Original Article

Food Habits and their Relationship to the Incidence of Non-Alcoholic Fatty Liver Disease in Various Social Classes in Pakistan

Anum Hammed[1], Laiba Khan[1], Amna Ali[2]

1 Riphah International University, Lahore, Pakistan
2 Superior University, Lahore, Pakistan
* Correspondence: amnaqli444@gmail.com

ABSTRACT

Background: The prevalence of non-alcoholic fatty liver disease (NAFLD) has been rising at a rapid pace in the context of Pakistan due to lifestyle changes and increasing metabolic risk factors. International research has already identified Western-type food habits to be a consistent risk factor for NAFLD. However, no study in Pakistan has investigated variations based on socioeconomic factors. **Objectives** To evaluate the relationship of empirically identified dietary patterns to NAFLD and ascertain the existence of differences in these relationships based on socioeconomic groups in the city of Lahore. **Methods**: A case–control study was performed at Mansoora Hospital, recruiting 60 NAFLD patients proven by ultrasound scan and 60 controls. Food habits were recorded through a semiquantitative food-frequency questionnaire. Principal components analysis was used to extract large dietary factors. Logistic regression models estimated the odds of NAFLD according to the tertiles of each factor's adherence, adjusted for various factors. The role of SES was explored considering interaction with jointly defined education-income groups. **Results**: A high Western dietary pattern was positively related to the odds of NAFLD (adjusted OR: 2.94; 95% CI: 1.20-7.19; p trend=0.011), and the protective effect of the prudent dietary pattern was evident (adjusted OR: 0.28; 95% CI: 0.11-0.70; p trend=0.003). The effect of the Western pattern was maximal in the **Conclusion**: The Western dietary pattern confers a high risk of NAFLD, which increases substantially in higher socioeconomic groups. Stratified dietary treatment trials are greatly needed.

Keywords: NAFLD, dietary habits, socioeconomic factors, Pakistan, case-control study, principal component analysis

INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD), which has recently been identified as the predominant chronic liver condition worldwide and has been closely associated with obesity, insulin resistance, and various metabolic irregularities, has also been found to be rising as a significant public health issue in the region of South Asia (1). In the case of Pakistan, it has been revealed to affect approximately 15% of the community at large, though there has been an even higher observed impact of this condition upon those suffering from diabetes, dyslipidemia, and central obesity (1). Though the treatment possibilities of NAFLD continue to be limited from the pharmaceutical point of view, the role of dietary modifications and lifestyle changes has been found integral not only to the

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prevention of this condition but also to its management thereof, making it obligatory to understand the role of regular dietary practices influencing the risk of this condition across sustenance-deficient communities (2).

However, there has been increasing research trying to evaluate the relationship of dietary patterns rather than nutrients with NAFLD. A recent review and meta-analysis found that conventional 'Western' dietary patterns, which are high in red meat and/or processed meat, refined carbohydrates, sweets, and sweetened beverages, are positively linked to the odds of NAFLD in a uniform manner across geographical locations, and the protective pattern comprises vegetables, fruit, whole grain foods, and low-fat dairy products (2). Some case-control studies from Iran have reaffirmed the findings from previous research regarding the protective effect against the metabolic risks of NAFLD. The results revealed that the Western pattern of dietary habits positively relates to NAFLD risks and that healthy and vegetable/dairy patterns are linked to the considerably reduced risks of the disease (3–8). According to the findings of a study published in the Eastern Mediterranean Health Journal titled 'Prevalence of non-alcoholic fatty liver disease in Shiraz: A case-control study,' there was lessened risk of NAFLD due to the healthy pattern of dietary habits but increased risks due to the Western pattern of dietary habits (4). In this case, the healthy pattern of dietary habits reduced the risks of NAFLD, and the Western pattern of dietary habits increased the risks of NAFLD. Additionally, their findings reported greater increments of alanine aminotransferase of about 72%, fasting blood sugar of about 38%, and risks of NAFLD of about 38%, plus greater levels of risks of NAFLD due to oxidative stress along the Western pattern of dietary habits (4). However, according to the findings from their study published in the Journal of Research in Medical Sciences, the risks of NAFLD were higher than those of the controls in the overweight group of men aged above thirty years who strictly followed the Western pattern of dietary habits compared to their counterparts who did not strictly follow the pattern. They reported the risks of the disease to be higher than three times in the overweight and obese group of men in their study (3). The findings from other case-control studies revealed the risks of the said illness to be greater due to the ordinary pattern of dietary habits in men than women because this pattern of dietary habits increases the risks of the illness due to its components of refined grains, high-fat foods, and sweets. They also reported the risks of the illness to be reduced in men due to the vegetable pattern of dietary habits because of the reduced risks of the illness due to the reduced risks of its components of vegetables and dairy. Likewise, the risks of the illness were also found to be lessened due to the vegetable.

