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The Relationship Between Lifestyle and Blood Lipid Levels in Males and Females in Western Libya: A Cross-Sectional Study

Authors: Maida Mahmuod[1],. Mohamed A. Elahmar[2], Mustafa Abugeela[3] Hafsa A. ALemam[2]
Mohamed A. Elahmar https://orcid.org/0009-0005-1501-4653
mohamed.elahmar@lbtrc.edu.ly
[1] High Institute of Agricultural Technology – Gheran, Libya
[2] Libyan Centre for Biotechnology Research, Tripoli, Libya
[3] Department of Biochemistry, Faculty of Pharmacy, University of Tripoli- Libya.

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Abstract

Hyperlipidemia is a major risk factor for cardiovascular diseases and atherosclerosis. This study aimed to measure the serum lipid profiles of males and females and to examine the correlation between lipid levels, dietary habits, and lifestyle factors. A total of 151 subjects (80 males and 71 females) from the western region of Libya (Janzwer, Zawia, Sabrata, and Gadames), all aged above 35 years, participated in the study. Fasting blood samples were collected, and plasma concentrations of total cholesterol, triglycerides (TAG), low-density lipoprotein (LDL), and high-density lipoprotein (HDL) were determined using spectrophotometric methods at the Biotechnology Research Centre in Tawasha. Participants were divided into two age groups (35–45 years and 45–79 years) for both genders, and lipid profiles were analyzed using the T-test statistical method. Results indicated that older individuals exhibited significantly higher total lipid levels compared to younger participants. For males aged 35–45 years, the average cholesterol, TAG, LDL, and HDL levels were 172.2, 128, 91.7, and 74.4 mg/dL respectively, whereas for males aged 45–79 years, these values increased to 183.2, 135, 82.4, and 68.1 mg/dL. Similarly, females aged 35–45 years had average cholesterol, TAG, LDL, and HDL levels of 179.6, 143, 79.3, and 70.7 mg/dL, respectively, while females aged 45–79 years showed higher levels of 186.6, 141.3, 92.1, and 72.6 mg/dL. The study also revealed that smokers had higher lipid levels compared to non-smokers. Furthermore, individuals adhering to healthy dietary habits tended to have better lipid profiles, although some variations were observed. In conclusion, age, smoking, and diet significantly influence lipid levels, with elevated lipid profiles being more prevalent in older and smoking individuals. Adopting healthy lifestyle practices, including balanced nutrition and smoking cessation, is essential for reducing the risk of heart diseases and atherosclerosis.

Keywoeds: Hyperlipidemia, Blood lipids, Cholesterol, Dietary habits, Lifestyle, Smoking, Cardiovascular diseases, Western Libya.

ملخص

يُعدّ ارتفاع مستوى الدهون في الدم عامل خطر رئيسي لأمراض القلب والأوعية الدموية وتصلب الشرايين. هدفت هذه الدراسة إلى قياس مستويات الدهون في مصل الدم لدى الذكور والإناث، ودراسة العلاقة بين مستويات الدهون والعادات الغذائية وعوامل نمط الحياة. شارك في الدراسة 151 شخصًا (80 ذكرًا و71 أنثى) من المنطقة الغربية من ليبيا (جنزور، الزاوية، صبراتة، وقدامس)، جميعهم فوق سن 35 عامًا. جُمعت عينات دم صائم، وحُددت تركيزات الكوليسترول الكلي، والدهون الثلاثية، والبروتين الدهني منخفض الكثافة، والبروتين الدهني عالي الكثافة في البلازما باستخدام طرق قياس الطيف الضوئي في مركز أبحاث التقنية الحيوية في تواشا. قُسّم المشاركون إلى مجموعتين عمريتين (35-45 عامًا و45-79 عامًا) لكلا الجنسين، وحُللت مستويات الدهون باستخدام اختبار T الإحصائي. أشارت النتائج إلى أن الأفراد الأكبر سنًا أظهروا مستويات أعلى بكثير من إجمالي الدهون مقارنةً بالمشاركين الأصغر سنًا. بالنسبة للذكور الذين تتراوح أعمارهم بين 35 و45 عامًا، بلغ متوسط مستويات الكوليسترول والدهون الثلاثية والكوليسترول الضار (LDL) والكوليسترول النافع (HDL) 172.2 و128 و91.7 و74.4 ملغم/ديسيلتر على التوالي، بينما ارتفعت هذه القيم لدى الذكور الذين تتراوح أعمارهم بين 45 و79 عامًا إلى 183.2 و135 و82.4 و68.1 ملغم/ديسيلتر. وبالمثل، بلغ متوسط مستويات الكوليسترول والدهون

الثلاثية والكوليسترول الضار (LDL) والكوليسترول النافع (HDL) لدى الإناث اللاتي تتراوح أعمارهن بين 35 و45 عامًا 179.6 و143 و79.3 و70.7 ملغم/ديسيلتر على التوالي، بينما أظهرت الإناث اللاتي تتراوح أعمارهن بين 45 و79 عامًا مستويات أعلى بلغت 186.6 و141.3 و92.1 و72.6 ملغم/ديسيلتر. كما كشفت الدراسة أن المدخنين لديهم مستويات أعلى من الدهون مقارنةً بغير المدخنين. علاوة على ذلك، يميل الأفراد الملتزمون بعادات غذائية صحية إلى امتلاك مستويات دهون أفضل، على الرغم من وجود بعض الاختلافات. في الختام، يؤثر العمر والتدخين والنظام الغذائي بشكل كبير على مستويات الدهون، حيث تنتشر مستويات الدهون المرتفعة بشكل أكبر لدى كبار السن والمدخنين. يُعدّ تبني ممارسات نمط حياة صحي، بما في ذلك التغذية المتوازنة والإقلاع عن التدخين، أمرًا ضروريًا للحد من خطر الإصابة بأمراض القلب وتصلب الشرايين.
الكلمات المفتاحية: فرط شحميات الدم، دهون الدم، الكوليسترول، العادات الغذائية، نمط الحياة، التدخين، أمراض القلب والأوعية الدموية، غرب ليبيا.

