ANCOVA[16] test was used to determine whether there is an interaction effect between the two independent variables, diet (considered the focal variable), and another factor (which could be exercise, caffeinated drinks, smoking, family history, or body mass index), on the dependent variable, liver fat level. This analysis controlled for the covariates, age and sex (all participants were females aged 18-25). The primary concern is the effect of the focal variable (diet) on liver fat level, and the hypothesis is that this effect might depend on the value of the moderator variable (the other independent factor).

Results

The questionnaire was used to investigate the participants' habits of fast food and caffeinated drink consumption. It also recorded exercise frequency, family history of HS, and body mass index (BMI). The questionnaire data were coded for each factor. Diet-related questions asked how often participants consumed foods containing carbs, sugar, and saturated fat per week. The coding for these choices was as follows: none coded as 0, 1-2 times per week coded as 1, 3-4 times coded as 2, and more than 4 times coded as 3. The same coding system was used for caffeinated drinks, exercise, and smoking. For the family history of NAFLD, the coding was 0 for no family history and 1 for the family history of NAFLD. BMI was coded into three categories: underweight coded as 0, normal weight as 1, and overweight as 2. The liver fat level was recorded from the MRS spectrum for each participant, where the fat peak was located at 1.03 PPM, as shown in Figure 1.

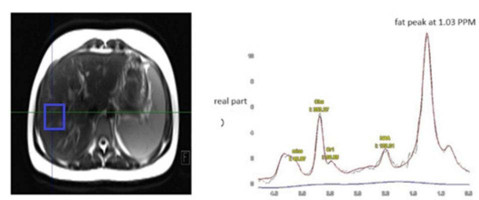

Fig. 1. *Abdominal MRI image and the corresponding MRS spectrum of a healthy volunteer: fat peak at 1.03 PPM.*

Table 1 presents the mean, minimum, maximum, and standard deviation values for the estimated liver lipids, along with lifestyle parameters (fast food consumption (diet), caffeinated drinks intake, smoking habits, family history, BMI, and exercise frequency) that are known to influence liver lipid levels.

The study examined the individual effects of diet, exercise, smoking, caffeinated drinks, family history, and BMI on liver lipid levels, and the results did not show a strong effect or reach statistical significance. Consequently, we explored the impact of the combined use of these factors on lipid levels. Specifically, we combined diet with the other factors and investigated the effects using a two-way ANCOVA test.

A two-way ANCOVA test was used to investigate the interaction between diet and liver fat levels and other lifestyle factors such as smoking, exercise, family history, caffeinated drinks, and BMI. In this analysis, diet is treated as the independent focal variable, while the other lifestyle factors are the moderator independent variables. Liver fat level is the dependent variable. Diet and exercise had a significant interaction effect on the liver lipid levels after adjusting for gender and age (*P*=0.036) (Table 2). All other tested lifestyle factors did not show a significant interaction effect on liver lipids even when combined with diet.

Table 1.
Lifestyle factors and liver lipid levels: Descriptive analysis.

Descriptive Statistics					
	N	Min	Max	Mean	Std. Deviation
Lipids	29	0.00	.97	0.2233	0.21006
Fast Food	29	0.00	7.00	1.6207	1.78113
Caffeinated Drink	29	0.00	1.00	0.8276	0.38443
Smoking	29	0.00	2.00	1.0345	0.56586
Exercise	29	0.00	1.00	0.1724	0.38443
BMI	29	0.00	2.00	1.0345	0.56586
Family history	29	0.00	1.00	0.7586	0.43549
Valid N (listwise)	29				

Table 2.
Two-way ACNOVA interaction test results.

Tests of Between-Subjects Effects						
Dependent Variable: Lipids						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	0.542[a]	7	0.077	2.342	0.062	0.438
Intercept	1.163	1	1.163	35.191	0.000	0.626
Fast Food	0.070	4	0.018	0.531	0.714	0.092
Exercise	0.054	1	0.054	1.628	0.216	0.072
Fast Food & Exercise	0.258	2	0.129	3.901	0.036	0.271
Error	0.694	21	0.033			
Total	2.681	29				
Corrected Total	1.236	28				

Discussion

Human health is affected by lifestyle and healthy habits, such as nutrition, sports activity, and other factors. Health practices are critical for human health and prevent disease. There has been a marked rise in the last decades of global lifestyle changes due to new social communication. In Saudi Arabia, changes in dietary behavior and physical activity have led to significant increases in chronic diseases such as obesity, diabetes, high blood pressure, and fatty liver. Behavioral factors such as smoking, fast fatty food, caffeinated drinks, and lack of physical activity and biological risk factors have contributed significantly to the development of these chronic non-communicable diseases.[13]

In summary, disease may be associated with social and food habits before it is a biological or physiological issue. Therefore, the young generation must change many habits and lifestyles. Fast food has a significant impact on liver fat levels. Previous studies investigating the association of fast food with liver fat levels showed that high consumption of carbohydrates, simple sugars, saturated fats, trans fat, animal protein (red meat), processed food, and a low fiber intake is associated with NAFLD development.[14] A study by Abe et al.[17] reported that fast-food consumption has significant effects on NAFLD.