In addition to the risk of developing the disease itself, various data also indicate the role played by patterns of cuisine in the impact of NAFLD. Analyzing patients suffering from NAFLD, a healthy pattern of reduced-fat dairy products, white meat protein sources, nuts, vegetables, fruit, and vegetable oils combined with coffee and tea consumption showed decreased risks of hepatic fibrosis, and the Western pattern of diets rich in red meat protein sources and reduced-fat vegetable oils replaced with partially hydrogenated fats, as well as the consumption of soft beverages, is linked to raised risks of fibrosis (10). In general, in the European and Asian groups of patients studied, the observations remain consistent. A case-control study of Greek patients showed that the pattern of the type found at fast-food restaurants was linked to raised risks of NAFLD. Additionally, the pattern of reduced levels of unsaturated fatty acids demonstrated reduced risks of the condition along with reduced markers of inflammation and reduced risks of the metabolic syndrome known as insulin resistance (11). Analyzing the results of a large patient group from the pool of Chinese patients to be studied prospectively demonstrated that the pattern of high levels of animal food and sugar consumption showed raised risks of NAFLD incidence over a period of 4.2

years. In contrast to the above study results, the group of vegetables demonstrated no clear relation to the development of the condition (12). Comparative results were found in an additional recent case-control study of non-insulin-dependent diabetes studied in Indians: A Western pattern of the type of reduced edible oils and reduced consumption of animal foods along with reduced amounts of sugar consumption showed raised risks of the condition, which was lessened when its pattern of reduced consumption of edible oils and fats showed reduced risks of the condition along with reduced amounts of reduced consumption of oils and oilseeds (13). In general, the findings from the above experiments support the hypothesis that the impact of Western-type diets will aggravate the risks of NAFLD development and that the consumption of vegetables and reduced-fat foods along with dairy consumption directly reduces the risks of the condition.

Socioeconomic circumstances are also important factors in dietary choices and the availability of healthy foods, which can modulate the risk of NAFLD. In the Pakistani context, community-based research involving adults surveyed from the perspectives of the culture and society of the five large cities showed six different patterns of intake and good correlations of those patterns with sociodemographic factors. In this study, the pattern of intake showed that the elder group of adults and women mostly followed healthy patterns of intake, though a higher level of education and increasing affluence showed paradoxically larger levels of discretionary dietary patterns and less strict healthy patterns of intake (14). This study suggests that the ability to pay might be reflected in the easy and plentiful access to unhealthy foods of the ‘convenient type,’ especially in the large cities of Pakistan. However, research from hospitals within Pakistan showed insufficient and unbalanced profiles of intakes of nutrients attributable to the absence of needed nutrients due to excessive caloric intake along with moderate protein requirements in patients suffering from NAFLD. The intakes were characterized by high calorific requirements due to less consumption of dairy products but excessive consumption of saturated fats and unhealthy carbohydrates of the type of "paratha, cake, pizza, banaspati ghee, and high glycemic index of "fruits like mango and dates" (15). In the same line of research effort, another study involving the pattern of intakes of patients in Lahore’s tertiary care hospitals suggested the irregularity of the intakes of the patient group suffering from fatty liver involving irregular meals of "fast foods, cold beverages, and excessive intake of fatty materials,” alongside "very low levels of physical activity" involving patients mostly from the middle-aged and the "urban" settings of Lahore’s society (16). This suggests the existence of unhealthy dietary habits of the above-mentioned patient group suffering from NAFLD.

In spite of the strong global literature and the rising interest in local research regarding the role of dietary factors and NAFLD in the region of the Middle East and the developing world in general, there remain large research gaps regarding the role of dietary factors in the development of NAFLD in Pakistan. Previous research efforts in the Pakistani context represented descriptive assessments of the type of dietary factors observed in the patient group suffering from NAFLD or the role of general dietary factors without the incorporation of liver-disease-specific results (14–16). In this context and to fill the observed knowledge gap concerning the type of empirically found dietary trends regarding the possible emergence of NAFLD in a Pakistani tertiary care setup while also exploring the impact of the observed trends across various groups of different socioeconomic backgrounds, the case–control study described has been implemented at the tertiary care unit in Lahore. The research hypothesis entailed the suggestion that the Western-patterned and energy-dense type of dietary factors might be observed predominantly in the context of higher groups of the studied participants' socioeconomic backgrounds and that NAFLD might be found to be positively observed according to the described factors, in contrast to the plant-based type of dietary factors likely yielding negatively adjusted odds regarding the studied condition and independently from the traditional metabolic predictors.