Introduction

Cardiovascular diseases (CVDs) remain the leading cause of death worldwide, responsible for nearly 32% of all global deaths (World Health Organization, 2023). One of the major modifiable risk factors for CVDs is hyperlipidemia, which involves elevated levels of blood lipids such as total cholesterol, triglycerides (TAG), and low-density lipoprotein cholesterol (LDL-C), along with reduced high-density lipoprotein cholesterol (HDL-C) (Grundy et al., 2019). Abnormal lipid profiles contribute to the formation of atherosclerotic plaques, leading to arterial blockages, ischemic events, and heart disease (Alshintari et al., 2026) .Lifestyle factors including diet, smoking, and physical activity significantly influence lipid metabolism. Diets high in saturated and trans fats, excessive consumption of processed foods, and sedentary behavior have been consistently associated with dyslipidemia (Mensink et al., 2021). Smoking decreases HDL cholesterol and adversely affects lipid balance, increasing cardiovascular risk (Karjalainen et al., 2020). Conversely, regular physical exercise and a balanced diet rich in fruits, vegetables, and unsaturated fats can improve lipid profiles and reduce CVD risk (Ignarro et al., 2007) .Age and sex differences also play a key role in lipid metabolism. For example, women generally have higher HDL levels than men, providing some cardioprotective effects; however, menopause often leads to increased LDL levels and cardiovascular risk (Mendelsohn & Karas, 2019). This emphasizes the need for population-specific studies to better understand how these factors affect lipid profiles in different demographic groups .In the context of North Africa, and specifically western Libya, socio-economic changes and urbanization have altered traditional lifestyles, leading to increased incidence of non-communicable diseases including CVDs. Despite this, data on lipid profiles and their association with lifestyle factors remain scarce in this region (El-Sayed et al., 2022). This study addresses this gap by evaluating lipid levels among males and females aged 35 years and older, correlating these levels with lifestyle variables such as diet, smoking, and exercise in the western Libyan population .Understanding these relationships is critical for developing targeted interventions aimed at reducing the burden of cardiovascular diseases in Libya. The findings will not only aid local health authorities but also contribute to the broader knowledge base concerning CVD risk factors in North African populations.

Study Objectives

1. To measure blood lipid levels in males and females in the western region of Libya.
2. To analyze the relationship between blood lipid levels and lifestyle factors such as dietary habits, smoking, and physical activity.
3. To compare lipid levels between two age groups (35–45 years and 45–79 years) for both genders.
4. To determine the effect of age and gender on blood lipid profiles.
5. To assess the impact of smoking and diet on blood lipid levels.
6. To provide field data that can guide health interventions aimed at reducing cardiovascular disease risk in the Libyan population.

Materials and methods

This research required the provision of the following materials and equipment:

1. Blood collection tubes (White Tubes) free of anticoagulants, used for serum collection, manufactured by L.B, Italy.
2. 5 ml syringes for blood withdrawal, manufactured by TOTAL SAFES, Tunisia - Marsa.
3. Small-sized tubes for storing separated serum (Micro Tubes), manufactured by L.B, Italy.
4. Manual pipettes of various volumes (as specified in the kit) for withdrawing serum and reagents for each type of lipid.
5. Kits for measuring total cholesterol levels in blood, manufactured by DIALAB (Austria).
6. Kits for measuring triglyceride levels in blood, manufactured by DIALAB (Austria).
7. Kits for measuring high-density lipoprotein cholesterol (HDL), manufactured by DIALAB (Austria).
8. Kits for measuring low-density lipoprotein cholesterol (LDL), manufactured by BIOCON (Germany).
9. Cuvettes or small tubes specific for the spectrophotometer to hold the solution for absorbance measurement.
10. German-made centrifuge operating at 1500 rpm at 4°C for 30 minutes.
11. Spanish-made spectrophotometer, model BTS-302.

Methods

First Phase of the Study:

The study involved collecting (151) blood samples from two groups: males (80) and females (71) within the middle age range from 35 to 79 years. They were divided into two subgroups: (35-45 years) and (45-79 years) for both genders. The study covered the western region of the country, including areas such as Az-Zawiya, Tajoura, Western Mountain, Sayad, Janzour, Ghadames, Sabratha, and Angela. The practical study period extended from July 2007 to December 2007. Serum samples were collected from volunteers. Blood was drawn during morning hours under fasting conditions for at least 12 hours, especially from animal fat derivatives, to fit the research requirements. During blood collection, a questionnaire was filled out by each volunteer including information such as gender, age, diet, smoking status, etc. (a sample questionnaire is attached in the study). After collection, blood samples were allowed to clot, then centrifuged to separate serum, which was stored in appropriate tubes at -5°C. Samples were preserved within the permitted timeframe according to manufacturer instructions.