Furthermore, overfeeding with carbohydrates (simple sugars) has been shown to lead to significant increases in liver fat content in most studies, as determined by Luukkonen et al.[18] and Jensen et al.[19] All these studies corroborate our findings that a diet combined with exercise strongly affects liver fat levels.

Our study showed a significant relationship between liver fat levels and the combination of exercise and diet, with $P<0.05$. This finding aligns with studies by Hallsworth & Adams,[5] which indicated that a lack of physical activity and exercise affects liver fat concentration. In a study by Stine et al.,[20] among NAFLD 87 subjects (60% female), with a mean age of 52 years and a mean body mass index (BMI) of 34.5 kg/m^2, the majority (75%) did not achieve ≥150 min/week of physical activity. Comparing their studies with ours, the limited number of participants significantly affected the accuracy of our results regarding the effect of exercise alone on liver fat levels. Moreover, factors such as age, gender, health condition, and different types of exercise may have varying impacts on these levels. However, the presented study showed the same effect of exercise when its impact is combined with diet.

In recent years, there has been a rise in the consumption of caffeinated beverages, particularly among university students. A study by Hayat et al.[21] found that coffee consumption was associated with a notable reduction in the risk of NAFLD. Their study also indicated a decrease in the risk of liver fibrosis development among NAFLD patients with regular coffee intake. Moreover, Calabrò et al.[22] suggested that habitual coffee consumption might prevent complications related to NAFLD, particularly liver fibrosis. The current study found no significant relationship between liver fat levels and the combined effect of diet and caffeinated drinks. The sample size, age groups, and other factors might have contributed to these contrary results.

Our study investigated the effect of BMI on the fat liver level and found an insignificant effect ($P>0.05$). Previous studies by Pasanta et al.[8] and Loomis et al.[23] suggested a strong correlation between BMI and liver fat levels. A study by Loomis et al.[23] supports the significant impact of BMI on fat liver levels and fatty liver diseases. The study included 8342 NAFLD cases in databases and reported that the risk of a recorded NAFLD diagnosis increased approximately linearly with increasing BMI.

A study by Pasanta et al.[24] assessed the association between liver fat content (LFC) and weight status in young adults using the proton magnetic resonance spectroscopy (1H MRS) technique. Liver fat content was found to be almost three times higher in the overweight/obese group (n=39 with an average BMI of 31.3 (0.5) kg/m^2) when compared to the control group (n=39 with an average BMI of 20.9 (0.3) kg/m^2). A 48.7% incidence of NAFLD in the overweight/obese group was found. BMI was a significant independent predictor for LFC after adjusting for age and sex (multiple linear regression; β=0.459, P<0.001).

The disagreement between the presented study and previous research on the impact of BMI on fatty liver might be due to the different types of participants, as our study is conducted on healthy young females, as well as the sample size and other factors.

In several studies, family history predicted an increased risk of liver fat levels among offspring. Long et al.[25] performed multivariable logistic regression models adjusted for age, sex, alcohol use, and BMI to generate the odds of hepatic steatosis (HS) according to parental HS. Approximately 23% (183/785) of participants had at least one parent with HS. In adjusted models, participants with at least one parent with HS had a nearly two-fold increased odds of HS compared to participants without a parental history of HS (OR=1.86, 95% confidence interval: 1.15-3.03). The main findings of the current study were that family history had no significant effect on increased liver fat levels, which might be due to the small sample size of our young female healthy participants.

Conclusion

Our results support the strong interaction effect of diet and exercise on liver fat levels. Adopting a healthy lifestyle characterized by healthy food choices and regular exercise may help maintain normal liver fat levels and reduce the risk of HS and NAFLD in young women.

Ethical Considerations

The study protocol was reviewed and approved by the Ethics Committee of Princes Nourah bint Abdulrahman University (PNU) [IRB log Number: 22-1005]. All participants provided written informed consent.

Competing Interests

The authors declare that they have no competing interests.

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