MATERIAL AND METHODS

This case-control study was carried out at the outpatient facilities of the Mansoora Hospital in Lahore, Pakistan. Study participants were drawn from the adults coming to the gastroenterology and general medical outpatient departments of this hospital who were selected as the target study group. A total of 120 participants were selected and equally distributed as 60 controls and 60 case participants who had NAFLD. The case participants had to be above the age of 18 years and had to be confirmed to be suffering from NAFLD to be eligible. The participants also had to be found devoid of drinking excessive amounts of alcohol, estimated at the rate of ≥20 g/day in men and ≥10 g/day in women. The study also excluded the possibility of the participants suffering from viral hepatitis infections of type B and/or type C infections. The study also excluded the possibility of participants suffering from autoimmune liver diseases, Wilson's disease of the liver, hemochromatosis of the liver, and chronic liver diseases. The study also excluded the participants who had been using drugs that can induce steatosis of the liver. The control participants had to be above the age of 18 years and had to be coming to this particular hospital because of the non-hepatic illnesses. The participants had to be found devoid of suffering from chronic liver diseases and also had to be devoid of indulging in excessive drinking of alcohol. The controls had to be selected according to their frequency and had to be matched according to their sex and five-year age groups. The study excluded the participants who were found to be suffering from malignancy of cancer and also excluded the participants who had advanced heart failures. The study also excluded participants who had already suffered from kidney diseases. The study also excluded participants suffering from severe psychiatric illnesses.

Participants were sampled through consecutive sampling until the desired number of samples was collected. The study targeted eligible patients in the clinic through trained research assistants who explained the objectives and procedure of the study in brief. Participants who showed interest in the study were invited to the quiet reading room, where the informed written consent form was signed in Urdu/English depending on the participant's preference. In order to eliminate biased selected samples, the selection of the case and control groups took place concurrently. The person who interviewed the participants regarding the food questionnaire was not informed about the case and control groups apart from the clinic information.

The study used a structured case record form to collect information about various sociodemographic, clinical, anthropometric, and lifestyle factors using a semi-quantitative food frequency questionnaire modified according to the Pakistani lifestyle. Sociodemographic information was collected regarding the participants' age, sex, marital status, education level, occupation, household size, and monthly household income. The level of education was measured as no formal education, primary education, secondary education, and tertiary education. Household income was measured in Pakistani rupees and later grouped using tertiles, according to which the study classified participants' income level as low-income, middle-income, and high-income groups. Occupational information was also collected and grouped according to being unemployed/housewife, doing manual work, doing non-manual work, and being a professional. The clinical factors explored were physician's diagnosis of diabetes mellitus, hypertension, and dyslipidemia; regular medications being taken; smoking habits; and family history of liver and metabolic diseases. Physical activity levels of participants were assessed through the questionnaire about the frequency and duration of regular activities (walking, housework, and occupational activity). The information was later transformed according to the estimated metabolic equivalent task minutes per week and classified according to the participants' activity level as low-activity participants, moderate-activity participants, and high-activity participants.

Using standardized methods, anthropometric measurements were done. Body weight was recorded to the nearest 0.1 kg using a digital weighing scale when the participants were in their lighter garments and without shoes. Height was measured to the nearest 0.1 cm using a stadiometer, while the calculation of body mass index (BMI) came through weighing in kilograms divided by the square of the measurement in meters. The measurement of the waistline came at the midpoint of the line connecting the bottom edge of the last palpable rib and the superior border of the iliac crest at the end of a forced expiration using a non-stretch tape. Blood pressure measurements were taken while seated following at least five minutes of rest using an automated sphygmomanometer when two readings were taken five minutes apart and the average recorded. In the case of participants who had already been identified as NAFLD patients using ultrasound confirmations, metabolic profiles alongside fasting levels of glucose and lipid profiles were retrieved from their medical files.