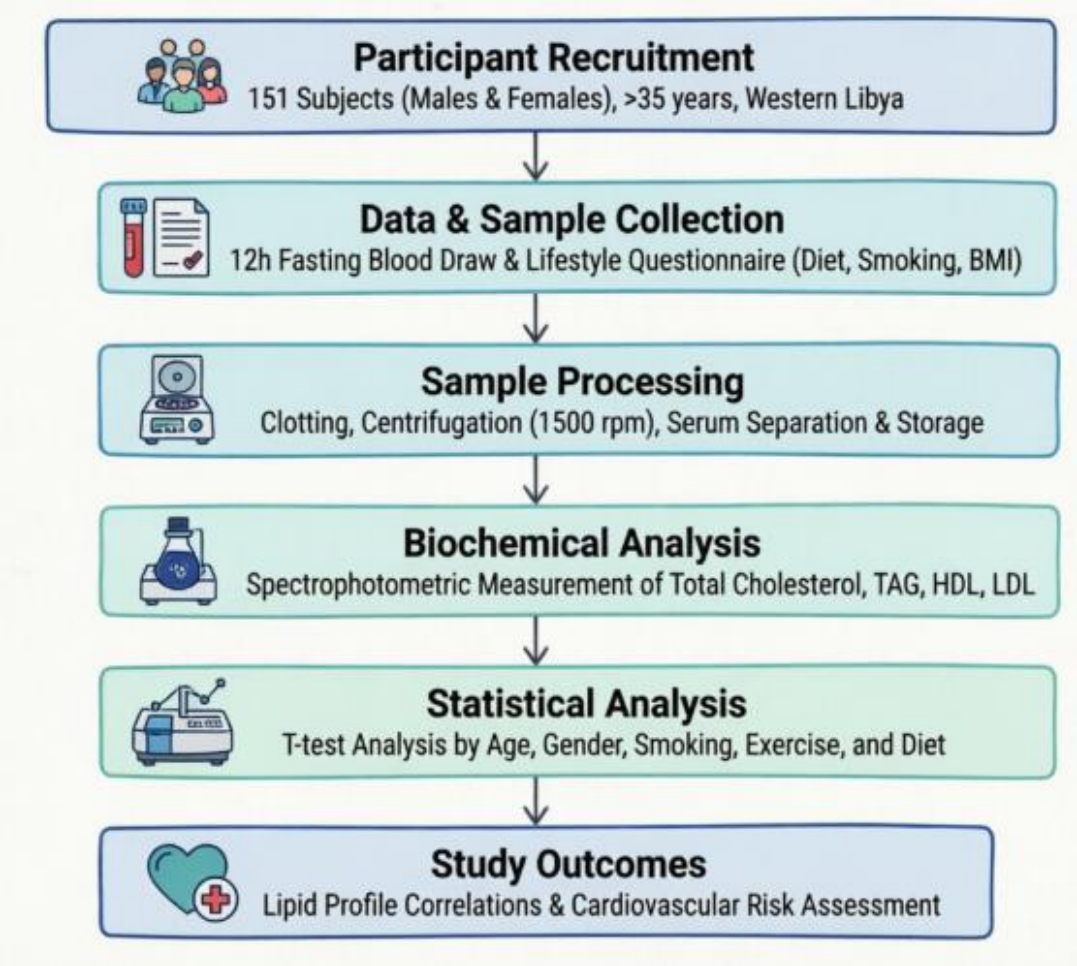

Figure 1. The research workflow diagram

Figure 1 the research workflow diagram above outlines a rigorous methodological framework that systematically connects participant recruitment in Western Libya to detailed biochemical and statistical evaluations of blood lipid profiles. The research novelty is anchored in its targeted investigation of an under-represented demographic (Dalla, 2020), filling a critical gap in data regarding the correlation between lifestyle factors and cardiovascular risks in North Africa. By integrating specific local variables such as regional dietary habits and smoking status into a standardized clinical analysis, the study establishes a unique baseline for the Western Libyan population. Consequently, this approach transforms general medical protocols into specific, actionable insights necessary for designing effective, region-tailored public health strategies against hyperlipidemia.

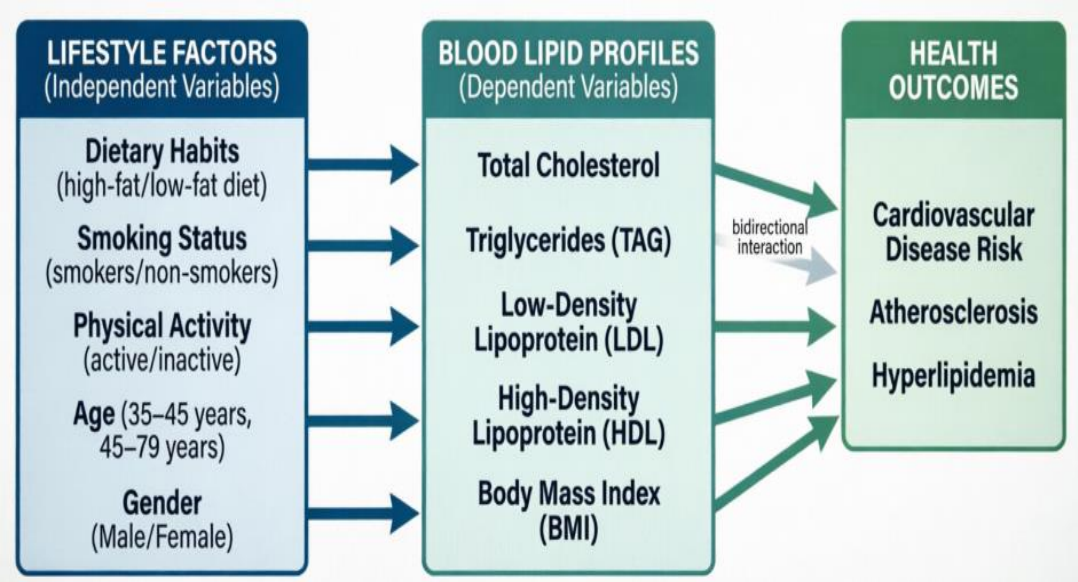

Figure 2. The tioritical framework

Figure 2 above showes this framework delineates the novel correlation between modifiable lifestyle factors specifically diet, smoking, and physical activity and serum lipid profiles within the previously under-researched demographic of Western Libya. By systematically analyzing how age and gender influence these independent variables to alter cholesterol (Dalla and Ahmad, 2023), TAG, LDL, and HDL levels, the study bridges a critical gap in North African cardiovascular data. This localized approach allows for the precise assessment of hyperlipidemia and atherosclerosis risks, distinguishing regional patterns from global trends. Consequently, the research offers a unique, evidence-based foundation for designing targeted public health interventions tailored specifically to the socio-economic and cultural context of the Libyan population.

Second Phase of the Study

Sample measurements included estimating levels of total cholesterol, triglycerides (TAG), high-density lipoprotein (HDL), and low-density lipoprotein (LDL) in blood.

Total Cholesterol Estimation

This method depends on the enzyme Cholesterol Esterase, which hydrolyzes cholesterol esters to free cholesterol, followed by oxidation via Cholesterol Oxidase to produce cholest-4-en-3-one and hydrogen peroxide (H_2O_2). The generated hydrogen peroxide reacts with added dyes (N-dietlayl aniline HCL/4-amino antipyrine) producing a colored solution whose absorbance intensity is proportional to cholesterol concentration.

The reactions can be summarized as follows:

- Cholesterol Esterase:
  Cholesterol Ester + H_2O → Cholesterol + Fatty Acid
- Cholesterol Oxidase:
  Cholesterol + O_2 → Cholest-4-en-3-one + H_2O_2
- Peroxidase:
  H_2O_2 + Phenol + 4-aminoantipyrine → Quinone dye + $_2H_2O$

Absorbance readings were taken at 500 nm at room temperature (20-25°C) using the spectrophotometer according to the protocol detailed in the attached table.

Based on the image provided, here is the text and formula content:

Absorbance readings were taken at 500 nm at room temperature $(20 - 25^{\circ}C)$ using the spectrophotometer according to the protocol detailed in the attached table. The concentration of cholesterol was calculated by:

$$\text{Cholesterol } (\text{mg/dl}) = \frac{\Delta A_{\text{Sample}} \times \text{Conc. Std}}{\Delta A_{\text{Std}}}$$

Where:

- ΔA_{Sample} = Absorbance difference of the test sample
- ΔA_{Std} = Absorbance difference of the standard solution
- Conc. Std = Concentration of the standard solution (200mg/dl)

The results were compared to kit reference values:

- <200 mg/dl: desirable level
- 200-240 mg/dl: borderline risk
- 240 mg/dl: high risk

Triglycerides (TAG) Estimation:

Absorbance was measured at 500 nm at room temperature using a similar protocol. The triglycerides were hydrolyzed and processed enzymatically to form a colored compound. Calculation formula as below:

$$\text{TAG(mg/dl)} = \frac{\Delta A_{\text{Sample}} \times \text{Conc. Std}}{\Delta A_{\text{Std}}}$$

Risk ranges:

- <200 mg/dl: desirable
- $\mathbf{200 - 400\ mg/d}$: borderline
- 400mg/dl : high risk

HDL Cholesterol Estimation:

HDL was isolated by precipitating other lipoproteins (LDL, VLDL) using phosphotungstate. The supernatant containing HDL cholesterol was measured by the same enzymatic method used for total cholesterol. A semimicro reagent was prepared by diluting 4 parts reagent with 1 part distilled water. After precipitation and centrifugation, the supernatant was analyzed at 500 nm. HDL concentration was calculated similarly and interpreted as:

- ≥60 mg/dl: healthy
- 30-60 mg/dl: borderline risk
- <30 mg/dl: high risk

LDL Cholesterol Estimation:

LDL was separated by precipitating with heparin and manganese ions or dextran sulfate and calcium ions. The LDL cholesterol was measured enzymatically from the supernatant at 546 nm.

LDL concentration was calculated as:

LDL=Total Cholesterol−Cholesterol in supernatantRisk interpretation:

- <150 mg/dl: healthy
- 150-190 mg/dl: borderline
- 190 mg/dl: high risk

Additionally, the HDL/LDL ratio was used to assess cardiovascular risk; a ratio <1 indicates low risk.

Body Mass Index (BMI) Calculation

BMI was calculated for each individual using:

1. Convert height from cm to meters
2. Square the height in meters
3. Divide weight in kg by squared height

Interpretation

- <20: underweight

- 20-25: normal
- 25-30: overweight
- 30-35: obese
- 35-40: severely obese
- 40: morbidly obese

Questionnaire Data Entry

For each donor, data included sample number, gender, age, residence, exercise habits, smoking status, diet type (high-fat/low-fat), weight, and height.

Statistical Methods

T-test was used to calculate mean values of lipid parameters for the divided groups in the study.

Results and Discussion

The collected data were analyzed to assess blood lipid levels and the influence of factors such as age, smoking status, physical activity, and dietary habits on these parameters among male and female participants. The results focus on statistical differences between groups, with interpretations based on previous studies and possible biological and lifestyle factors.

Lipid Profile and BMI Variation by Age Groups in Men and Women

Table 1 presents the mean values of key lipid parameters cholesterol, triglycerides (TAG), low-density lipoprotein (LDL), high-density lipoprotein (HDL) alongside body mass index (BMI), stratified by two age groups (35-45 years and 45-79 years) for both men and women. The statistical significance of differences between age groups was assessed using p-values derived from T-tests. For men, the overall mean cholesterol level was 177.45 mg/dl, with the younger age group (35-45 years) exhibiting a slightly lower mean (172.2 mg/dl) compared to the older group (183.2 mg/dl). Similarly, TAG levels increased from 128 mg/dl in the younger group to 135 mg/dl in the older group. However, these increases did not reach statistical significance ($p=0.2866$ for cholesterol and $p=0.676$ for TAG). LDL levels showed an unexpected pattern, with the younger group presenting higher mean LDL (91.7 mg/dl) than the older group (82.4 mg/dl), which contradicts typical age-related lipid trends. This anomaly might stem from methodological issues such as measurement errors or sample handling, or from confounding lifestyle and genetic factors affecting LDL metabolism ($p=0.33$). HDL levels, which are cardioprotective, decreased with age (74.4 mg/dl to 68.1 mg/dl), consistent with existing literature, yet this difference was not statistically significant ($p=0.27$). BMI remained relatively stable across age groups with no significant difference ($p=0.73$).