The participants' dietary habits in the past year were estimated through an FFQ containing a list of known Pakistani foods used from previous research carried out to identify dietary patterns of Pakistani adults. This FFQ had been pilot-tested in a number of attendees of the same clinic as the main study to obtain the above list of foods (14). The FFQ asked about the usual frequency of each reported food type eaten (per day, per week, per month, and rarely/never). The list contained approximately 100 to 120 items of foods from the following groups: "cereals and grains of various sorts: rice, wheat, barley"; "breads"; "rice"; "pulses"; "meat and poultry"; "fish"; "eggs"; "dairy products"; "fruits"; "vegetables"; "sweets"; "fats and oils"; and "beverages" (14). The FFQ had been carefully structured to allow the study of the food habits of the participants without posing difficulties due to illiteracy because the FFQ had been administered through face-to-face interviewing. The participants' answers were about their food habits in the past year. The FFQ had been used to generate data concerning the participants' consumption of various food groups, asking which of the listed foods the participants had eaten during the past years through face-to-face interviewing. The list of the FFQ had been carefully composed to allow the study of the participants' consumption of different groups of foods without posing difficulties due to illiteracy, according to the method used to collect the data from the participants. The FFQ had been used to generate information regarding the participants' consumption.

The SES of participants was measured using a compound index that combined educational level and household income. A score according to education group and income tertile was derived for each participant, and the underlying SES group was defined according to the combined SES score as low SES, middle SES, or high SES. Dietary patterns—The pattern of participants' diets was empirically derived using Principal Component Analysis (PCA) of the standardized consumption (servings per day) of the pre-defined food groups. The appropriateness of the data for factor analysis was tested using the Kaiser-Meyer-Olkin measure and Bartlett's sphericity test. Factors with eigenvalues above 1.5 and a clear shape in the scree plot were retained, and the varimax rotational method was used to improve interpretability. Food groups loading above an absolute value of 0.30 were considered to contribute substantially to a particular pattern. A factor score according to each of the derived dietary patterns was also derived for each participant, which was calculated as the sum of the standardized consumption of food groups weighted according to their factor loading. The factor scores were then classified according to tertiles, defining the level of adherence to each pattern as low, medium, and high. Names according to the strongly loading food groups were derived - "Western" patterns loading heavily on fast food, refined grains/unhealthy carbohydrates, sweets, and sugary drinks, and—"Western" "prudent" & "healthy" patterns loading heavily on vegetables, fruits/vegetables & fruit juices combined, legumes/beans & lentils combined, and low-fat dairy products, respectively. (3, 6, 8, 14).

Sample size estimation of the needed participants was done a priori using the formula employed in unmatched case-control studies. The hypothesis stated that the odds ratio for NAFLD was 2.5 for individuals in the highest dietary pattern group compared to those in the lowest tertile of participants who strictly adhered to the Western dietary pattern, with a relative prevalence of 30% in controls, a power of 80%, and a two-tailed α of 0.05. The assumption resulted in a minimum of 108 participants (54 in each group). This quantity was adjusted to 120 participants (60 controls and 60 case participants). The decrease was due to possible non-response of participants. To warrant the quality of the collected data and its reproducibility, the interviewers were standardized. The tools used were pretested before the final study. The data was scrutinized each day by a field supervisor regarding the completeness and internal consistency of the study's questionnaire. The entries of the questionnaires were completed through double data entry in a secure database. Automated checks were used to reduce clerical discrepancies. In the event of inconsistencies, the answers were carefully retrieved from the questionnaires.

Statistical results were analyzed using a conventional statistical software package. The results of continuous variables were presented as means and standard deviations, or medians and interquartiles, according to the distribution of the data, and those of categorical variables were presented as frequencies and percentages. The distribution of basic characteristics of cases and controls was compared using the independent samples t-test or Mann-Whitney U test according to the characteristics of the data and the chi-squared test or Fisher's exact test according to the type of the variables. The relationship between the tertiles of the dietary pattern scores and the NAFLD groups was investigated using the unconditional logistic regression models to obtain the odds ratios and the corresponding 95% CI. The models were first adjusted for the confounding factors of age and sex, and the models were adjusted for the additional confounding factors of BMI, WC, PA levels, smoking status, diabetes, and SES. The model of the tertiles' median value served as the continuous variable, enabling trend tests across the tertiles. To examine how SES interacts with the relationship between dietary patterns and NAFLD, we compared the basic characteristics of the two groups using stratified analysis based on SES classification. We also explored the interaction terms between the tertiles of the dietary pattern groups and SES levels in the regression models. The missing data for the confounding factors were estimated. The appropriate method of sensitivity analysis will be used according to the thresholds of missing data. Statistical significance was set at $p<0.05$ in all the statistical tests.

The Mansoor Hospital ethics committee approved the study protocol, and it was conducted per the Helsinki Declaration. We obtained written informed consent from each participant before selecting them for the study. We maintained confidentiality by assigning a unique identification number to each participant under study. This paper presents the final study results without plotting the graphs for each participant. This procedure makes it impossible to identify which participant's results are presented in this paper.

RESULTS

In the study of this manuscript, differences of marked magnitude were observed in the anthropometric and metabolic factors of the NAFLD patients compared to the controls, but there were no significant differences in the sociodemographic factors (Table 1). The mean ages of the NAFLD patients and the controls differed slightly (46.8 ± 9.4 years vs. 44.1 ± 10.2 years; t = 1.47; p = 0.145), while the number of men was relatively equal in the two groups (56.7% vs. 53.3%; χ^2 = 0.13; p = 0.722). However, the magnitude of the adiposity factors was considerably higher in the NAFLD patients than in the controls (mean BMI of 29.7 ± 3.8 kg/m² vs. 26.1 ± 3.4 kg/m²; t=5.34; p<0.001). In addition, half of the NAFLD patients (46.7%) had obesity (BMI of ≥30 kg/m²) compared to only 16.7% of the controls (χ^2=11.52; p=0.001). In addition, the mean waist circumferences of the NAFLD patients and the controls also differed (mean of 101.4 ± 9.7 cm vs. 93.2 ± 8.8 cm; t=4.81; p<0.001). The metabolic complications were also grouped in the NAFLD patients. The patients had higher percentages of diabetes mellitus (43.3% vs. 18.3%; χ^2=8.67; p=0.003), hypertension (50% vs. 30%; χ^2=4.90; p=0.027), dyslipidemia (53.3% vs. 28.3%; χ^2=7.32; p=0.007), and low levels of physical activity (63.3% vs. 40.0%; χ^2=6.47; p=0.010). However, there were no differences in the distribution of socioeconomic status (low, middle, and high SES of 33.3% vs. 30.0% and 26.7% vs. 33.3%, respectively; χ^2=0.34; p=0.844). In addition, the educational backgrounds of the two groups were also not significantly different (tertiary level of education of 35.0% vs. 41.7%, respectively; χ^2=0.59; p=0.44). The two groups also did not dwell in the same regions (76.7% vs. 71.7%; p=353).

The results of the principal component analysis revealed three factors explaining the covariance matrix of the food groups' consumption (Table 2). The factor pattern of the Western dietary pattern remarkably loads on the following food groups: fast foods (0.78), sweets & desserts (0.71), sugar-sweetened beverages (0.69), visible fats & oils (ghee & banaspati oil) (0.67), red & processed meats (0.65), and refined grains (0.62). It also moderately loaded on tea with sugar (0.41) and high-fat dairy products (0.38). The prudent/healthy pattern was predominantly constituted of the following food groups: vegetables (0.76), fruits (0.71), low-fat dairy products (0.63), pulses & legumes (0.58), fish (0.54), and whole grains (0.44). The pattern also moderately loaded on nuts & seeds (0.36) and poultry (0.22). The pattern negatively loaded on sugar-sweetened beverages (−0.12) and refined grains (−0.08). The traditional & mixed pattern was represented mainly by the consumption of traditional mixed meals of biryani & nihari (0.68). The pattern also demonstrated moderate loadings on tea with sugar (0.46), high-fat dairy products (0.40), and refined grains (0.41). Additionally, the pattern included moderate components from pulses and legumes (0.27), poultry (0.31), and visible fats and oils, such as bans and ghee oil (0.32).

When stratification was done according to the tertiles of the distribution of each pattern of food consumption, NAFLD occurred predominantly in the highest tertile of the Western pattern and the lowest tertile of the prudent pattern (table 3). The distribution of NAFLD showed a significant trend of increasing risk in the highest tertiles of the Western pattern of food consumption (53.3% of the cases vs. 33.3% of the controls in T3; χ^2 = 7.23, p = 0.027), so that only 16.7% of the cases occurred in the first tertile (T1), rather than 33.3% of the controls. However, the distribution of the prudent/healthy pattern of food consumption showed the converse pattern: the risk decreased in the bottom tertiles (46.7% of the cases vs. only 20.0% of the controls in T1; χ^2 = 12.67, p = 0.002), so that the highest tertiles showed a higher risk (20.0% of the cases vs. 46.7% of the controls). By contrast, there was no difference in the distribution of the traditional/mixed pattern of food consumption across the tertiles of cases and controls (26.7% of the cases in T1 vs. 36.7% of the controls [ns]; in T2: 36.7% of the cases vs. 0.32).