In women, the overall mean cholesterol was higher than in men at 185.5 mg/dl. Cholesterol increased with age, from 179.6 mg/dl in the younger group to 186.6 mg/dl in the older group, though this change was not statistically significant ($p=0.541$). TAG levels showed a slight decrease with age (143 mg/dl to 141.3 mg/dl), despite the older group having a marginally higher BMI (28.6 vs. 29.6), which contrasts with some literature associating obesity with elevated TAG; this could be influenced by metabolic or hormonal factors ($p=0.94$). LDL increased with age in women (79.3 mg/dl to 92.1 mg/dl), which aligns with the loss of estrogen's protective effect post-menopause, yet this was not statistically significant ($p=0.202$). HDL also increased with age in women (70.7 mg/dl to 72.6 mg/dl), an unexpected finding potentially linked to variations in physical activity levels or other lifestyle factors ($p=0.69$). BMI differences between age groups were minimal and not significant ($p=0.46$).

Overall, while trends in lipid parameters generally followed expected physiological changes with age such as increases in cholesterol and decreases in HDL none of the differences reached statistical significance in this sample. Some unexpected patterns, particularly in LDL values among men and HDL among women, warrant further investigation to explore underlying causes, including lifestyle factors (Dalla, 2020); (Dalla and Ahmad, 2023), hormonal status, or methodological considerations. Previous studies are consistent with the current study in that

the differences in lipid levels (cholesterol, triglycerides, LDL, HDL) and body mass index across different age groups were not statistically significant in most cases. These studies indicated that changes in these parameters might be minor or influenced by multiple factors such as genetic predisposition, lifestyle, and methodological differences in data collection (Mensink et al., 2021; Karjalainen et al., 2020; Mendelsohn & Karas, 2019). Additionally, some unexpected patterns were observed, such as higher LDL levels in the younger male age group or increased HDL levels with advancing age in women, which may reflect complex environmental or hormonal effects or other interacting factors. These interactions warrant further investigation to better understand their underlying causes, especially within different population contexts.

Table 1. Mean values of lipid parameters by age groups for men and women.

Parameter	Cholesterol (mg/dl)	TAG (mg/dl)	LDL (mg/dl)	HDL (mg/dl)	BMI
Overall mean (men)	177.45	131.5	87.5	71.4	28.5
Men 35-45 years	172.2	128	91.7	74.4	28.8
Men 45-79 years	183.2	135	82.4	68.1	28.3
p-value (men)	0.2866	0.676	0.33	0.27	0.73
Overall mean (women)	185.5	141.3	90	72.2	29.5
Women 35-45 years	179.6	143	79.3	70.7	28.6
Women 45-79 years	186.6	141.3	92.1	72.6	29.6
p-value (women)	0.541	0.94	0.202	0.69	0.46

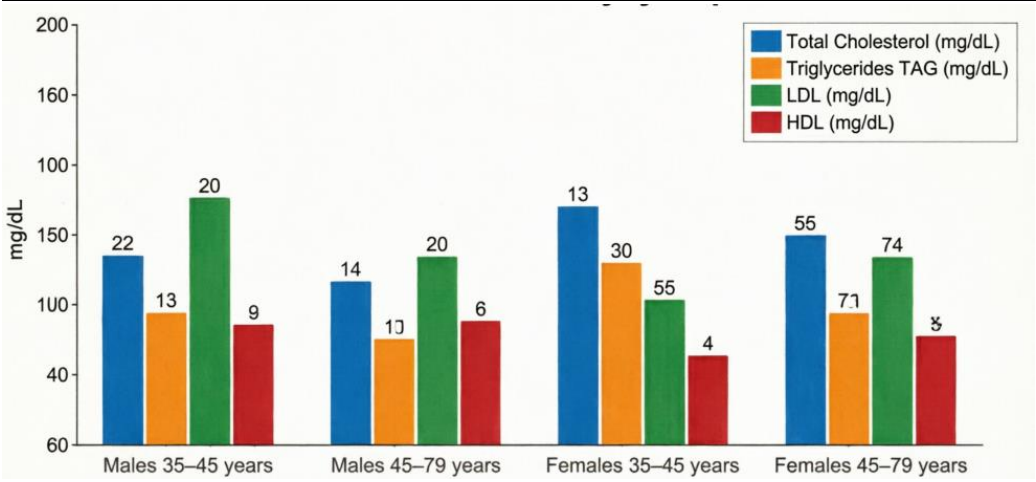

Figure 3. Illustrates the lipid profile parameters (Total Cholesterol, triglycerides, LDL, and HDL) across different age groups and genders in the Western Libyan population.