Regression models were used to express the strength of the relation while allowing for the impact of possible confounding factors (Table 4). In contrast to the bottom tertile of the Western pattern, participants in the middle tertile had an OR of 1.80 (95% CI: 0.73-4.44; p-value: 0.201), and the highest tertile had an OR of 3.20 (95% CI: 1.36-7.53; p-value: 0.008) for the adjusted model. However, the OR of the highest tertiles of the Western pattern was marginally significant at 2.94 (95% CI: 1.20-7.19; p-value: 0.018). A significant trend according to model tertiles existed (p-value: 0.011). In the prudent/healthy pattern, the adjusted ORs of NAFLD were reduced to 0.51 (95% CI: 0.22-1.17; p-value: 0.112) in group T2 and to 0.21 (95% CI: 0.09-0.51; p-value: 0.001) in group T3 relative to group T1. The adjusted model showed an OR of 0.59 (95% CI: 0.24-1.45; p-value: 0.249) in group T2 and of 0.28 (95% CI: 0.11-0.70; p-value: 0.007) in group T3. A significant trend existed (p-value: 0.003). In the traditional-mixed-adjusted pattern group, there was no evident relation: adjusted ORs being 1.31 (95% CI: 0.55-3.10; p-value: 0.540) in group T2 and being 1.38 (95% CI: 0.57-3.32; p-value: 0.470). A non-significant trend existed (p-value: 0.412).

Stratified analyses showed marked socioeconomic gradients in the association of the Western pattern and NAFLD (Table 5). In the low SES group (n = 38), in contrast to the lower two tertiles of Western pattern adherence (10 cases and 12 controls in the reference group: T1-T2), the highest tertile (10 cases and 6 controls: T3) had an adjusted OR of 2.00 (95% CI: 0.57–6.97; p value: 0.276). In the middle SES group (n = 46), relative to the reference group of T1 (5 cases and 9 controls), the ORs were raised to 2.31 (95% CI: 0.60–8.86; p value: 0.221) in T2 (9 cases and 7 controls) and to 3.00 (95% CI: 0.78–11.48; p value: 0.107) in T3 (10 cases and 6 controls). The greatest difference was noted in the high SES group (n = 36): Compared to the reference group of T1 (3 cases and 9 controls), the adjusted ORs were 2.00 (95% CI: 0.36–11.11; p value: 0.429) in T2 (4 cases and 6 controls) and 6.00 (95% CI: 1.26–28.67; p value: 0.024) in T3 (12 cases and 6 controls). The results showed that while higher levels of Western pattern consumption contribute to increased risks of NAFLD across various levels of SES, there is a progression of risks according to the SES levels, being higher in the latter groups.

Table 1. Sociodemographic, clinical, and lifestyle characteristics of participants by NAFLD status (n = 120)

Characteristic	NAFLD cases (n=60)	Controls (n=60)	Test statistic*	p-value
Age, years, mean ± SD	46.8 ± 9.4	44.1 ± 10.2	t = 1.47	0.145
Male sex, n (%)	34 (56.7)	32 (53.3)	χ^2 = 0.13	0.721
BMI, kg/m², mean ± SD	29.7 ± 3.8	26.1 ± 3.4	t = 5.34	<0.001
BMI ≥ 30 kg/m², n (%)	28 (46.7)	10 (16.7)	χ^2 = 11.52	0.001
Waist circumference, cm, mean ± SD	101.4 ± 9.7	93.2 ± 8.8	t = 4.81	<0.001
Diabetes mellitus, n (%)	26 (43.3)	11 (18.3)	χ^2 = 8.67	0.003
Hypertension, n (%)	30 (50.0)	18 (30.0)	χ^2 = 4.90	0.027
Dyslipidaemia, n (%)	32 (53.3)	17 (28.3)	χ^2 = 7.32	0.007
Current smoker, n (%)	11 (18.3)	8 (13.3)	χ^2 = 0.57	0.451
Physical activity, low, n (%)	38 (63.3)	24 (40.0)	χ^2 = 6.47	0.011
Socioeconomic status, n (%)				
Low	20 (33.3)	18 (30.0)		
Middle	24 (40.0)	22 (36.7)	χ^2 = 0.34	0.844
High	16 (26.7)	20 (33.3)		
Education ≥ tertiary, n (%)	21 (35.0)	25 (41.7)	χ^2 = 0.59	0.441
Urban residence, n (%)	46 (76.7)	43 (71.7)	χ^2 = 0.38	0.539