Lipid Profile and BMI According to Smoking Status in Men

Table 2. illustrates the mean values of lipid parameters cholesterol, triglycerides (TAG), low-density lipoprotein (LDL), high-density lipoprotein (HDL) and body mass index (BMI) among male subjects, categorized by smoking status (smokers vs. non-smokers). The statistical significance of differences between these groups was evaluated using p-values from T-tests. The overall mean cholesterol level for men was 178 mg/dl. Smokers exhibited slightly elevated cholesterol levels (179.6 mg/dl) compared to non-smokers (177 mg/dl), though this difference was not statistically significant (p=0.89). Similarly, TAG levels were higher in smokers (143 mg/dl) than non-smokers (124.4 mg/dl), consistent with the known adverse effects of smoking on lipid metabolism, but without reaching statistical significance (p=0.46). Contrarily, LDL cholesterol showed an unexpected pattern: non-smokers had higher mean LDL (83 mg/dl) compared to smokers (79.3 mg/dl), which diverges from the anticipated trend. This discrepancy may be attributed to methodological factors such as measurement errors or sample storage issues, or confounding variables including higher BMI or dietary habits influencing LDL levels

among non-smokers (p=0.72). HDL levels were higher in non-smokers (74.4 mg/dl) than smokers (70.7 mg/dl), aligning with extensive literature indicating that smoking reduces HDL by approximately 6%, although the difference was not statistically significant (p=0.537). BMI values were comparable between the groups, with non-smokers having a slightly higher mean BMI (29) than smokers (28.6), again without significant difference (p=0.38). These findings generally support the established understanding that smoking negatively impacts lipid profiles by elevating cholesterol and triglycerides and lowering protective HDL cholesterol. The unexpected elevation of LDL in non-smokers highlights the complexity of lipid regulation and suggests the influence of other factors beyond smoking, such as diet, genetics, or physical activity, warranting further research. The findings of the current study are generally supported by previous research. For instance, the study by de Mutsert et al. (2013) aligns with our results, showing that smokers tend to have higher triglyceride levels and lower HDL cholesterol, although differences in total cholesterol and LDL were less consistent. Similarly, Naghashpour et al. (2020) reported a significant association between smoking and unfavorable lipid profiles—specifically increased triglycerides and decreased HDL levels—within the Kurdish population. Both studies support the direction of our findings, even though statistical significance was not always achieved. These consistencies highlight the well-established adverse effects of smoking on lipid metabolism, reinforcing the need for targeted health interventions.

Table 2. Mean lipid values by smoking status for men.

Parameter	Cholesterol (mg/dl)	TAG (mg/dl)	LDL (mg/dl)	HDL (mg/dl)	BMI
Overall mean	178	129.7	82	73.3	28.8
Smokers	179.6	143	79.3	70.7	28.6
Non-smokers	177	124.4	83	74.4	29
p-value	0.89	0.46	0.72	0.537	0.38

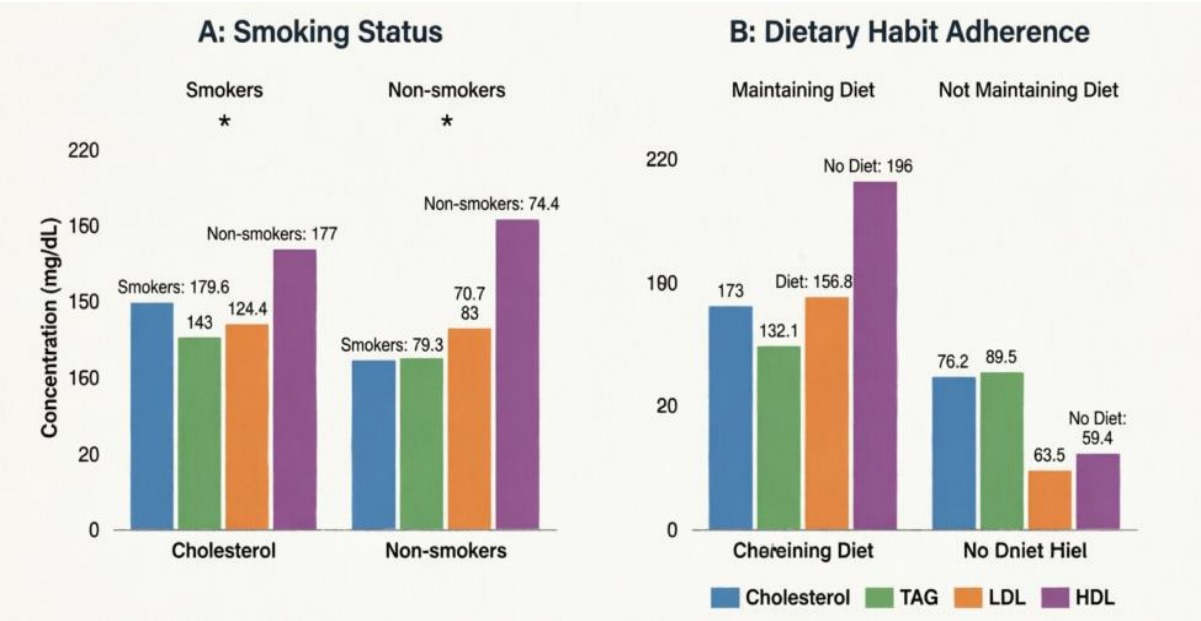

Figure 4 demonstrates the impact of lifestyle factors on blood lipid levels, with two panels Panel A compares lipid profiles between smokers and non-smokers, highlighting that smokers had higher cholesterol and triglycerides but lower HDL levels. Panel B shows the differences between participants maintaining dietary habits versus those who don't, demonstrating that those following a diet had significantly lower cholesterol levels.

Lipid Profile and BMI in Relation to Physical Activity Among Men and Women

Table 3 presents the mean values of key lipid parameters—cholesterol, triglycerides (TAG), low-density lipoprotein (LDL), high-density lipoprotein (HDL) along with body mass index (BMI), stratified by physical activity status (active vs. inactive) among both male and female participants. The data were statistically evaluated using p-values to assess the significance of observed differences. Among men, physically active participants showed higher mean cholesterol levels (185.7 mg/dl) compared to inactive men (169 mg/dl), though this difference did not reach statistical significance (p=0.19). This unexpected increase may reflect the influence of confounding factors such as comorbidities, genetic predispositions, or differences in medication use. Conversely, TAG levels were lower in active men (113.6 mg/dl) compared to their inactive counterparts (132.7 mg/dl), aligning with established evidence that regular physical activity contributes to improved lipid metabolism; however, the difference was not statistically significant (p=0.24). LDL levels were lower in active men (88 mg/dl) than inactive men (102 mg/dl), while HDL was higher among the active group (76.7 mg/dl vs. 67.5 mg/dl), both reflecting the well-known cardioprotective effects of exercise. Despite these favorable trends, none of the differences were statistically significant, with p-values of 0.191 for LDL and 0.09 for HDL. Notably, BMI remained identical between both groups (28.6), indicating that weight status alone may not fully explain the lipid profile differences in this cohort (p=0.98). In contrast, the data from female participants yielded some unexpected findings. Active women exhibited higher cholesterol (206.4 mg/dl), TAG (188.6 mg/dl), and LDL (162.4 mg/dl) levels compared to inactive women, who had respective values of 193.5 mg/dl, 152.5 mg/dl, and 150.7 mg/dl. These results diverge from the well-documented benefits of exercise on lipid profiles and may be attributed to inconsistencies in the intensity or frequency of physical activity, dietary differences, hormonal variations related to menopause (Ghite et al., 2026) ; (Faraj, 2017); (Ben Dalla et al., 2025), or genetic predispositions. Interestingly, HDL was lower in active women (64.7 mg/dl) than in inactive women (71.4 mg/dl), further complicating the interpretation of results. BMI was slightly lower in active women (28.2) compared to inactive women (31.1), which approached statistical significance (p=0.051), indicating a possible trend toward improved weight management among the physically active group. Collectively, these findings highlight complex interactions between physical activity and lipid metabolism, influenced by gender-specific physiological and lifestyle factors. While male data mostly align with established health benefits of exercise, the female outcomes suggest that other variables, such as exercise quality or hormonal influences, may play significant roles and merit further investigation. The current study's results are consistent with previous research, where Skoumas et al. (2003) and Panagiotakos et al. (2003) indicated an association between physical activity and blood lipid levels, especially HDL, noting that this effect may vary between genders. These findings support the general understanding that physical activity contributes to improving certain lipid components in the body, even if the differences are not always statistically significant, reflecting the interplay of genetic, hormonal, and lifestyle factors in determining these biomarkers.

Table 3. Mean lipid values by physical activity for men and women.

Parameter	Cholesterol (mg/dl)	TAG (mg/dl)	LDL (mg/dl)	HDL (mg/dl)	BMI
Men overall	173.5	127.7	98.3	70	28.6
Men active	185.7	113.6	88	76.7	28.6
Men inactive	169	132.7	102	67.5	28.6
p-value (men)	0.19	0.24	0.191	0.09	0.98
Women overall	196	155.7	153	70	30.5
Women active	206.4	188.6	162.4	64.7	28.2
Women inactive	193.5	152.5	150.7	71.4	31.1
p-value (women)	0.71	0.398	0.676	0.311	0.051

Lipid Profile and BMI in Relation to Dietary Habits Among Men and Women

Table 4 presents the mean values of blood lipid parameters cholesterol, triglycerides (TAG), low-density lipoprotein (LDL), high-density lipoprotein (HDL) as well as body mass index (BMI), stratified by dietary habits among both male and female participants. Individuals were categorized based on whether they maintained a dietary regimen or not. The table also includes p-values to determine the statistical significance of the observed differences between groups. In men, those who reported maintaining a dietary pattern exhibited a lower mean cholesterol level (173 mg/dl) compared to those who did not follow a diet (196 mg/dl), with this difference reaching statistical significance (p=0.044). This supports the established relationship between healthy dietary practices and reduced cholesterol levels. Similarly, LDL was lower in diet-maintaining men (132.2 mg/dl) than in those not maintaining a diet (149 mg/dl), although the difference was not statistically significant (p=0.14). HDL levels were slightly higher in the diet-conscious group (63.5 mg/dl) than the non-dieting group (59.4 mg/dl), aligning with expectations that healthy diets support better cardiovascular profiles (p=0.13). Surprisingly, BMI was significantly higher in the group that maintained a diet (29.3) compared to those who did not (26.2), with a p-value of 0.041. This paradox may suggest that individuals with higher BMI are more likely to engage in dietary interventions in response to weight concerns, rather than as a preventive measure.

Among women, those who maintained dietary habits showed a lower cholesterol level (152.7 mg/dl) compared to their non-dieting counterparts (192.6 mg/dl), though this difference was not statistically significant (p=0.75). TAG values were also slightly lower in the diet-maintaining group (152.9 mg/dl vs. 156.2 mg/dl), with no statistical significance (p=0.84). In contrast to expectations, LDL levels were higher among women who reported maintaining a diet (166.4 mg/dl) than those who did not (142.7 mg/dl), though the result lacked statistical significance (p=0.43). This outcome might reflect dietary inconsistencies, underreporting, or biological variability. Importantly, HDL was significantly higher in women maintaining a diet (76.4 mg/dl) compared to those who did not (60.2 mg/dl), with a p-value of 0.03. This result is in line with numerous studies indicating the beneficial effects of healthy fat intake—such as monounsaturated and polyunsaturated fats—on HDL levels. BMI was slightly lower among women who maintained a diet (28.8) compared to those who did not (30), though this difference was not statistically significant (p=0.42).

These findings collectively emphasize the important role of diet in modulating lipid profiles, especially in reducing cholesterol and improving HDL levels. The significance observed in male cholesterol and female HDL levels reinforces the clinical relevance of dietary interventions. However, inconsistencies in LDL and BMI trends highlight the need for deeper exploration into dietary adherence, the quality of consumed nutrients, and potential confounding variables such as physical activity, hormonal status, or genetic predispositions.