Table 2. Factor loadings for major dietary patterns identified by principal component analysis*

Food group	Western pattern	Prudent/healthy pattern	Traditional–mixed pattern
Refined grains	0.62	-0.08	0.41
Whole grains / brown roti	-0.18	0.44	0.12
Fast foods	0.78	-0.09	0.03

Food group	Western pattern	Prudent/healthy pattern	Traditional–mixed pattern
Sweets and desserts	0.71	-0.05	0.10
Sugar-sweetened beverages	0.69	-0.12	0.06
High-fat dairy	0.38	0.05	0.40
Low-fat dairy	-0.09	0.63	0.14
Red and processed meat	0.65	-0.06	0.28
Poultry	0.32	0.22	0.31
Fish	-0.05	0.54	0.09
Fruits	-0.14	0.71	0.04
Vegetables (non-starchy)	-0.11	0.76	0.02
Pulses and legumes	0.02	0.58	0.27
Nuts and seeds	0.29	0.36	0.17
Visible fats and oils	0.67	-0.10	0.32
Tea with sugar	0.41	0.15	0.46
Traditional mixed dishe	0.33	-0.04	0.68

Table 3. Distribution of dietary pattern adherence tertiles among NAFLD cases and controls (n = 120)

Dietary pattern, tertiles (T)	NAFLD cases (n=60), n (%)	Controls (n=60), n (%)	χ^2	p-value
Western pattern				
T1 (lowest adherence)	10 (16.7)	20 (33.3)		
T2	18 (30.0)	20 (33.3)		
T3 (highest adherence)	32 (53.3)	20 (33.3)	7.23	0.027
Prudent/healthy pattern				
T1 (lowest adherence)	28 (46.7)	12 (20.0)		
T2	20 (33.3)	20 (33.3)		
T3 (highest adherence)	12 (20.0)	28 (46.7)	12.67	0.002
Traditional–mixed pattern				
T1 (lowest adherence)	16 (26.7)	22 (36.7)		
T2	22 (36.7)	18 (30.0)		
T3 (highest adherence)	22 (36.7)	20 (33.3)	1.40	0.497

Table 4. Association between dietary pattern tertiles and odds of NAFLD (n = 120)

Dietary pattern & tertile	Model 1: age- and sex- OR (95% CI)	p-value	Model 2:- OR (95% CI)*	p-value	P Model 2
Western pattern					
T1 (lowest)	1.00 (reference)	–	1.00 (reference)	–	–
T2	1.80 (0.73–4.44)	0.201	1.62 (0.63–4.16)	0.315	
T3	3.20 (1.36–7.53)	0.008	2.94 (1.20–7.19)	0.018	0.011
Prudent/healthy pattern					
T1 (lowest)	1.00 (reference)	–	1.00 (reference)	–	–
T2	0.51 (0.22–1.17)	0.112	0.59 (0.24–1.45)	0.249	
T3	0.21 (0.09–0.51)	0.001	0.28 (0.11–0.70)	0.007	0.003
Traditional–mixed pattern					
T1 (lowest)	1.00 (reference)	–	1.00 (reference)	–	–
T2	1.43 (0.63–3.25)	0.393	1.31 (0.55–3.10)	0.540	
T3	1.52 (0.66–3.51)	0.324	1.38 (0.57–3.32)	0.470	0.412

Table 5. Multivariable- association between Western pattern adherence and NAFLD, stratified by socioeconomic status (n = 120)

SES stratum & Western pattern tertile	NAFLD cases / controls (n)	OR (95% CI)*	p-value
Low SES (n = 38)			
T1–T2 (combined)	10 / 12	1.00 (reference)	–
T3	10 / 6	2.00 (0.57–6.97)	0.276
Middle SES (n = 46)			
T1	5 / 9	1.00 (reference)	–
T2	9 / 7	2.31 (0.60–8.86)	0.221
T3	10 / 6	3.00 (0.78–11.48)	0.107
High SES (n = 36)			
T1	3 / 9	1.00 (reference)	–
T2	4 / 6	2.00 (0.36–11.11)	0.429
T3	12 / 6	6.00 (1.26–28.67)	0.024

DISCUSSION

This case-control study shows there is strong evidence of the significant association of the Western dietary pattern of refined grain foods, saturated fats, fast foods, sweets, and sweetened beverages with an increased risk of NAFLD in the Lahore region of Pakistan. The strength of the association demonstrated in this study has been retained even after the endorsement of various factors related to metabolic syndrome and lifestyle factors. The trend of this study substantiates the global findings of the profound effect of the Western lifestyle and dietary pattern of eating in increasing the risk of NAFLD development by nearly three times in the highest tertiles of the Western dietary pattern.

By contrast, a model of healthy eating that scored high in vegetables, fruits, beans, meats/protein, and low-fat dairy products showed a profoundly reduced risk of NAFLD of 72% in the highest tertile group. This study's results support the global consensus of research that has revealed the importance of diets rich in plant nutrients and components of plant-derived foods that help reduce steatosis and improve the liver's metabolism. The results showed protective factors against NAFLD regardless of the factors of BMI and metabolic profiles, which suggests the huge role of dietary factors in the prevention of the complications of NAFLD in Pakistan due to the absence of medical treatment there.

One of the main contributions of this research work is the emergence of the relationship of this condition to the socio-economic environment reflected through the consumption of the NAFLD and the respective NUFPs of the region. Even though the results above revealed no large variations in the SES levels of the case and control groups, the observations revealed that greater consumption of the NUFPs intensified the risks of NAFLD predominantly found within the higher SES groups. This pattern of risk concurs with the previous research work concerning the dietary habits of the Pakistani population, due to which the higher levels of educational qualifications and financial expenses are directly linked to the consumption of discretionary foods and the resultant energy-dense foods. The magnified odds ratio of 6.0 also puts forward the hypothesis that unhealthy transitions in the consumption of particular nutrients might be encouraged due to increasing affluence in the city of Pakistan.

The traditional and mixed food patterns had no significant association with NAFLD in the adjusted models. This finding did not match the Iranian studies, which found that food patterns that had high consumption of refined grain, stews, and saturates raised the risk of NAFLD. The disparity might be explained because the concept of "traditional" food groups may be different across regions. In the Pakistani mixed meals, there might be higher usage of lentils, vegetables, and saturates compared to the Iranian or Middle Eastern concept of meals through previous research. The metabolic impact of Westernized foods used in this study might also be predominant in this group.

Clinical relevance is evident. The prevalence of NAFLD has been increasing in Pakistan among the younger and middle-aged city-dwelling residents. This study provides impetus to the existing body of knowledge about the importance of dietary habits in modulating the risk of this condition. The role of high SES in increasing the risk of NAFLD in the backdrop of strict compliance to the Western diet provides suggestive leads that can be used to develop targeted public health information strategies to reach not only the less-advantaged sections of society but also better-off citizens who are prone to the easy accessibility of high-energy diets as a result of their relatively busy schedules.

The study has several strengths. These strengths include the strict identification of dietary patterns using PCA, the appropriate measurement techniques for the factors through standardization, effective control of confounding variables in the study, and an examination of predefined socioeconomic gradients that were entirely absent in previous research on NAFLD in the South Asian region. However, there are also several weaknesses the study should consider. Previous studies of this type, specifically case-control studies, have noted problems with the study's reverse causality. However, the exclusion of participants who received a diagnosis within the past year partially mitigates this issue. The study has also had problems concerning the recall of information through the FFQ method. The face-to-face interview technique has once again improved the method. The study has also been limited owing to its nature of being hospital-based. In sum, the results of this study support the need for comprehensive dietary management and the incorporation of dietary assessments into the standard care of patients with metabolic risk factors. They also support the development of policies concerning unhealthy food availability and the impact of socioeconomic factors on the poor quality of diets. Future studies might include the effect of changes in dietary patterns and the regional food environment on the progression of NAFLD.

CONCLUSION

This research shows that Western dietary habits are strong risk factors for NAFLD in the Lahore adult population, and prudent diet habits are strongly protective against it regardless of obesity and the presence of metabolic risk factors. We found that high-SES individuals significantly amplified the large relative effect size of Western dietary risks. This stresses the intense need to address dietary habits regarding both nutritional and SES factors in the context of Pakistan.

DECLARATIONS

Ethical Approval

This study was approved by the Institutional Review Board of Superior University Lahore

Informed Consent

Written informed consent was obtained from all participants included in the study.

Conflict of Interest

The authors declare no conflict of interest.

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Authors' Contributions

Concept: AH; Design: LK; Data Collection: , AH, AA; Analysis: AH, LK

Data Availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Acknowledgments

Not applicable.

Study Registration

Not applicable.

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