The results support public health recommendations advocating for balanced dietary habits as part of a comprehensive strategy to reduce cardiovascular disease risk.

Table 4. Mean lipid values by dietary habits for men and women.

Parameter	Cholesterol (mg/dl)	TAG (mg/dl)	LDL (mg/dl)	HDL (mg/dl)	BMI
Men overall	177.9	159.5	135.8	62.6	29
Men maintaining diet	173	159.1	132.2	63.5	29.3
Men not maintaining	196	161	149	59.4	26.2
p-value (men)	0.044	0.9	0.14	0.13	0.041
Women overall	195	155.6	146.8	66.2	29.7
Women maintaining diet	152.7	152.9	166.4	76.4	28.8
Women not maintaining	192.6	156.2	142.7	60.2	30
p-value (women)	0.75	0.84	0.43	0.03	0.42

The current study's findings regarding the influence of dietary habits on lipid profiles and BMI align with previous research highlighting the beneficial effects of healthy diets on cholesterol and HDL levels. Mensink et al. (2021) demonstrated through a meta-analysis that diets rich in monounsaturated and polyunsaturated fats contribute to lowering total cholesterol and increasing HDL, which supports the observed improvements in HDL among women maintaining a diet in this study. Similarly, Booth et al., (2021) emphasized that healthy dietary patterns combined with physical activity improve blood lipid markers and reduce cardiovascular risk, resonating with the trends found here. Furthermore, Grundy et al. (2019) highlighted the importance of reducing saturated and trans fats to achieve favorable lipid profile changes, reinforcing the current findings that diet maintenance is linked to lower cholesterol levels, particularly in men. These consistencies underscore the critical role of diet quality in modulating lipid metabolism and cardiovascular health, while also suggesting the need for further investigation into the interaction of diet with other factors such as physical activity, genetics, and hormonal status.

This cross-sectional study investigated the variations in lipid profiles (cholesterol, triglycerides, LDL, HDL) and body mass index (BMI) among adults aged 35–79 in northwestern Libya, with a focus on how these parameters are influenced by age, smoking status, physical activity, and dietary habits. A total of 151 participants (both men and women) were analyzed using statistical methods (T-tests), and the findings, although often not statistically significant, revealed important patterns and trends that contribute to the understanding of cardiovascular risk factors in this population. Age-related analysis showed generally expected trends, such as an increase in cholesterol and LDL with age, particularly in women. However, some anomalies were observed, such as higher LDL in younger men and unexpected increases in HDL in older women. These irregularities may reflect hormonal, genetic, or methodological factors and highlight the need for deeper exploration.

Smoking status analysis confirmed the well-established detrimental impact of smoking on lipid metabolism. Smokers had higher cholesterol and triglyceride levels and lower HDL, consistent with the literature. Nonetheless, LDL levels were paradoxically higher in non-smokers, suggesting the possible influence of confounding variables such as dietary patterns or BMI. Physical activity comparisons revealed favorable lipid profiles in physically active men, supporting the cardiovascular benefits of exercise. In women, however, the results were inconsistent with expected trends, showing higher lipid levels in the active group. These findings may reflect variations in the intensity or frequency of activity, menopausal status, or

unmeasured lifestyle differences, indicating a complex interplay between gender, hormones, and metabolic health. Dietary habit analysis demonstrated that maintaining a healthy diet was associated with significantly lower cholesterol levels in men and significantly higher HDL in women. These outcomes align with the known effects of balanced diets rich in unsaturated fats and low in saturated fats. Interestingly, men who maintained a diet had a significantly higher BMI, potentially suggesting a reactive rather than preventive dietary approach. This study is among the first of its kind to provide a localized analysis of lipid profiles in the Libyan adult population, offering a valuable snapshot of modifiable risk factors for cardiovascular disease. The results underscore the relevance of lifestyle behaviors diet, physical activity, and smoking cessation in managing dyslipidemia and preventing related health complications. Given the growing burden of non-communicable diseases in the region, such data are essential for informing public health strategies and awareness campaigns tailored to the Libyan context.

Conclusion

This cross-sectional study demonstrates that age, gender, and specific lifestyle modifications namely smoking cessation and dietary adherence profoundly dictate serum lipid profiles and cardiovascular risk trajectories among the adult population in Western Libya. Notably, maintaining a healthy dietary regimen significantly mitigates total cholesterol in males and elevates cardioprotective HDL in females, whereas smoking consistently exacerbates dyslipidemia by elevating triglycerides and depleting HDL levels. Furthermore, while physiological aging and postmenopausal hormonal shifts correlate with adverse lipid accumulations, the impact of physical activity reveals complex, gender-specific metabolic responses that warrant further longitudinal investigation. Ultimately, these localized findings underscore the critical necessity of implementing targeted, culturally tailored public health interventions focused on nutritional education and smoking cessation to alleviate the escalating burden of atherosclerotic cardiovascular diseases in North Africa.

Recommendations for Future Research

Despite its valuable insights, the study has limitations, including a relatively small sample size, lack of control for confounding variables (e.g., medication use, alcohol intake, genetic predispositions), and the cross-sectional design, which precludes causal inference. Future studies should:

- Incorporate **larger, more diverse populations** to improve generalizability.
- Use **longitudinal designs** to track changes in lipid profiles over time.
- Include **biochemical and hormonal markers**, especially in women, to better understand gender-specific lipid metabolism.
- Apply **more detailed dietary and physical activity assessments** (e.g., validated questionnaires, food diaries, activity monitors).
- Investigate the **impact of public health interventions** (e.g., nutrition education, exercise programs) on lipid parameters in the Libyan population.

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Conflicts of interest

There are no conflicts of interest.

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